Lower socioeconomic status is associated with higher intended consumption from oversized portions of unhealthy food

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Abstract

Socioeconomic status is one of the strongest predictors of obesity, and of living in deprived neighbourhoods with unhealthy food environments. Little is known, however, about the psychological processes that translate features of such environments into socioeconomic differences in eating behaviour. One important feature of unhealthy food environments is the prevalence of oversized portions of unhealthy food. The present study tested whether individuals with lower socioeconomic status intend to consume more from large portions than those with higher socioeconomic status, and examined the psychological processes underlying this effect. A large-scale online experiment was conducted in which participants (N = 511) indicated how much they would eat from small and large portions of healthy and unhealthy snacks. The mediating effects of trait impulsivity and perceptions of how much was considered appropriate to eat were also assessed. Participants with lower socioeconomic status intended to eat more from the large portions than from the small portions of the unhealthy snacks, which would equate to a potential 15-22% increase in energy intake. These effects were partially mediated by trait impulsivity and perceptions of how much is appropriate to eat. These findings point to a significant health burden of low socioeconomic status: when exposed to unhealthy food environments, specific psychological processes might increase the amount of unhealthy food those with lower socioeconomic intend to consume. This study critically informs the emerging understanding of the psychology of socioeconomic status and eating behaviour.

Keywords: health behaviour, eating behaviour, socioeconomic status, open data

Socioeconomic status is one of the strongest predictors of obesity (e.g., Darmon & Drewnowski, 2008). The prevalence of obesity in England is, for example, 45% lower for women with the highest household incomes than with the lowest household incomes, and 47% lower for women with degree-level qualifications than with no qualifications (Moody & Neave, 2015; Roberts, Cavill, Hancock, Rutter, 2013). Socioeconomic status is also a strong predictor of living in deprived neighbourhoods with unhealthy food environments. Adults living in the most deprived areas in England are 46% more likely to be obese than adults living in the least deprived areas (Baker, 2016). More deprived areas also have an increased density of fast-food outlets, thus increasing exposure and access to oversized portions of attractive, unhealthy food (e.g., Burgoine et al., 2016). This leads to two important questions: (1) How do people with lower socioeconomic status respond when exposed to oversized portions of unhealthy foods? and (2) What are the psychological processes that translate exposure to oversized portions into overconsumption, especially amongst individuals with lower socioeconomic status?

Whilst previous work has studied the associations of socioeconomic status with diet-related health inequalities, this work has not examined the psychological processes that link socioeconomic status with drivers of health inequalities, such as overconsumption of unhealthy food. The present study therefore tests whether individuals with lower socioeconomic status intend to consume more from large portions of unhealthy food than individuals with higher socioeconomic status. Furthermore, the present study tests the hypotheses that increased impulsivity and perceptions of how much is appropriate to eat underlie these effects and are therefore central psychological processes that might contribute to socioeconomic differences in unhealthy food consumption. Whilst previous work has shown that individuals who are made to feel low levels of interpersonal power have a preference for larger food portions (Dubois, Rucker, & Galinsky, 2012), people's intended consumption from small versus large portions as a function of actual socioeconomic status has not been examined, along with the underlying psychological processes. Building on previous research showing that those with a

lower socioeconomic status are disproportionately exposed to unhealthy food environments, of which large portion sizes are a salient feature (e.g., Burgoine et al., 2016), our work suggests that specific psychological processes might predispose those with lower socioeconomic status to overeat when exposed to those environments.

Food portions, especially portions of unhealthy foods, have grown substantially in recent decades (e.g., Young & Nestle, 2012). Most people overeat when presented with a large portion compared with a small portion of food, a phenomenon known as the 'portion-size effect' (for meta-analyses, see Hollands et al., 2015; Zlatevska, Dubelaar, & Holden, 2014). The portion-size effect is especially pronounced – and especially problematic – for unhealthy food (e.g., Hollands et al., 2015). As a result, the availability of oversized portions of unhealthy foods has been identified as playing a key role in the current obesity crisis (Marteau, Hollands, Shemilt, & Jebb, 2015). Importantly, we propose that this may be especially likely for people with a lower socioeconomic status, and we report a study testing this idea. We also examine whether exposure to large portions contributes to intentions to overconsume unhealthy food via individual differences in impulsivity, and via altered perceptions of how much is appropriate to eat.

Impulsivity refers to the inability to suppress responses to short-term rewards in favour of greater longer-term rewards, and to stop oneself from responding to tempting stimuli. Lower socioeconomic status has been associated with increased impulsivity and reduced response inhibition (e.g., Hackman, Farah, & Meaney, 2010). Indeed, the experience of deprivation and inequality may increase engagement in risky and impulsive behaviours (Griskevicius, Tybur, Delton, & Robertson, 2011; Haushofer & Fehr, 2014; Payne, Brown-Iannuzzi, & Hannay, 2017). Higher trait impulsivity has also been associated with increased consumption of unhealthy food (e.g., Guerrieri, Nederkoorn, & Jansen, 2008). Given this converging evidence, we therefore hypothesised that, in the face of large portions of attractive unhealthy food, higher impulsivity could explain increased intended consumption amongst those with lower socioeconomic status.

Furthermore, lower socioeconomic status could also increase how much people intend to consume from oversized portions by altering perceptions of how much is appropriate to eat. Appropriateness has been found to play an important role in the portion-size effect, such that the size of a served portion or food package acts as a cue for how much is 'appropriate' or socially acceptable to eat. As a result of these normative processes, consumption increases when larger portions are available, especially if the food is attractive (e.g., Versluis & Papies, 2016a). People living in more deprived neighbourhoods have a higher likelihood of being exposed to larger portions of unhealthy food (e.g., Burgoine et al., 2016), and those with lower socioeconomic status consume more unhealthy food in general (e.g., Darmon & Drewnowski, 2008; Pechey et al., 2013). These experiences may make larger portions of unhealthy food seem 'normal' and overconsumption from these portions seem appropriate (Robinson & Kersbergen, 2018). Thus, it is possible that perceptions of how much is appropriate to eat drive the increased susceptibility for overconsumption amongst those with lower socioeconomic status.

In the present study, an online methodology was used to obtain a large sample of participants from a wide range of socioeconomic backgrounds. We presented participants with images of various healthy and unhealthy snacks and measured how much they intended to eat from each food portion (see Marchiori, Papies, & Klein, 2014; Robinson, Te Raa & Hardman, 2015; Versluis & Papies, 2016b; Wilkinson et al., 2012). We categorised the snacks *a priori* as 'healthy' and 'unhealthy' with the snacks differing on numerous characteristics, including calorie content, nutritional value, and levels of processing and preservatives. We validated these categorisations against participants' representations by asking participants to rate the healthiness of each snack. We also assessed trait impulsivity, and how much participants thought would be appropriate to eat from each food portion.

We obtained four measures of socioeconomic status. First, as measures of 'objective' socioeconomic status, we asked participants to report their highest educational qualification and, second, their current household income. Third, we asked participants to report their household

postcode, which we linked to the English Index of Multiple Deprivation (Smith, Noble, Noble, Wright, & McLennan, 2015). This serves to index geographic neighbourhood deprivation, which has been shown to predict obesity prevalence. Fourth, participants reported their perceived current wealth as 'subjective' socioeconomic status has been shown to be a strong predictor of various health outcomes (for a recent meta-analysis, see Cundiff & Matthews, 2017) and participants' perceptions of their material resources could, for example, affect their impulsive responses to rewarding food, thus increasing the portion-size effect for the unhealthy snacks.

We addressed four hypotheses. First, we hypothesised that intended consumption would be higher from larger than from smaller portions. Second, we hypothesised that the portion-size effect on intended consumption would be larger for unhealthy snacks than for healthy snacks. These hypotheses are in line with earlier findings (see meta-analyses, Hollands et al., 2015; Zlatevska, Dubelaar, & Holden, 2014). Third, we hypothesised that this pattern would be especially pronounced amongst people with lower socioeconomic status (as measured by educational qualification, household income, neighbourhood deprivation, and perceived current wealth). Fourth, we hypothesised that the effect of socioeconomic status on the portion-size effect for intended consumption of the unhealthy snacks would be mediated, in part, by trait impulsivity and by perceptions of how much is appropriate to eat.

In addition to addressing our four hypotheses, we also explored the role of a present time perspective (Keough, Zimbardo, & Boyd, 1999)[1]. According to life-history theories, those with low socioeconomic status may prioritise immediate reward over longer-term goals (i.e. adopt a present time perspective; Daly & Wilson, 2005), which is similar to impulsivity but could reflect a more general preference to focus on present enjoyment in one's decision-making. Thus, we also examined

[1] Whilst we collected data on present time orientation (as part of a wider research project on socioeconomic status and eating behaviour) we did not originally plan to examine this variable as a mediator in the present study. We thank an anonymous Reviewer for raising this suggestion.

whether a present time perspective mediated the effect of socioeconomic status on the portion-size effect for intended consumption of the unhealthy snacks.

Method

Design

The experiment had a 2 (portion size: small vs. large) × 2 (snack healthiness: healthy vs. unhealthy) within-participants design. The socioeconomic status of each participant was operationalised as a discrete categorical variable for highest educational level (low vs. high) and as continuous variables for household income, neighbourhood deprivation, and perceived current wealth. Participants viewed half of the food items in a small portion size and the other half in a large portion size. The mapping between each food item and portion size was counterbalanced across participants. Participants were not informed about the snack healthiness or portion-size manipulations.

Participants

530 adults from the general population were recruited through the online platform Prolific Academic. Participants were excluded from the data analyses if they reported having a food allergy (N = 2), reported experiencing technical problems (N = 6), or provided an incomplete or invalid postcode (N = 11). Seven additional participants were excluded from the analyses involving household income because they did not provide a response to this question (N = 6) or because the income provided was identified as an outlier in box-plot analyses (N = 1). Thus, there were 511 participants for all analyses, except those with household income where there were 504 participants.

The target sample size and exclusion criteria were decided in advance of data collection. An *a priori* power calculation was performed using G*Power 3.1 (Faul, Erdfelder, Lang, & Buchner, 2009). Although multilevel models were the planned analysis, a power calculation was performed for a standard linear regression to approximate the required sample size. Cohen's f^2 of 0.02, corresponding to a 'small' effect, was defined as the minimally-interesting effect size since there was

no previous research on which an informed effect-size estimate could be based. With 80% power and $p < 0.05$, it was determined that a minimum sample size of 485 participants was required to detect an effect of socioeconomic status on the portion-size effect (i.e. intended consumption for the large portions minus intended consumption for the small portions; see 'Analyses' below for more information) for the unhealthy snacks.

Participants received monetary compensation in return for their participation (£1.50). Eligible participants were 18-70 years and were currently living in England (a full list of exclusion criteria is presented in the Supplemental Materials). This experiment was approved by the local research ethics committee at the Institute of Neuroscience and Psychology, University of Glasgow (application no.: 300170007). Informed consent was obtained after the nature and possible consequences of the study were explained. Participants could withdraw at any time during study completion.

Sample Characteristics

Table 1 presents the sample characteristics. The sample was largely comparable to the general population in England and Wales on several key characteristics. For example, the sample household income was comparable to the mean average household income across England and Wales before tax or other deductions (£37,270; Office for National Statistics, 2018), the sample neighbourhood deprivation closely matched the mean neighbourhood deprivation across all areas in England (21.67; range: 0.48-92.60; based on the English Index of Multiple Deprivation score; Smith, Noble, Noble, Wright, & McLennan, 2015), and the sample body mass index (kg/m^2; BMI) was comparable to the mean BMI across England (27.4 kg/m^2; Fuller, Mindell, & Prior, 2017). Note, however, that the present sample was more educated than the general population in which 27% of adults living in England and Wales reported having an undergraduate degree or above in the 2011 census (Office for National Statistics, 2013).

Characteristic	*N*	*%*
Gender		
Female	341	67
Male	170	33
Highest Educational Qualification		
No formal qualifications	6	1
Secondary school (e.g., GCSEs or equivalent)	116	23
College (e.g., A-levels, AS-levels, vocational qualification, or equivalent)	172	34
Undergraduate degree (e.g., BA, BSc, or equivalent)	155	30
Graduate degree (e.g., MA, MSC, MPhil, or equivalent)	47	9
Doctoral degree (e.g., PhD or equivalent)	15	3
	M	***SD***
Age (years)	37.81	27.15
Pre-Tax Household Income (GBP)	35, 931.24	25, 965.91
Neighbourhood Deprivation	24.81	16.47
BMI (kg/m^2)	27.49	6.88
Self-reported hunger (0 = not at all hungry; 100 = extremely hungry)	37.81	27.15

Table 1. Sample characteristics. *M* = mean; *SD* = standard deviation

Stimuli

Participants were presented with images of four unhealthy snacks (fries, crisps, chocolate minstrels, cookies) and four healthy snacks (carrot sticks, cucumber, grapes, blueberries). There were two portion sizes: the 'small' portion corresponded to a regular serving (as determined by manufacturer recommendations or by UK National Health Service recommended servings for the unhealthy and healthy snacks, respectively). The 'large' portion was 2x the small portion to the nearest whole food unit (weights and calorie contents are presented in the Supplemental Materials). Each food was photographed on white plate in both the small and large portion sizes. As a size reference, a standard pen was placed to the right of the plate. The full stimulus set can be accessed here: https://osf.io/6438n/?view_only=c5a5b81c00544590948fc3f878456c49.

Measures of Socioeconomic Status

Highest education level. Education was measured using the question "What is your highest educational qualification?". Participants selected one of the following options: *No formal qualifications, Secondary school (e.g., GCSEs or equivalent), College (e.g., A-levels, AS-levels,*

vocational qualification or equivalent), Undergraduate degree (e.g., BA, BSc or equivalent), Graduate degree (e.g., MA, MSc, MPhil or equivalent), Doctoral degree (e.g., PhD or equivalent). Participants with qualifications below undergraduate degree were categorised as 'low educational attainment' (N = 294, 58%); participants with an undergraduate degree or above were classed as 'high educational attainment' (N = 217, 42%).

Household income. Participants were asked: "What is your annual pre-tax household income, including all earners in your household, in GBP?" and were instructed to enter the full amount, and in the case that they lived in a multiple occupancy household, to report only the income that they had personal access to.

Neighbourhood deprivation. This variable was assessed by asking participants to report their full household postcode. Each postcode was linked to the English Index of Multiple Deprivation (Smith, Noble, Noble, Wright, & McLennan, 2015), which provides a weighted score of deprivation within geographic areas with a population of approximately 1500 residents. The English Index of Multiple Deprivation is an aggregate measure comprising several domain indicators: income deprivation (22.5%); employment deprivation (22.5%); education, skills and training deprivation (13.5%); health deprivation and disability (13.5%); crime (9.3%); barriers to housing and services (9.3%); and living environment deprivation (9.3%). The relative contributions of these indicators to the aggregate measure are presented in parentheses. Higher scores reflect greater deprivation. For example, across all areas in England, the average score in the most deprived areas (lowest three deciles) was 41.56 whereas the average score in the least deprived areas (highest three deciles) scores was 6.88 (Smith, Noble, Noble, Wright, & McLennan, 2015). Note that whilst scores were analysed to maximise statistical power in the present study, we verified that the overall pattern of results remains the same when the scores are replaced with English Index of Multiple Deprivation deciles as a fixed effect predictor.

Perceived current wealth. Participants rated their agreement or disagreement with three statements (modified from Hill, Prokosch, DelPriore, Griskevicius, & Kramer, 2016); “I feel that I live in a relatively wealthy neighbourhood”, "I feel relatively wealthy compared to others”, and “I feel that I have enough money”, on a scale between 0 (*Strongly disagree*) and 100 (*Strongly agree*; $\alpha = 0.68$).

Procedure

All data were collected between 1 - 7pm on 29/08/2017 via Qualtrics. After providing informed consent, participants were instructed to rate their current hunger on a 0-100 scale with anchors *not hungry at all* and *extremely hungry* (randomised amongst other mood questions: *Happy, Calm, Hungry, Thirsty, Excited*).

Participants then completed the intended consumption task. On each screen, they were presented with a food image (order randomized anew for each participant). The following instruction was presented above each image: “Imagine you are just about to have a snack. What percentage of this food portion would you consume?” (for an example, see Figure 1). Participants moved a point on a sliding scale between 0 and 100 (place markers increased in 10-point intervals). Participants could place the point anywhere on the scale. After participants had indicated their intended consumption for the eight snacks, they indicated the percentage of the portion they thought was an appropriate amount for an average adult to consume as a snack, again on the 0-100 scale.

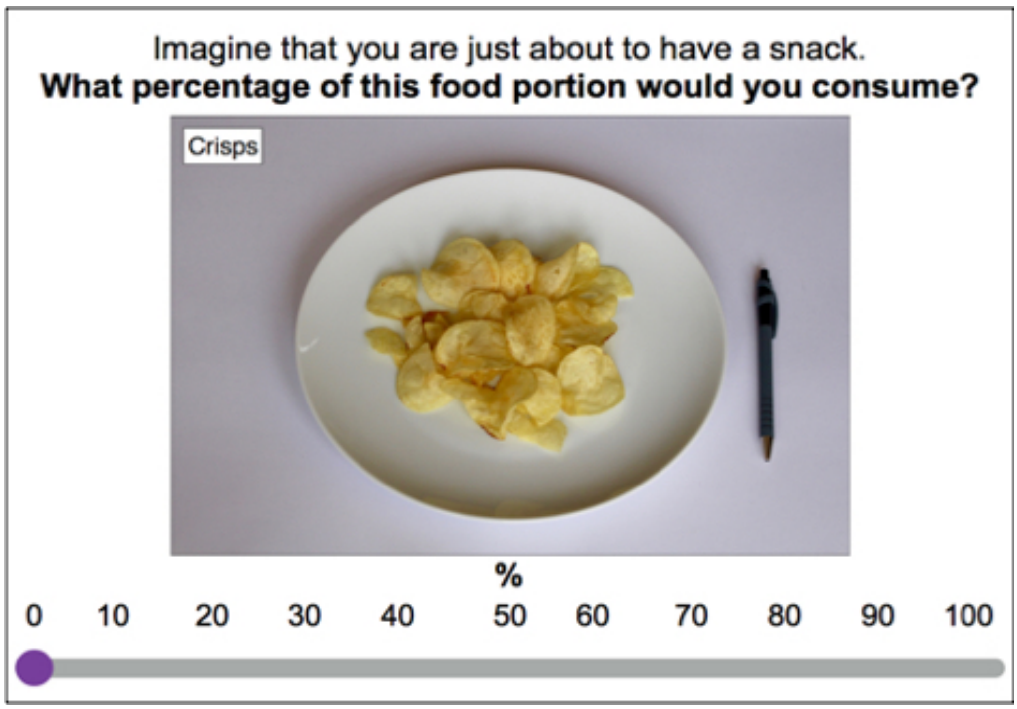

Figure 1. The portion-size task, showing an example of a small portion of an unhealthy snack. The food image was presented in the middle of the screen. All snacks were presented on a standard-sized white plate. A standard-sized pen was placed next to the plate for scale. The question appeared above the food image and the scale (0-100) appeared beneath it.

Next, participants completed a series of measures about the snacks presented in the task. To ensure that these measures were not influenced by portion size, participants were presented with text labels rather than images ("fries", "crisps", "minstrels", "chocolate chip cookies", "raw carrot sticks", "cucumber", "grapes", "blueberries"). On 0-100 scales, they reported how much they liked each food (*Not at all* to *Very much)*, how frequently they usually consume each food (*Never* to *Very often*), and how healthy they considered each food to be (*Not healthy at all* to *Very healthy*).

In the final section, participants completed the 30-item Barratt Impulsiveness Scale (Patton, Stanford, & Barratt, 1995; $\alpha = 0.83$), the eight-item present scale of the Zimbardo Time Perspective Inventory (Keough et al., 1999; $\alpha = 0.62$), and a series of demographic measures, including age, height, and weight[2]. In this section, participants also completed the measures of socioeconomic status

[2] This study is part of a larger project that focuses on how socioeconomic status influences eating behaviour. To inform our future studies, we included a battery of additional measures designed to assess trait-eating behaviour, plate clearing tendencies and self control. A full list is included in the Supplemental Materials. These measures were not analysed in relation to the hypotheses addressed here.

(for details, see above). Finally, to assess awareness of the study hypotheses, participants were asked to report "What do you think we were expecting to find in this study?". Only two participants mentioned a link between portion size and income (P1: "what people conceive to be a normal sized food portion depending on their current income and their family's income as a child"; P2: "Portion sizes, diet, income"). Inclusion of these participants did not change the overall pattern of results so their data were analysed. Following completion of the study, participants were presented with an on-screen debrief sheet.

Analyses

All data processing and analyses were completed using R (R Development Core Team, 2014). All data files and R scripts can be accessed on the Open Science Framework (https://osf.io/6438n/?view_only=c5a5b81c00544590948fc3f878456c49).

Pre-processing. Participants provided the percentage of each food portion that they would consume (i.e. intended consumption) and the percentage of each food portion that they considered appropriate to consume. Based on the total weight (in grams) and the energy density (in calories; kcals) for each food item and portion size, we used these percentage values to compute the proportion of the total grams and calories that each participant would consume and considered appropriate to consume for each food item and portion size. The raw percentage values provided by participants for each portion size and food item are provided online: https://osf.io/6438n/?view_only=c5a5b81c00544590948fc3f878456c49.

Then, the computed values in grams were standardized to *z*-scores to allow us to examine the main effect of snack healthiness, as the baseline weight of the healthy snacks was greater than the baseline weight of the unhealthy snacks (99 g vs. 65 g, respectively).

Confirmatory analyses. First, the means of intended consumption (*z*-scores and calories) were computed as a function of snack healthiness (healthy, unhealthy), portion size (small, large) and participant. To examine our hypotheses that (1) participants would intend to consume more from the

larger compared with smaller portions and (2) that this portion-size effect would be larger for the unhealthy snacks than for healthy snacks, Analyses of Variance were performed on both the *z*-scores and calories with portion size (small vs. large) and snack healthiness (healthy vs. unhealthy) as within-participants factors.

To further examine the evidence for these hypotheses, we also computed Bayes factors to determine support for the null or alternative hypotheses, as frequentist analyses can only test whether a null hypothesis can be rejected but not whether it is supported by the data. Although Bayes factors are continuous, discrete categories have been suggested to aid interpretation, such that the observed data can be interpreted as 'anecdotal', 'moderate', 'strong', 'very strong', or 'extreme' evidence for the presence or absence of an effect. According to these categories, a Bayes factor of < 0.10 constitutes 'strong' support and a Bayes factor of < 0.33 'moderate' support for the null hypothesis. Conversely, a Bayes factor of > 10 constitutes 'strong' support and a Bayes factor of > 3 'moderate' support for the alternative hypothesis. A Bayes factor < 1 and > 0.33 or > 1 and < 3 constitutes 'anecdotal' (i.e. weak) evidence for the null and alternative hypotheses, respectively. A Bayes factor of 1 is inconclusive (for full interpretations of Bayes factors, see Lee & Wagenmakers, 2013). In the present study, Bayes factors were calculated using the BayesFactor package in R, using the default prior of 0.707 (Morey, Rouder, & Jamil, 2015). The default prior corresponds to a medium-to-large sized effect, which is broadly equivalent to the anticipated size of the portion-size effect on consumption (based on a meta-analysis by Zlatevska et al., 2014).

Second, to test our hypothesis that the portion-size effect for the unhealthy snacks would be more pronounced amongst those with lower socioeconomic status, we computed a series linear multilevel models using the lmerTest package in R (Kuznetsova et al., 2013). We first tested for the interacting effects of socioeconomic status, portion size and snack healthiness on intended consumption (*z*-scores). Then, we conducted planned analyses to examine the interacting effects of socioeconomic status and portion size on intended consumption of the unhealthy snacks only

(*z*-scores and calories). For completeness, analyses of intended consumption of the healthy snacks, for which we had no specific hypotheses, are also presented in the main text. Separate multilevel models were computed for each measure of socioeconomic status. Predictors were scaled and mean-centred. Random slopes (and intercepts) were specified for the effect of portion size for each participant and food item. Note that including self-reported hunger, gender, consumption frequency or liking as an additional fixed effect (in separate models) did not alter the overall pattern of results presented (see Supplemental Materials). Therefore, the results of the analyses without these variables included are presented in the main text.

Third, to examine our hypothesis that the effects of socioeconomic status on the portion-size effect for the unhealthy snacks would be mediated by trait impulsivity and by perceptions of how much is appropriate to eat, we conducted a series of mediation analyses. Separate mediation analyses were conducted for each mediator and for each socioeconomic status indicator. Frequentist mediation analyses were conducted using the mediation package in R with nonparametric bootstrapping (samples: 10,000; Tingley, Yamamoto, Hirose, Keele, & Imai, 2014) and Bayesian mediation analyses were computed using the BayesMed package (Nuijten, Wetzels, Matzke, Dolan, & Wagenmakers, 2014). For both the frequentist and Bayesian mediation analyses, we computed the mean intended consumption (*z*-scores) from the large portions minus the mean intended consumption (*z*-scores) from the small portions of unhealthy snacks (i.e. the portion-size effect) for each participant. Note that, as detailed above, participants viewed each food item as either a small portion or a large portion meaning that we could not compute the portion-size effect for each individual snack item within-participants.

Exploratory analyses. We also explored whether the effects of socioeconomic status on the portion-size effect for the unhealthy snacks was mediated by present time perspective.
The results of these exploratory analyses are presented in the Supplemental Materials.

Results

The Effects of Portion Size and Snack Healthiness on Intended Consumption

Participants intended to eat more from the large portion (M = 1.43; SD = 1.08) than from the small portion (M = 0.56; SD = 0.53), $F(1, 510) = 949.93$, $p < 0.001$, $gen.\ \eta^2 = 0.231$, which replicates previous findings and supports our first hypothesis. Furthermore, and again as predicted, this portion-size effect was larger for the unhealthy snacks (M = 1.06, SD = 0.83) than for the healthy snacks (M = 0.69; SD = 0.86), as indicated by the reliable two-way interaction between portion size and snack healthiness, $F(1, 510) = 59.78$, $p < 0.001$, $gen.\ \eta^2 = 0.013$. This supports our second hypothesis.

Converted to calories, participants would have consumed more calories from the large portions of the unhealthy snacks (M = 241 kcals, SD = 106 kcals) than from the small portions (M = 142 kcals, SD = 51 kcals), $t(510) = 20.56$, $p < 0.001$, $g_{av} = 1.26$, $BF_{10} = 1.83e+65$. Similarly, calorie intake would have been greater from the large portions of the healthy snacks (M = 36 kcals, SD = 21 kcals) compared with the small portions (M = 23 kcals, SD = 10 kcals), $t(510) = 13.67$, $p < 0.001$, $g_{av} = 0.84$, $BF_{10} = 1.32e+33$.

Taken together, these findings replicate previous work showing that, as predicted, participants intended to consume more from the large portions than from the small portions, especially for the unhealthy snacks.

Socioeconomic Status as a Moderator of the Portion-Size Effect for Healthy and Unhealthy Snacks

Next, we examined the evidence for our third hypothesis that, when compared to those with higher socioeconomic status, the portion-size effect for the unhealthy snacks would be more pronounced for participants with lower socioeconomic status.

As shown in Table 2, consistent with our third hypothesis, we found reliable three-way interactions between snack healthiness and portion size with highest educational level (Model 1) household income (Model 2), and neighbourhood deprivation (Model 3), *p*s ≤ 0.036.

					Variance Explained	
Model	***Standardised Estimate***	***SE***	***t***	***p***	R^2m	R^2c
Model 1: Highest Educational Qualification					0.240	0.615
(Intercept)	0.9962	0.0355	28.04	< **0.001**		
Snack healthiness	0.2825	0.0321	8.81	< **0.001**		
Portion size	0.4391	0.0345	12.73	< **0.001**		
Education	-0.0393	0.0239	-1.65	0.101		
Snack healthiness by Portion size	0.0933	0.0340	2.74	0.024		
Snack healthiness by Education	-0.0553	0.0183	-3.02	**0.003**		
Portion size by Education	-0.0300	0.0147	-2.04	**0.042**		
Snack healthiness by Portion size by Education	-0.0309	0.0135	-2.29	**0.022**		
Model 2: Household Income*					0.243	0.615
(Intercept)	0.9980	0.0353	28.26	< **0.001**		
Snack healthiness	0.2846	0.0318	8.96	< **0.001**		
Portion size	0.4393	0.0339	12.95	< **0.001**		
Income	-0.0602	0.0240	-2.51	**0.012**		
Snack healthiness by Portion size	0.0951	0.0334	2.85	**0.021**		
Snack healthiness by Income	-0.0605	0.0184	-3.29	**0.001**		
Portion size by Income	-0.0230	0.0149	-1.55	0.123		
Snack healthiness by Portion size by Income	-0.0297	0.0136	-2.19	**0.029**		
Model 3: Neighbourhood deprivation					0.238	0.615
(Intercept)	0.9962	0.0356	28.01	< **0.001**		
Snack healthiness	0.2824	0.0320	8.82	< **0.001**		
Portion size	0.4391	0.0345	12.74	< **0.001**		
Neighbourhood deprivation	-0.0003	0.0240	-0.01	0.989		
Snack healthiness by Portion size	0.0933	0.0340	2.75	**0.024**		
Snack healthiness by Neighbourhood deprivation	0.0602	0.0183	3.29	**0.001**		
Portion size by deprivation	0.0019	0.0148	0.13	0.898		
Snack healthiness by Portion size by Neighbourhood deprivation	0.0284	0.0135	2.10	**0.036**		
Model 4: Perceived Current Wealth					0.244	0.616
(Intercept)	0.9962	0.0354	28.12	< **0.001**		
Snack healthiness	0.2824	0.0320	8.83	< **0.001**		
Portion size	0.4391	0.0348	12.64	< **0.001**		
Perceived current wealth	-0.0601	0.0238	-2.52	**0.012**		
Snack healthiness by Portion size	0.0933	0.0343	2.72	**0.025**		
Snack healthiness by Perceived current wealth	-0.0652	0.0183	-3.57	< **0.001**		
Portion size by Perceived current wealth	-0.0484	0.0147	-3.30	**0.001**		
Snack healthiness by Portion size by Perceived current wealth	-0.0223	0.0136	-1.64	0.101		

Table 2. Overview of the linear multilevel models with the fixed effects of snack healthiness, portion size, and socioeconomic status indicator. Separate models were conducted for each of the socioeconomic status indicators. Estimate is the coefficient, t and p refer to the t-value and p-value for

each fixed effect, respectively. SE refers to the standard error. R^2m is the variance explained by the fixed effects; R^2c is the variance explained by the fixed effects plus the random effects. *N = 511 for all Models, except Model 2 (household income) where N = 504 due to exclusions.

Socioeconomic Status as a Moderator of the Portion-Size Effect for Unhealthy Foods

Next, we conducted planned analyses of intended consumption of the unhealthy snacks only to further examine our central third hypothesis that the portion-size effect for the unhealthy snacks would be more pronounced amongst those with a lower socioeconomic status.

Highest educational level. The portion-size effect was 21% larger for participants with low educational qualifications than for participants with high educational qualifications (Figure 2), as indicated by a reliable two-way interaction between portion size and education (p = 0.002; Table 3). This supports our third hypothesis. Converted to calories, the portion-size effect was 110.67 kcals for participants with low educational qualifications, and 87.67 kcals for participants with high educational qualifications, reflecting a 21% difference. Taken together, these analyses show that the portion-size effect on intended consumption of the unhealthy snacks is moderated by education, such that lower education is associated with a larger portion-size effect for unhealthy food.

Household income. The portion-size effect was larger for participants with lower household incomes than with higher household incomes (Figure 2), as indicated by a reliable two-way interaction between portion size and income (p = 0.007; Table 3). This represents an 18% increase in the portion-size effect for participants with lower household income (1 SD below the mean; Aiken & West, 1991) compared with participants with higher household incomes (1 SD above the mean). Converted to calories, the portion-size effect for participants with relatively low household incomes (-1 SD) was 107.30 kcals and the portion-size effect for participants with relatively high household incomes (+1 SD) was 91.11 kcals, representing a 15% difference. Thus, household income moderates the portion-size effect on intended consumption of unhealthy snacks, replicating the pattern of results observed for highest educational level.

Neighbourhood deprivation. Although the numerical trend shows that the portion-size effect was larger for participants living in more deprived neighbourhoods, the two-way interaction between portion size and neighbourhood deprivation was not statistically significant ($p = 0.125$; Table 3; Figure 2). Note, however, that the three-way interaction between neighbourhood deprivation, portion size, and snack healthiness was reliable (see Table 2): the portion-size effect for the unhealthy snacks was numerically larger and the portion-size effect for the healthy snacks was numerically smaller for participants living in more deprived neighbourhoods.

Perceived current wealth. The portion-size effect was larger for participants with low perceived current wealth than with high perceived current wealth (Figure 2), as indicated by the reliable two-way interaction between portion size and perceived current wealth ($p < 0.001$; Table 3). This represents a 24% increase in the portion-size effect for participants with low perceived current wealth (1 SD below the mean) compared with participants with high perceived current wealth (1 SD above the mean). Converted to calories, the portion-size effect for participants with low perceived current wealth (-1 SD) was 111.23 kcals and the portion-size effect for participants with high perceived current wealth (+1 SD) was 87.14 kcals, reflecting a 22% difference. These analyses confirm that the effect of portion size on intended consumption of unhealthy food was moderated by perceived current wealth, replicating the pattern of results observed for highest educational level, household income, and neighbourhood deprivation, again supporting our third hypothesis.

We also examined the question of whether the moderating effect of perceived current wealth was due to differences in actual wealth (i.e., household income) and, vice versa, whether the moderating effect of household income was due to differences in perceived current wealth. Importantly, these analyses showed that the moderating effects of household income and perceived current wealth, respectively, remained significant when the other variable (perceived current wealth and household income) was included as an additional fixed effect. This suggests that both actual and

perceived material deprivation increase the portion-size effect for unhealthy foods. These results are reported in detail in the Supplemental Materials.

Finally, we addressed the additional question of whether the moderating effects of education, household income, and perceived current wealth were due to differences in weight status. When BMI was included as an additional fixed effect, the two-way interactions between these socioeconomic status indicators and portion size on intended consumption of the unhealthy snacks remained reliable[3]. These results are reported in the Supplemental Materials.

Model	*Standardised Estimate*	*SE*	*t*	*p*	**Variance Explained** R^2m	R^2c
Model 1: Highest Educational Qualification (Baseline = Low)					0.261	0.655
(Intercept)	1.2785	0.0349	36.65	< **0.001**		
Portion size	0.5323	0.0253	21.00	< **0.001**		
Education	-0.0946	0.0296	-3.20	**0.001**		
Portion size by Education	-0.0610	0.0195	-3.13	**0.002**		
Model 2: Household Income					0.267	0.654
(Intercept)	1.2824	0.0346	37.10	< **0.001**		
Portion size	0.5343	0.0245	21.80	< **0.001**		
Income	-0.1209	0.0295	-4.09	< **0.001**		
Portion size by Income	-0.0527	0.0196	-2.68	**0.007**		
Model 3: Neighbourhood Deprivation					0.253	0.655
(Intercept)	1.2785	0.0351	36.40	< **0.001**		
Portion size	0.5323	0.0256	20.81	< **0.001**		
Neighbourhood deprivation	0.0597	0.0298	2.01	**0.046**		
Portion size by Neighbourhood deprivation	0.0302	0.0196	1.54	0.125		
Model 4: Perceived Current Wealth					0.268	0.655
(Intercept)	1.2785	0.0349	36.69	< **0.001**		
Portion size	0.5323	0.0255	20.85	< **0.001**		
Perceived current wealth	-0.1251	0.0294	-4.26	< **0.001**		
Portion size by Perceived current wealth	-0.0706	0.0194	-3.63	< **0.001**		

Table 3. Overview of the linear multilevel models conducted on the intended consumption of the unhealthy snacks with the fixed effects of portion size and socioeconomic status indicator. Separate models were conducted for each of the socioeconomic status indicators. Estimate is the coefficient, t and p refer to the t-value and p-value for each fixed effect, respectively. SE refers to the standard error R^2m is the variance explained by the fixed effects; R^2c is the variance explained by the fixed effects plus the random effects. *Note that N = 511 for all Models, except Model 2 (Household Income) where N = 504 due to exclusions.

[3] We included BMI as a covariate since many previous studies have shown that BMI predicts consumption of unhealthy food and higher BMI is more prevalent amongst those with lower socioeconomic status. However, we recognise that there are limitations with using BMI as a marker of body weight (e.g., Burkhauser & Cawley, 2008) and that perceptions of body weight may be a stronger predictor of eating behaviour.

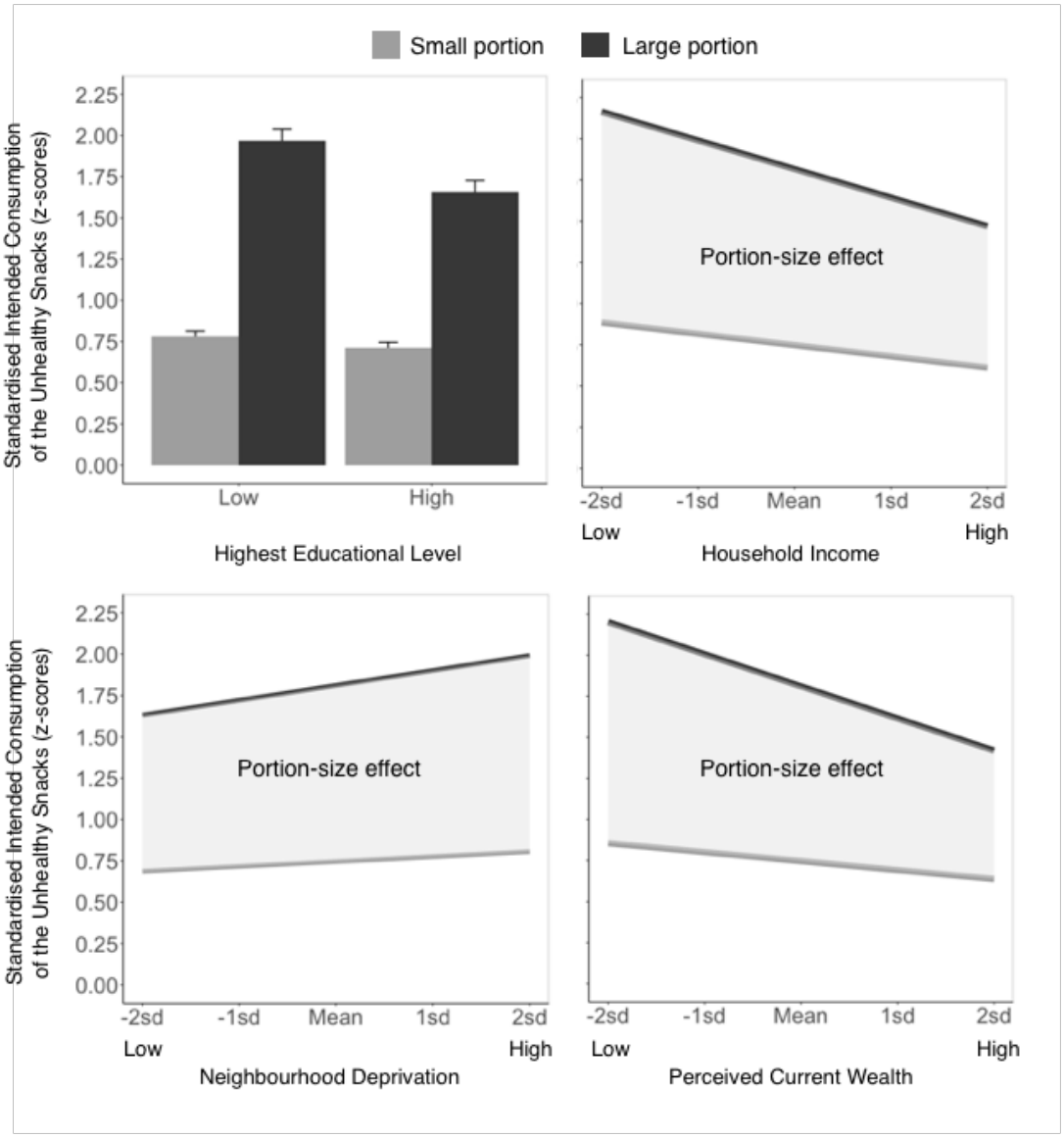

Figure 2. Intended consumption of the unhealthy snacks as a function of portion size and each socioeconomic status indicator. Standardised intended consumption values are predicted from the multilevel models with portion size (small, large) and socioeconomic status as fixed effect predictors. The portion-size effect reflects the difference in intended consumption between the small portion and the large portion (as illustrated by the grey shaded regions).

The Portion-Size Effect for Healthy Snacks

Whilst participants with lower socioeconomic status displayed a larger portion-size effect for the unhealthy snacks, the portion-size effect for the healthy snacks did not reliably change across levels of socioeconomic status ($ps \geq 0.197$; see Table 5). Numerically, the portion-size effect for the healthy snacks was larger amongst those with higher educational qualifications, those with higher household

incomes and those living in less deprived areas (1%, 4% and 14%, respectively) but smaller amongst those with higher perceived current wealth (14%). Combined, there was no reliable evidence to suggest that socioeconomic status moderates the portion-size effect on intended consumption of healthy food, and the numerical direction of the effect varied across the socioeconomic status indicators.

					Variance Explained	
Model	***Estimate***	***SE***	***t***	***p***	R^2m	R^2c
Model 1: Highest Educational Qualification (Baseline = Low)					0.109	0.517
(Intercept)	0.7139	0.058	12.24	**< 0.001**		
Portion size	0.3458	0.065	5.32	**0.006**		
Education	0.0161	0.031	0.53	0.598		
Portion size by Education	0.0008	0.021	0.04	0.967		
Model 2: Household Income					0.107	0.517
(Intercept)	0.7136	0.058	12.32	**< 0.001**		
Portion size	0.3442	0.064	5.35	**0.005**		
Income	0.0003	0.031	0.01	0.991		
Portion size by Income	0.0067	0.021	0.32	0.745		
Model 3: Neighbourhood Deprivation					0.113	0.517
(Intercept)	0.7139	0.058	12.27	**< 0.001**		
Portion size	0.3458	0.065	5.34	**0.006**		
Neighbourhood deprivation	-0.0605	0.030	-1.99	**0.047**		
Portion size by Neighbourhood deprivation	-0.0265	0.021	-1.29	0.197		
Model 4: Perceived Current Wealth					0.109	0.518
(Intercept)	0.7139	0.058	12.30	**< 0.001**		
Portion size	0.3458	0.065	5.31	**0.006**		
Perceived current wealth	0.0057	0.031	0.19	0.852		
Portion size by Perceived current wealth	-0.0263	0.021	-1.28	0.200		

Table 4. Overview of the linear multilevel models conducted on the intended consumption of the healthy snacks with the fixed effects of portion size and socioeconomic status indicator. Separate models were conducted for each of the socioeconomic status indicators. Estimate is the coefficient, t and p refer to the t-value and p-value for each fixed effect, respectively. R^2m is the variance explained by the fixed effects; R^2c is the variance explained by the fixed effects plus the random effects. *Note that N = 511 for all Models, except Model 2 (Household Income) where N = 504 due to exclusions.

Mediation via Trait Impulsivity

Trait impulsivity partially mediated the effects of highest educational level ($p < 0.001$), household income ($p = 0.007$), and perceived current wealth ($p < 0.001$) on the portion-size effect for the unhealthy snacks (see Table 5). These findings are consistent with our fourth hypothesis. There was also a reliable mediating effect of trait impulsivity for the effect of neighbourhood deprivation on the

portion-size effect (p = 0.004) but the total effect and proportion mediated were not significant ($ps \geq$ 0.100). As shown in Figure 3, Bayesian mediation analyses revealed 'extreme' evidence for mediation via impulsivity for the effects of highest educational level (BF = 23407.58) and perceived current wealth on the portion-size effect (BF = 23545.36). There was also 'moderate' evidence for mediation via impulsivity for neighbourhood deprivation (BF = 3.92) and 'anecdotal' evidence for mediation via impulsivity for household income (BF = 2.75). In sum, these findings suggest that increased intended consumption from large portions of unhealthy snacks amongst participants with lower socioeconomic status can be, in part, attributed to heightened trait impulsivity relative to participants with higher socioeconomic status.

	Standardised Estimate	***95% CI Lower***	***95% CI Upper***	***p***
Highest Educational Level (Baseline = Low)				
Indirect effect	-0.043	-0.069	-0.021	< **0.001**
Direct effect	-0.079	-0.151	-0.007	**0.031**
Total effect	-0.122	-0.193	-0.052	< **0.001**
Proportion mediated	0.351	-0.159	0.872	< **0.001**
Household Income				
Indirect effect	-0.024	-0.045	-0.006	**0.007**
Direct effect	-0.082	-0.152	-0.011	**0.023**
Total effect	-0.106	-0.177	-0.035	**0.004**
Proportion mediated	0.222	0.061	0.687	**0.011**
Neighbourhood Deprivation				
Indirect effect	0.026	0.008	0.049	**0.004**
Direct effect	0.034	-0.037	0.105	0.347
Total effect	0.060	-0.012	0.132	0.100
Proportion mediated	0.431	-1.639	3.226	0.103
Perceived Current Wealth				
Indirect effect	-0.002	-0.003	-0.001	< **0.001**
Direct effect	-0.005	-0.008	-0.001	**0.007**
Total effect	-0.007	-0.010	-0.003	< **0.001**
Proportion mediated	0.303	0.143	0.643	< **0.001**

Table 5. Overview of the causal mediation analyses to examine the indirect effect of trait impulsivity. Separate mediation analyses were conducted for each of the SES indictors (highest educational level, household income, neighbourhood deprivation, perceived current wealth) on the portion-size effect of the unhealthy snacks. *p* refers to the p-valence; CI refers to the confidence interval.

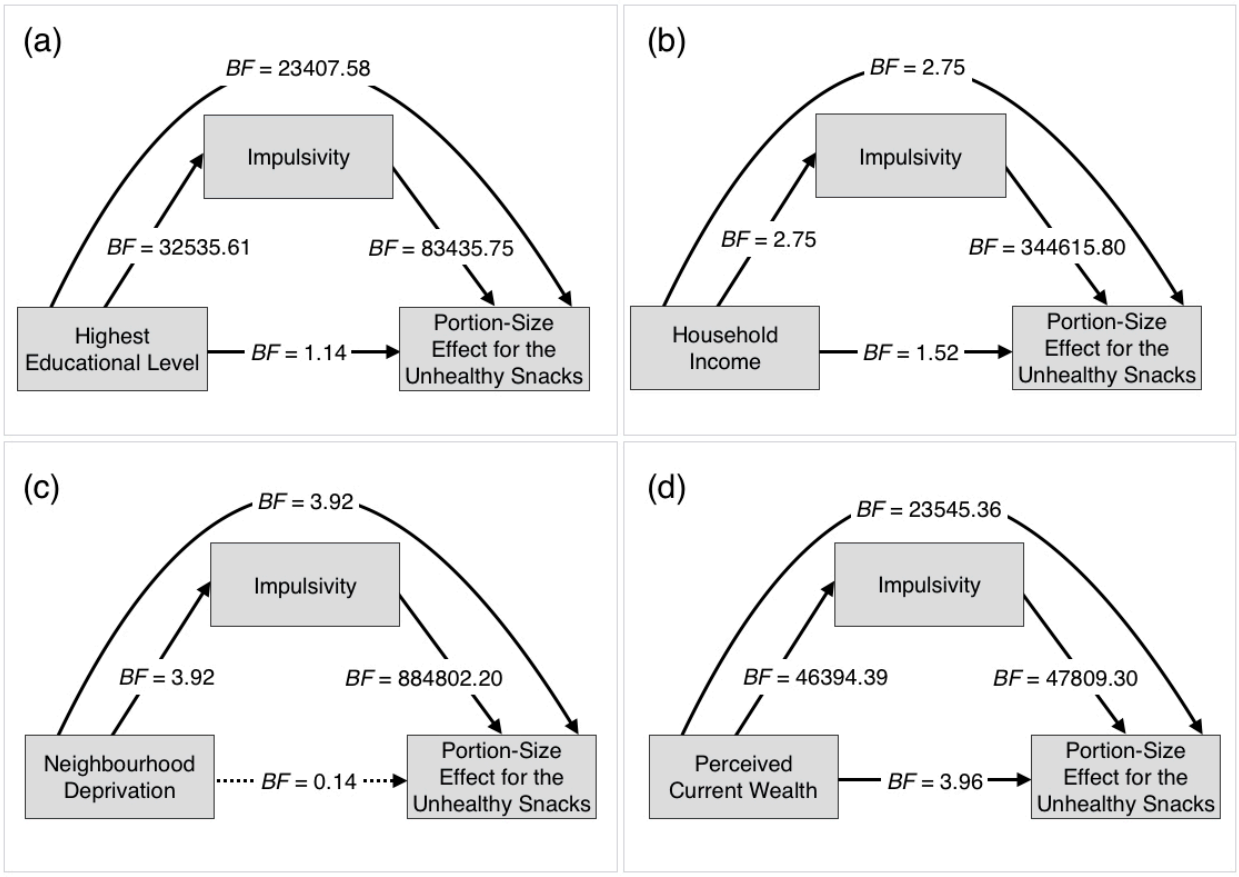

Figure 3. Bayes Factors for each path within the mediation models to examine the mediating effect of trait impulsivity on the relationships between (a) highest educational level; (b) household income; (c) neighbourhood deprivation; (d) perceived current wealth and the portion-size effect for the unhealthy snacks. The portion-size effect was computed as the difference between the mean average intended consumption (*z*-scores) from the large portions minus the mean average intended consumption (*z*-scores) from the small portions. The mediation effect is represented by the overarching arrow. Note that Bayes Factors > 1 indicate evidence for the path (solid lines) whereas Bayes Factors < 1 indicate no evidence for the path (dotted lines).

Mediation via Appropriateness

The effects of highest educational level and household income on the portion-size effect for the unhealthy snacks were partially mediated by perceptions of how much would be appropriate to eat from each portion (see Table 6). As shown in Figure 4, Bayesian analyses revealed ‘moderate’ and ‘anecdotal’ support for the indirect effect of appropriateness for highest educational level and household income, respectively. Furthermore, differences in appropriateness fully mediated the effect of neighbourhood deprivation on the portion-size effect but note that the total model and proportion mediated were not significant (*p*s ≥ 0.098). Bayesian analyses showed that the increased

portion-size effect amongst those with lower perceived current wealth was not explained by differences in appropriateness (Figure 4). In sum, the increased portion-size effects amongst participants with lower educational qualifications and lower household incomes can be partially explained by increases in how much these participants considered appropriate to consume from the large portions.

	Standardised Estimate	***95% CI Lower***	***95% CI Upper***	***p***
Highest Educational Level (Baseline = Low)				
Indirect effect	-0.703	-0.121	-0.025	**0.002**
Direct effect	-0.177	-0.315	-0.043	**0.012**
Total effect	-0.248	-0.393	-0.108	**< 0.001**
Proportion mediated	0.284	0.109	0.652	**0.003**
Household Income				
Indirect effect	-0.029	-0.056	-0.005	**0.014**
Direct effect	-0.078	-0.145	-0.002	**0.043**
Total effect	-0.106	-0.177	-0.034	**0.005**
Proportion mediated	0.272	0.047	0.890	**0.019**
Neighbourhood Deprivation				
Indirect effect	0.029	0.005	0.057	**0.015**
Direct effect	0.030	-0.038	0.096	0.370
Total effect	0.060	-0.012	0.130	0.098
Proportion mediated	0.490	-1.535	3.219	0.106
Perceived Current Wealth				
Indirect effect	-0.001	-0.002	0.001	0.310
Direct effect	-0.006	-0.009	-0.003	**< 0.001**
Total effect	-0.007	-0.010	-0.003	**< 0.001**
Proportion mediated	0.086	-0.105	0.261	0.310

Table 6. Overview of the causal mediation analyses to examine the indirect effect of appropriateness. Separate mediation analyses were conducted for each of the SES indicators on the portion-size effect for the unhealthy snacks. *p* refers to the p-valence; CI refers to the confidence interval.

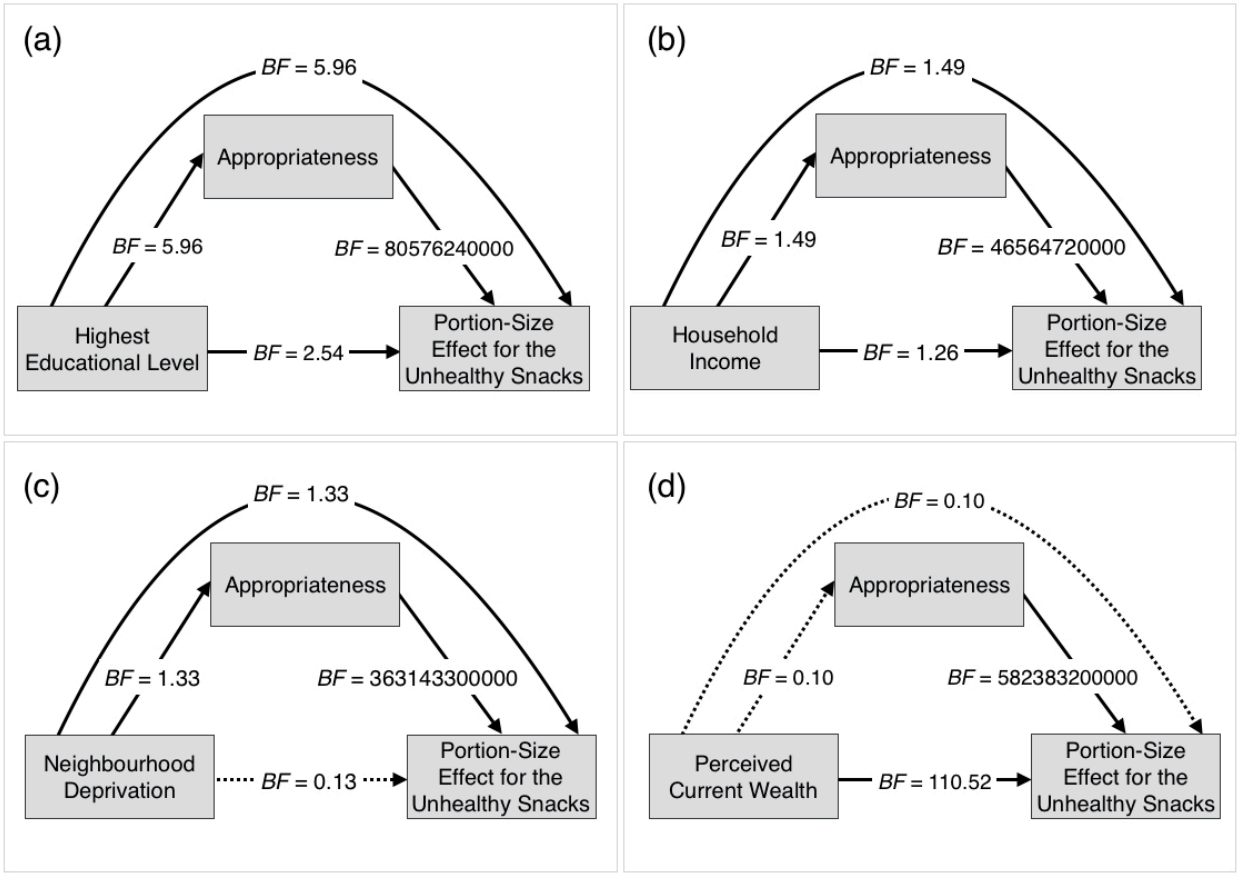

Figure 4. Bayes Factors for each path within the mediation models to examine the mediating effect of appropriateness on the relationships between (a) highest educational level; (b) household income; (c) neighbourhood deprivation; (d) perceived current wealth and the portion-size effect for the unhealthy snacks. The portion-size was computed as the difference between the mean average intended consumption (*z*-scores) from the large portions minus the mean average intended consumption (*z*-scores) from the small portions. The mediation effect is represented by the overarching arrow. Note that Bayes Factors > 1 indicate evidence for the path (solid lines) whereas Bayes Factors < 1 indicate no evidence for the path (dotted lines).

Manipulation Checks and Data Quality Checks

As expected, participants rated the unhealthy snacks as less healthy (M = 11.89, SD = 15.23) than the healthy snacks (M = 93.25, SD = 12.07), $t(510) = 103.61$, $p < 0.001$, $g_{av} = 7.36$, $BF_{10} = 2.03\text{+e}340$, showing that participants' perceptions of food healthiness were in accordance with our *a priori* classifications of the snack food items into the 'healthy' and 'unhealthy' categories. Furthermore, as expected, participants liked the unhealthy snacks more (M = 82.98, SD = 22.70) than the healthy snacks (M = 62.06, SD = 33.33), $t(510) = -17.61$, $p < 0.001$, $g_{av} = -1.13$, $BF_{10} = 1.17\text{e+}51$, and consumed the unhealthy snacks more often (M = 58.41, SD = 28.82) than the healthy snacks (M =

47.80, *SD* = 32.95), $t(510) = -8.18$, $p < 0.001$, $g_{av} = -0.51$, $BF_{10} = 1.91+e+12$. Thus, the manipulation of snack healthiness successfully elicited the expected differences with respect to these variables.

As shown in Table 7, intended consumption of the unhealthy food was positively correlated with hunger ($r = 0.254$, $p < 0.001$), liking ($r = 0.620$, $p < 0.001$), trait impulsivity ($r = 0.258$, $p < 0.001$), and BMI ($r = 0.114$, $p = 0.010$). Thus, the intended consumption measure was influenced by factors known to influence actual eating behaviour, suggesting it to be a valid proxy of actual consumption. The link between intended and actual consumption is further addressed in the Discussion.

The frequency of consuming the unhealthy snacks was negatively correlated with household income ($r = -0.138$, $p = 0.002$; Table 7) and perceived current wealth ($r = -0.136$, $p = 0.002$; Table 7), and was positively correlated with neighbourhood deprivation ($r = 0.115$, $p = 0.009$; Table 7). Furthermore, participants with lower educational attainment reported consuming the unhealthy snacks more often ($M = 61.44$, $SD = 28.15$) than participants with higher education attainment ($M = 54.29$, $SD = 29.21$; $t = -2.95$, $p < 0.001$). There were no reliable relationships between the frequency of consuming the healthy snacks and any of the socioeconomic status indicators. Across all measures, participants with lower socioeconomic status reported consuming the unhealthy snacks more often than participants with higher socioeconomic status.

Next, we verified that participants did not simply select the same percentage across the small and large portions. Specifically, participants intended to consume a lower percentage of the large portions ($M = 60.90\%$, $SD = 29.20\%$) than the small portions ($M = 74.44\%$; $SD = 28.21\%$), $F(1, 510) = 220.80$, $p < 0.001$, *gen.* $\eta^2 = 0.056$), averaged over the healthy and unhealthy snacks. Participants intended to consume a lower percentage of the healthy snacks ($M = 60.55\%$, $SD = 30.88\%$) than the unhealthy snacks ($M = 74.79\%$, $SD = 26.17\%$), $F(1, 510) = 123.67$, $p < 0.001$, *gen.* $\eta^2 = 0.062$. Thus, the percentage measure was sensitive to the portion-size and snack healthiness manipulations.

Finally, we explored whether there were any differences between the percentage of each portion participants *intended* to consume and the percentage participants considered *appropriate* to consume. Averaged over the healthy and unhealthy snacks, participants intended to consume a slightly lower percentage of the small and large portions (M = 67.67%, SD = 29.49%) than they considered appropriate to consume (M = 69.44%, SD = 27.07%). This was reflected in a reliable main effect of question type (intended consumption, appropriate consumption), $F(1, 510) = 4.65$, $p = 0.032$, $\eta^2 = 0.002$. Furthermore, whilst participants intended to consume more of the unhealthy snacks (M = 74.79%, SD = 26.17%) than the healthy snacks (M = 60.55%, SD = 30.88%), they considered it appropriate to consume more of the healthy snacks (M = 82.48%, SD = 20.75%) than of the unhealthy snacks (M = 56.40%, SD = 26.36%). This was reflected in a reliable two-way interaction between question-type and snack healthiness, $F(1, 510) = 729.82$, $p < 0.001$, $\eta^2 = 0.173$. Thus, participants' responses were sensitive to the question asked and the healthiness of the snack presented.

	Mean (SD)	Variables											
		Intended consumption – unhealthy	**Intended consumption – healthy**	**Income**	**Neighbourhood deprivation**	**Perceived current wealth**	**Impulsivity**	**Liking - unhealthy**	**Frequency - unhealthy**	**Liking - healthy**	**Frequency - healthy**	**Hunger**	**BMI**
Intended consumption – unhealthy (z-scores)	1.28 (0.67)	-	-	-	-	-	-	-	-	-	-	-	-
Intended consumption – healthy (z-scores)	0.71 (0.69)	0.267**	-	-	-	-	-	-	-	-	-	-	-
Income	35931 (25966)	-0.181**	0.001**	-	-	-	-	-	-	-	-	-	-
Neighbourhood deprivation	24.81 (16.47)	0.089**	-0.090**	-0.229**	-	-	-	-	-	-	-	-	-
Perceived current wealth (*scale range*: 0-100)	44.87 (21.49)	-0.186**	0.002**	0.411**	-0.337**	-	-	-	-	-	-	-	-
Impulsivity (*scale range*: 30-120)	62.46 (10.45)	0.258**	0.004**	-0.120**	0.125**	-0.227**	-	-	-	-	-	-	-
Liking – unhealthy (*scale range*: 0-100)	82.98 (16.29)	0.620**	0.038**	-0.133**	0.046**	-0.114**	0.161**	-	-	-	-	-	-
Frequency – unhealthy (*scale range*: 0-100)	58.41 (20.41)	0.441**	-0.037**	-0.138**	0.115**	-0.136**	0.320**	0.557**	-	-	-	-	-
Liking – healthy (*scale range*: 0-100)	62.06 (20.66)	-0.059**	0.635**	-0.026**	-0.057**	0.072**	-0.146**	-0.043**	-0.093	-	-	-	-
Frequency – healthy (*scale range*: 0-100)	47.80 (21.45)	-0.107**	0.494**	-0.029**	-0.041**	0.067**	-0.068**	-0.113**	0.020	0.770**	-	-	-
Hunger (*scale range*: 0-100)	37.81 (27.15)	0.254**	0.058**	-0.062**	0.088**	-0.122**	0.228**	0.129**	0.211**	0.013	0.062	-	-
BMI	27.49 (6.88)	0.114**	0.012**	-0.068**	0.131**	-0.164**	0.118**	0.013**	-0.015	-0.065	-0.047	0.017	-
	N (%)												
Education	Low = 294 (58) High = 217 (42)	-2.94**	0.48**	7.66**	-4.17**	6.26**	-5.22**	-2.22**	-3.95**	-0.10	-0.89	-2.95*	-1.62

Table 7. The relationships between key study variables. Pearson correlation coefficients are presented for the continuous variables; t-value are presented for the categorical variable. $N = 511$ for all measures, except household income where $N = 504$. ** $p < 0.001$, * $p < 0.01$.

Discussion

This study examined some of the psychological mechanisms that might contribute to translating exposure to large portions of unhealthy foods, a prominent feature of unhealthy food environments, into socioeconomic differences in body weight. We found consistent evidence of a small but reliable effect that people with lower socioeconomic status intended consume more from large portions of unhealthy foods, which are known to be highly salient and accessible in unhealthy food environments. The present results also show that this is partially driven by both increased impulsivity and increased perceptions of how much is appropriate to eat. Thus, not only are people with a lower socioeconomic status disproportionately exposed to unhealthy food environments (e.g., Burgoine et al., 2016), specific psychological processes might also predispose them to overeat when exposed to those environments. These processes may play a key role in understanding the increased prevalence of obesity amongst those with lower socioeconomic status in many developed nations.

The portion-size effect on intended consumption of unhealthy snacks was 18-24% larger for participants with lower educational attainment, household incomes, and perceived current wealth. Converted to calories, this would equate to a potential 15-22% increase in energy intake of up to 24 kcals for a single snacking occasion. Although this may not seem a large number, it has been shown that increases in body weight in England between 1999 and 2009 were equivalent to consumption of an additional 24 kcals per day during this period (Department of Health, 2011) indicating it to be sufficient to elicit health disparities in overweight. Consistent with previous work, the present study also found that participants with lower socioeconomic status reported consuming the unhealthy snacks more often than participants with higher socioeconomic status. Thus, not only may people with lower socioeconomic status intend to consume more from large portions of unhealthy snacks, they also eat unhealthy snacks more often. Again, the combined effects of exposure and access to large portions of unhealthy food (e.g., Burgoine et al., 2016), higher number of consumption occasions of unhealthy snacks, and impulsivity and appropriateness perceptions that facilitate

overeating, are likely to contribute the socioeconomic differences in overweight and obesity in developed societies.

The finding that appropriateness perceptions predict the portion-size effect is consistent with previous work suggesting that the portion size serves as an 'anchor' indicating how much is appropriate to eat, from which consumers often adjust incompletely (e.g., Marchiori et al., 2014). This finding is further in line with work showing that social norms have a strong effect on eating behaviour more generally (Robinson, Thomas, Aveyard, & Higgs, 2014). Importantly, the present study also demonstrated that appropriateness perceptions partially mediated the effect of socioeconomic status on the portion-size effect, suggesting that those with lower socioeconomic status (especially those with low educational attainment) intended to eat more from the large portions because they found it *appropriate* to eat a relatively larger percentage of the presented food. These perceptions could result from the exposure to unhealthy food environments, including easy access to large portions of unhealthy food and advertising of typically large portions of unhealthy food (e.g., Yancey et al., 2009). Thus, living in unhealthy food environments could contribute to overeating through two mechanisms: not only are large portions more accessible, but repeated exposure to oversized portions of unhealthy food could 'normalise' overconsumption when faced with these portions. Future research should examine other processes through which overconsumption from large portions of unhealthy food becomes more socially appropriate and the mechanisms through which socioeconomic status moderates this.

The increased portion-size effect displayed by participants with lower socioeconomic status was also partially mediated by differences in trait impulsivity. This suggests that those with lower socioeconomic status value the short-term reward of unhealthy food consumption more than those with higher socioeconomic status, increasing the amount they intend to consume when faced with large portions of attractive food. To our knowledge, no previous work has addressed the role of impulsivity in responses to large food portions. Future research should examine this relationship and the underlying mechanisms in more detail. Since impulsive or habitual behaviours are often elicited

by contextual information at the moment of choice, viewing overconsumption from large portions as the result of impulsive processes also opens up new areas for interventions to tackle the portion-size effect by, for example, reducing the automaticity of continued eating by modifying features of the external environment to encourage more mindful eating and so increase the ease with which consumers can inhibit impulsive consumption (see Cheema & Soman, 2008; Versluis & Papies, 2016b). Interventions may particularly benefit from targeting the psychological processes that drive overconsumption amongst those with lower socioeconomic status (see e.g., Newton, Newton, & Wong, 2017). Finding strategies to change automatic processes is particularly important since previous work has shown that information-based interventions targeting deliberative processes in health behaviour are largely ineffective and could widen socioeconomic differences in health outcomes (e.g., Beauchamp, Backholer, Magliano, & Peeters, 2014).

Our findings are consistent with research showing that experiencing low power increases preferences for larger food portions (Dubois et al., 2012), and that being reminded of resource scarcity increases preferences for high-calorie foods and immediate, rather than delayed rewards, especially in people with lower socioeconomic status backgrounds (Griskevicius et al., 2011; Laran & Salerno, 2013). The present work, however, is the first to demonstrate how objective indicators of socioeconomic status (e.g., income, education) affect how much people intend to eat from large compared to small portions and thus how susceptible they are to the portion-size effect. In other words, our work showed not only that participants with fewer resources intended to eat more unhealthy food overall, but that they intended to eat more especially from large portions and were thus particularly susceptible to the normative cues about consumption that portion size may provide (e.g., Marchiori et al., 2014).

In addition, since the snacking scenarios we presented to participants were most likely private eating situations, rather than public ones, it is unlikely that consumption from large portions would have been used to signal high social status in the present study (in contrast to Dubois et al., 2012). Rather, our mediation analyses point to impulsive and short-term-oriented decision making, and to

appropriateness perceptions, as crucial processes for understanding the effects of socioeconomic status on the portion-size effect. Importantly, and also in line with previous work, we found that both actual income, which can be seen as an objective indicator of socioeconomic status, and perceived current wealth, a more subjective indicator, independently predicted the portion-size effect for unhealthy food. Future research should examine in more detail the psychological mechanisms through which each of these variables affects food choices. Related to this, our pattern of results suggests that the individual-level indicators of socioeconomic status (education level and perceived current wealth) showed more consistent and reliable direct and indirect associations with intended consumption compared with the household- and area-level indicators (household income and neighbourhood deprivation). Whilst it is possible that this results from common-method variance (i.e. measurement of education and perceived current wealth on the same individual-level as the mediators and dependent variable), future research is required to examine this further.

Limitations and Future Research

A natural next step in this research area would be to replicate the current findings with actual consumption as an outcome measure. Importantly, intended consumption in this study positively correlated with factors known to predict actual eating, such as hunger and liking (e.g., Robinson et al., 2017). In line with previous work (e.g., Wilkinson et al., 2012), the measure of intended consumption in the present study is likely to map well onto actual consumption. In addition, a recent meta-analysis demonstrated a larger effect of portion size on actual consumption (d = 0.45) than on intended consumption (d = 0.18; Zlatevska, Dubelaar, & Holden, 2014), suggesting that our findings may actually underestimate the true effect of socioeconomic status on consumption from large portions. Nevertheless, the present study did not assess factors that affect actual food intake, such as taste and satiety experiences. Thus, future studies should assess whether these additional factors modulate the effect of socioeconomic status on the portion-size effect.

We found no reliable moderating effect of socioeconomic status on the portion-size effect on intended consumption of the healthy snacks. This is consistent with the finding that the intended

consumption of healthy foods did not correlate with impulsivity. Previous work shows that healthy food more generally is less likely to elicit impulsive eating and produces a smaller portion-size effect (both effects replicated in the present study) and is therefore less likely to trigger the processes that lead to an increased portion-size effect in individuals with lower socioeconomic status. In addition, individuals with lower socioeconomic status are less likely to be frequently exposed to large portions of healthy snacks, making it less 'normal' to eat large amounts of such foods. In line with this argument, recent work examining children's actual beverage consumption showed that children from families with higher socioeconomic status displayed a larger 'healthy' portion-size effect on water consumption (Best, Mojescik, Ryce, & Papies, in preparation). This effect could be driven by increased water consumption amongst families with higher socioeconomic status, such that children from these families consider consuming larger amounts of water normal. Future research should therefore examine whether higher socioeconomic status is similarly associated with a larger portion-size effect on actual healthy snack consumption in adults and children, and the mechanisms underlying such an effect.

Various features of the current study could be modified in future research to examine the specific drivers of the moderating effect of socioeconomic status on the portion-size effect for unhealthy food. First, the current study used a very conservative portion size manipulation, in which the small portion corresponded to a regular (i.e. recommended) serving and the large portion to a double serving (i.e. a 100% increase between the small and large portions). Both portions were selected to be both typical and feasible to consume as a snack. However, this could be seen as a subtle manipulation given that the median increase from the small to the large portion in the portion-size literature is 167% (Hollands et al., 2015). It is therefore likely that the effects of socioeconomic status would be even more pronounced with more extreme manipulations of portion size, which may correspond well to 'super-sized' portions available in current food environments (Young & Nestle, 2012).

Second, the current study distinguished between ‘healthy’ and ‘unhealthy’ snacks, informed by numerous features of the food items, including their calorie content, nutritional value, and levels of preservatives and processing. Whilst the healthiness ratings obtained from participants were consistent with our *a priori* categorisations of the food items, future research could independently manipulate these features to examine their separate roles in driving the portion-size effect and the extent to which socioeconomic status moderates it.

Third, future research should further examine the mediating roles of impulsivity and appropriateness and the underlying mechanisms. A limitation of the current work is that we asked participants to indicate how much they considered appropriate to consume from each portion, after they had indicated how much they would eat. Although participants provided quite different responses to the appropriateness and intended consumption question, indicating that it would be appropriate to eat more of the healthy food and less of the unhealthy food than they themselves intended to do, this procedure could still have encouraged them to base their appropriateness judgments to some degree on their own intended consumption. To prevent this, future research could experimentally manipulate, rather than measure, appropriateness perceptions, counterbalance the order of the intended consumption and appropriateness judgments, or further examine the factors that predict these responses.

Conclusion

Obesity is a global public health crisis. This paper shows how large portions of unhealthy food, a salient feature of the unhealthy food environment, can disproportionately affect those with lower socioeconomic status, thus contributing to the emerging psychology of socioeconomic status and eating behaviour.

References

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple Regression: Testing and Interpreting Interactions*. Sage.

Baker, C. (2016). *Obesity statistics*. House of Commons Library: Briefing paper no. 3336. Retrieved from https://researchbriefings.files.parliament.uk/documents/SN03336/SN03336.pdf

Beauchamp, A., Backholer, K., Magliano, D., & Peeters, A. (2014). The effect of obesity prevention interventions according to socioeconomic position: A systematic review. *Obesity Reviews*, *15*(7), 541-554. http://doi.org/10.1111/obr.12161

Burgoine, T., Forouhi, N. G., Griffin, S. J., Brage, S., Wareham, N. J., & Monsivais, P. (2016). Does neighbourhood fast-food outlet exposure amplify inequalities in diet and obesity? A cross-sectional study. *The American Journal of Clinical Nutrition*, *103*, 1540–1547. http://doi.org/10.3945/ajcn.115.128132.Obesity

Burkhauser, R. V., & Cawley, J. (2008). Beyond BMI: the value of more accurate measures of fatness and obesity in social science research. *Journal of Health Economics*, *27*(2), 519-529. https://doi.org/10.1016/j.jhealeco.2007.05.005

Cheema, A., & Soman, D. (2008). The effect of partitions on controlling consumption. *Journal of Marketing Research*, *45*(6), 665–675. https://doi.org/10.1509/jmkr.45.6.665

Cundiff, J. M., & Matthews, K. A. (2017). Is subjective social status a unique correlate of physical health? A meta-analysis. *Health Psychology*, *36*(12), 1109–1125. http://doi.org/10.1037/hea0000534

Darmon, N., & Drewnowski, A. (2008). Does social class predict diet quality? *American Journal of Clinical Nutrition*, *87*(5), 1107–1117. http://doi.org/87/5/1107 [pii]

Daly, M., & Wilson, M. (2005). Carpe diem: Adaptation and devaluing the future. *The Quarterly Review of Biology*, *80*(1), 55-60. http://doi.org/10.1086/431025

Department of Health (2011). *Statement of the Calorie Reduction Expert Group* (Policy Paper). Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/215561/dh_127554.pdf

Dubois, D., Rucker, D. D., & Galinsky, A. D. (2012). Super size me: Product size as a signal of status. *Journal of Consumer Research*, *38*(6), 1047–1062. https://doi.org/10.1086/661890

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, 41(4), 1149-1160.

Fuller, E., Mindell, J., & Prior, G. (2017). *Health Survey for England 2016*. London: NHS Digital.

Griskevicius, V., Tybur, J. M., Delton, A. W., & Robertson, T. E. (2011). The influence of mortality and socioeconomic status on risk and delayed rewards: A life history theory approach. *Journal of Personality and Social Psychology*, *100*(6), 1015–1026. https://doi.org/10.1037/a0022403

Guerrieri, R., Nederkoorn, C., & Jansen, A. (2008). The interaction between impulsivity and a varied food environment: Its influence on food intake and overweight. *International Journal of Obesity*, *32*(4), 708–714. http://doi.org/10.1038/sj.ijo.0803770

Hackman, D. A., Farah, M. J., & Meaney, M. J. (2010). Socioeconomic status and the brain: Mechanistic insights from human and animal research. *Nature Reviews Neuroscience*, *11*(9), 651. http://doi.org/10.1038/nrn2897

Haushofer, J., & Fehr, E. (2014). On the psychology of poverty. *Science*, *344*(6186), 862-867. http://doi.org/10.1126/science.1232491

Hill, S. E., Prokosch, M. L., DelPriore, D. J., Griskevicius, V., & Kramer, A. (2016). Low childhood socioeconomic status Promotes eating in the absence of energy need. *Psychological Science*, *27*(3), 354–364. http://doi.org/10.1177/0956797615621901

Hollands, G., Shemilt, I., Marteau, T. M., Jebb, S. A., Lewis, H. B., Wei, Y., Higgins, J., & Ogilvie, D. (2017). Portion, package or tableware size for changing selection and consumption of food, alcohol and tobacco. *The Cochrane Database of Systematic Reviews*, *9*(9), 1–387. http://doi.org/10.1002/14651858.CD011045.pub2.www.cochranelibrary.com

Keough, K. A., Zimbardo, P. G., & Boyd, J. N. (1999). Who's smoking, drinking, and using drugs? Time perspective as a predictor of substance use. *Basic and Applied Social Psychology*, *21*(2), 149-164. http://dx.doi.org/10.1207/15324839951036498

Kuznetsova, A., Bruun Brockhoff, P., & Haubo Bojesen Christensen, R. (2013) *lmerTest: Tests for random and fixed effects for linear mixed effect models (lmer objects of lme4 package)* (Version R 2.0-3). Retrieved from http://CRAN.R-project.org/package=lmerTest

Laran, J., & Salerno, A. (2013). Life-history strategy, food choice, and caloric consumption. *Psychological Science*, *24*(2), 167–173. https://doi.org/10.1177/0956797612450033

Lee, M. D. & Wagenmakers, E.-J. (2013). *Bayesian Cognitive Modeling: A Practical Course.* Cambridge University Press.

Marchiori, D., Papies, E. K., & Klein, O. (2014). The portion size effect on food intake. An anchoring and adjustment process?. *Appetite*, *81*, 108-115. http://doi.org/10.1016/j.appet.2014.06.018

Marteau, T. M., Hollands, G. J., Shemilt, I., & Jebb, S. A. (2015). Downsizing: policy options to reduce portion sizes to help tackle obesity. *BMJ*, *351*, h5863.

https://doi.org/10.1136/bmj.h5863

Moody, A., & Neave, A. (2016). *Health Survey for England 2015.* London: NHS Digital.

Morey, R. D., Rouder, J. N., & Jamil, T. (2015). *BayesFactor: Computation of Bayes Factors for Common Designs* (Version 0.9.11-1). Retrieved from https://cran.r-project.org/web/packages/BayesFactor/

Newton, F. J., Newton, J. D., & Wong, J. (2017). This is your stomach speaking: Anthropomorphized health messages reduce portion size preferences among the powerless. *Journal of Business Research*, *75*, 229-239. http://dx.doi.org/10.1016/j.jbusres.2016.07.020

Nuijten, M. B., Wetzels, R., Matzke, D., Dolan, C. V., & Wagenmakers, E. J. (2015). A default Bayesian hypothesis test for mediation. *Behavior Research Methods*, *47*(1), 85–97. http://doi.org/10.3758/s13428-014-0470-2

Office for National Statistics (2013). *Economic and Social Characteristics of the Resident Population of England and Wales by Nationality and Country of Birth in 2011*, (July), 1–47. Retrieved from https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/economicandsocialcharacteristicsoftheresidentpopulationofenglandandwalesbynationalityandcountryofbirthin2011/2013-07-12

Office for National Statistics (2018). *Household Disposable Income and Inequality: Financial Year Ending 2015*. Retrieved from https://www.ons.gov.uk/peoplepopulationandcommunity/personalandhouseholdfinances/incomeandwealth/bulletins/householddisposableincomeandinequality/financialyearending2015#redistribution-of-income-through-cash-benefits-and-direct-taxes

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the Barratt impulsiveness scale. *Journal of Clinical Psychology*, *51*(6), 768–774.

Payne, B. K., Brown-Iannuzzi, J. L., & Hannay, J. W. (2017). Economic inequality increases risk taking. *Proceedings of the National Academy of Sciences*, *114*(18), 4643–4648. https://doi.org/10.1073/pnas.1616453114

Pechey, R., Jebb, S. A., Kelly, M. P., Almiron-Roig, E., Conde, S., Nakamura, R., Shemilt, I., Suhrcke, M., & Marteau, T. M. (2013). Socioeconomic differences in purchases of more vs. less healthy foods and beverages: Analysis of over 25,000 British households in 2010. *Social Science and Medicine*, *92*, 22–26. http://doi.org/10.1016/j.socscimed.2013.05.012

R Development Core Team. (2014). *R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.* Retrieved from http://www.R-project.org/

Roberts, K., Cavill, N., Hancock, C., & Rutter, H. (2013). *Social Economic Inequalities in Diet and Physical Activity.* London: Public Health England.

Robinson, E., & Kersbergen, I. (2018). Portion size and later food intake: Evidence on the "normalizing" effect of reducing food portion sizes. *The American Journal of Clinical Nutrition, 107*(4), 640–646. https://doi.org/10.1093/ajcn/nqy013

Robinson, E., Te Raa, W., & Hardman, C. A. (2015). Portion size and intended consumption. Evidence for a pre-consumption portion size effect in males? *Appetite*, *91*, 83–89. http://doi.org/10.1016/j.appet.2015.04.009

Robinson, E., Thomas, J., Aveyard, P., & Higgs, S. (2014). What everyone else Is eating: A systematic review and meta-analysis of the effect of informational eating norms on eating behavior. *Journal of the Academy of Nutrition and Dietetics, 114*(3), 414–429. https://doi.org/10.1016/j.jand.2013.11.009

Smith, A. T., Noble, M., Noble, S., Wright, G., & McLennan, D. (2015). *The English Indices of Deprivation 2015: Research Report*. London: Department for Communities and Local Government.

Tingley, D., Yamamoto, T., Hirose, K., Keele, L., & Imai, K. (2014). Mediation: R Package for Causal Mediation Analysis. *Journal of Statistical Software, 59*(5), 1–38. http://doi.org/10.18637/jss.v059.i05

Versluis, I., & Papies, E. K. (2016a). The role of social norms in the portion size effect: Reducing normative relevance reduces the effect of portion Size on consumption decisions. *Frontiers in Psychology, 7*(May), 1–12. http://doi.org/10.3389/fpsyg.2016.00756

Versluis, I., & Papies, E. K. (2016b). Eating less from bigger packs: Preventing the pack size effect with diet primes. *Appetite, 100*, 70–79. http://doi.org/10.3389/fpsyg.2016.00756

Wilkinson, L. L., Hinton, E. C., Fay, S. H., Ferriday, D., Rogers, P. J., & Brunstrom, J. M. (2012). Computer-based assessments of expected satiety predict behavioural measures of portion-size selection and food intake. *Appetite, 59*(3), 933-938. http://doi.org/ 10.1016/j.appet.2012.09.007.

Yancey, A. K., Cole, B. L., Brown, R., Williams, J. D., Hillier, A., Kline, R. S., Ashe, M., Grier, S. A., Backman, D., & McCarthy, W. J. (2009). A cross-sectional prevalence study of ethnically targeted and general audience outdoor obesity-related advertising. *The Milbank Quarterly, 87*(1), 155–184. https://doi.org/10.1111/j.1468-0009.2009.00551.x

Young, L. R., & Nestle, M. (2012). Reducing portion sizes to prevent obesity: A call to action. *American Journal of Preventive Medicine, 43*(5), 565–568. https://doi.org/10.1016/j.amepre.2012.07.024

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. http://doi.org/10.1509/jm.12.0303

Supplemental Material

Full Inclusion and Exclusion Criteria

To be eligible to take part, participants had to verify that they met all of the following inclusion criteria:

- aged between 18-70 years
- currently live in England
- consume an omnivorous diet
- normal or corrected-to-normal vision

Furthermore, participants were excluded from participation if they:

- had any past or present eating disorders
- had any allergies to food or drink products or any other reason to limit consumption of specific foods
- had any learning disabilities or synaesthesia
- had a psychological, psychiatric, or neurological condition
- had colour-blindness
- were following any specific diet (e.g. weight loss, gluten-free)

Additional Measures

This experiment is part of a wider project that examined the factors that contribute to unhealthy eating. As such, we included a series of additional measures. These measures were not analyzed in the context of the hypotheses addressed in this paper.

Measure Description	***Scale***
What time did you last eat today?	Participants selected a time on the 24-hour clock to the nearest five minutes. If participants did not eat today, they could select "I have not eaten today". In this case, participants were asked "What time did you last eat yesterday?". If participants did not eat yesterday, they could select "I did not eat yesterday". In this case, participants were asked to specify the date and time they last ate.
How much did you last eat?	Small snack; Large snack; Small meal; Large meal; Other
Trait self-control measured using the 13-items Tangney, Baumeister, & Boone (2004) self-control scale.	1 = *not at all* to 7 = *very much*
Executive function measured using 5-items from the Buchanan et al. (2010) WEB-EXEC scale.	1 = *no problems experienced;* 4 = *a great many problems experienced*
Future-orientation measured using the 13-item future scale of the Zimbardo Time Perspective Inventory (Keough, Zimbardo, & Boyd, 1999).	Very untrue; Untrue; Neutral; True; Very true
Eating behaviours measured using the 21-item three-factor eating questionnaire (Cappelleri et al., 2009; Stunkard & Messick, 1985)	Items 1-17: *Definitely false; Mostly false; Mostly true; Definitely true* Item 18: *Unlikely; Slightly likely; Moderately likely; Very likely* Item 19: *Never; Rarely; Sometimes; At least once a week* Item 20: *Only at meal times; Sometimes between meals; Often between meals; Almost always* Item 21: *1; 2; 3; 4; 5; 6; 7; 8*
Plate cleaning tendencies measured using the 50 items from Robinson, Aveyard, & Jebb (2014) plate-cleaning scale.	50 = *Strongly disagree* to 100 = *Strongly agree*
Portion control in advance of consumption ("*Before I start eating, I usually decide how much of the food serving I'm going to consume*").	0 = *Strongly disagree* to 100 = *Strongly agree*

Childhood plate cleaning ("*When I was a child, I was taught to finish all the food I was served*").	0 = *Strongly disagree* to 100 = *Strongly agree*
What is your current employment status?	Unemployed; Student; Self-employed; Employed (part-time); Employed (full-time); Retired; Other
Which of the following options best describes your current occupational status?	Large employers and higher managers and administrative occupations (e.g. Chief Executive, Production Manager); Higher professional occupations (e.g. Doctor, Barrister, Dentist); Lower managerial, administrative and professional occupations (e.g. Nurse, Actor, Journalist); Intermediate occupations (e.g. Fireman, Photographer, Airline Cabin Crew); Small employers and own account workers (e.g. self employed: Builder, Hairdresser, Fisherman); Lower supervisory, craft and related occupations (e.g. Train Driver, Plumber, Electrician); Semi-routine occupations (e.g. Postman, Care Assistant, Shop Assistant); Routine occupations (e.g. Bus Driver, Refuse Collector, Waitress); Never worked and long-term unemployed
Where do you currently live?*	England; Scotland; Wales; Northern Ireland; Other
What is your current housing situation?	Own my own home; Rent; Shared rental with non-family member(s) (House of Multiple Occupancy); Live with family; Other
Including yourself, how many people in your household are financially dependent on your income?	Free text entry
What is your annual household income, after tax and mandatory contributions, including all earners in your household, in GBP?*	Free text entry
Which of the following best describes your current diet?*	Omnivore; Pescatarian; Vegetarian; Vegan; Other
Have you got any specific food or drink allergies?	Yes/No (if yes is selected: "Please provide us with some details about your food and/or drink allergies here:" [free text entry])
To what extent are you currently trying to lose weight?	0 = *Not at all;* 100 = *Very much*

Childhood socioeconomic status measured using 3 items modified from Hill et al. (2016): "*I feel my family had enough money for things when I was growing up", "I feel I grew up in a relatively wealthy neighbourhood", "When I was a child, I felt relatively wealthy compared to other children my age"*.	0 = *Strongly disagree;* 100 = *Strongly agree*
Did you experience any technical problems with this survey? Did you notice anything wrong, or any errors? If so, please write any comments you many have below.	Free text entry
What do you think we were expecting to find in this experiment?	Free text entry

* Included to check that participants met the inclusion criteria.

Buchanan, T., Heffernan, T. M., Parrott, A. C., Ling, J., Rodgers, J., & Scholey, A. B. (2010). A short self-report measure of problems with executive function suitable for administration via the Internet. *Behavior Research Methods*, *42*(3), 709-714.

Cappelleri, J. C., Bushmakin, A. G., Gerber, R. A., Leidy, N. K., Sexton, C. C., Lowe, M. R., & Karlsson, J. (2009). Psychometric analysis of the Three-Factor Eating Questionnaire-R21: results from a large diverse sample of obese and non-obese participants. *International Journal of Obesity*, *33*(6), 611.

Keough, K. A., Zimbardo, P. G., & Boyd, J. N. (1999). Who's smoking, drinking, and using drugs? Time perspective as a predictor of substance use. *Basic and Applied Social Psychology*, *21*(2), 149-164.

Robinson, E., Aveyard, P., & Jebb, S. A. (2015). Is plate clearing a risk factor for obesity? A cross-sectional study of self-reported data in US adults. *Obesity*, *23*(2), 301-304.

Stunkard, A. J., & Messick, S. (1985). The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *Journal of Psychosomatic Research*, *29*(1), 71-83.

Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality*, *72*(2), 271-324.

Weights (grams) and Energy Density (kcals) as a Function of Portion Size and Snack Food Item

There were eight snack foods comprising four healthy snacks (fries, crisps, chocolate minstrels, cookies) and four healthy snacks (carrot sticks, cucumber, grapes, blueberries). The 'large' portion corresponded to double the small portion to the nearest whole food unit. For the unhealthy snacks, the average weight of the small portion was 43g (*SD* = 26g; M_{calories} = 175 kcals, SD_{calories} = 52 kcals) and the average weight of the large portion was 87g (SD = 52g; M_{calories} = 350 kcals, SD_{calories} = 107 kcals). For the healthy snacks, the average weight of the small portion was 66g (SD = 18g; M_{calories} = 31

kcals; $SD_{calories}$ = 20 kcals) and the average weight of the large portion was 133 g (SD = 39 g; $M_{calories}$ = 63 kcals, $SD_{calories}$ = 40 kcals).

Snack	*Small Portion*	*Large Portion*
French Fries (McDonald's, US)	80 g (230 kcals)	160 g (461 kcals)
Ready-Salted Crisps (Walkers Snack Foods Ltd, UK)	25 g (132 kcals)	50 g (263 kcals)
Minstrels (Mars, UK)	42 g, 15 minstrels (209 kcals)	85 g, 32 minstrels (423 kcals)
Mini Maryland Chocolate Chip Cookies (Burton's Biscuit Co, UK)	26 g (130 kcals)	51 g (254 kcals)
Carrot Batons (Tesco Stores Ltd, UK)	43 g, 10 batons (18 kcals)	83 g, 20 batons (35 kcals)
Cucumber Slices (Tesco Stores Ltd, UK)	80 g, 5cm, 10 slices (12 kcals)	160 g, 10 cm, 20 slices (25 kcals)
Green Grapes (Tesco Stores Ltd, UK)	82 g, 14 grapes (54 kcals)	167 g, 28 grapes (110 kcals)
Blueberries (Tesco Stores Ltd, UK)	60 g, 31 blueberries (41 kcals)	120 g, 68 blueberries (82 kcals)

Table S1. Grams (g), calories (kcals), and, where appropriate, units as a function of food item and portion size.

Stimuli

The stimuli used in the experiment as a function of snack healthiness, portion size and sweet/savory. Note that high-resolution images of the stimuli can be accessed and downloaded via the Open Science Framework (https://osf.io/6438n/?view_only=c5a5b81c00544590948fc3f878456c49).

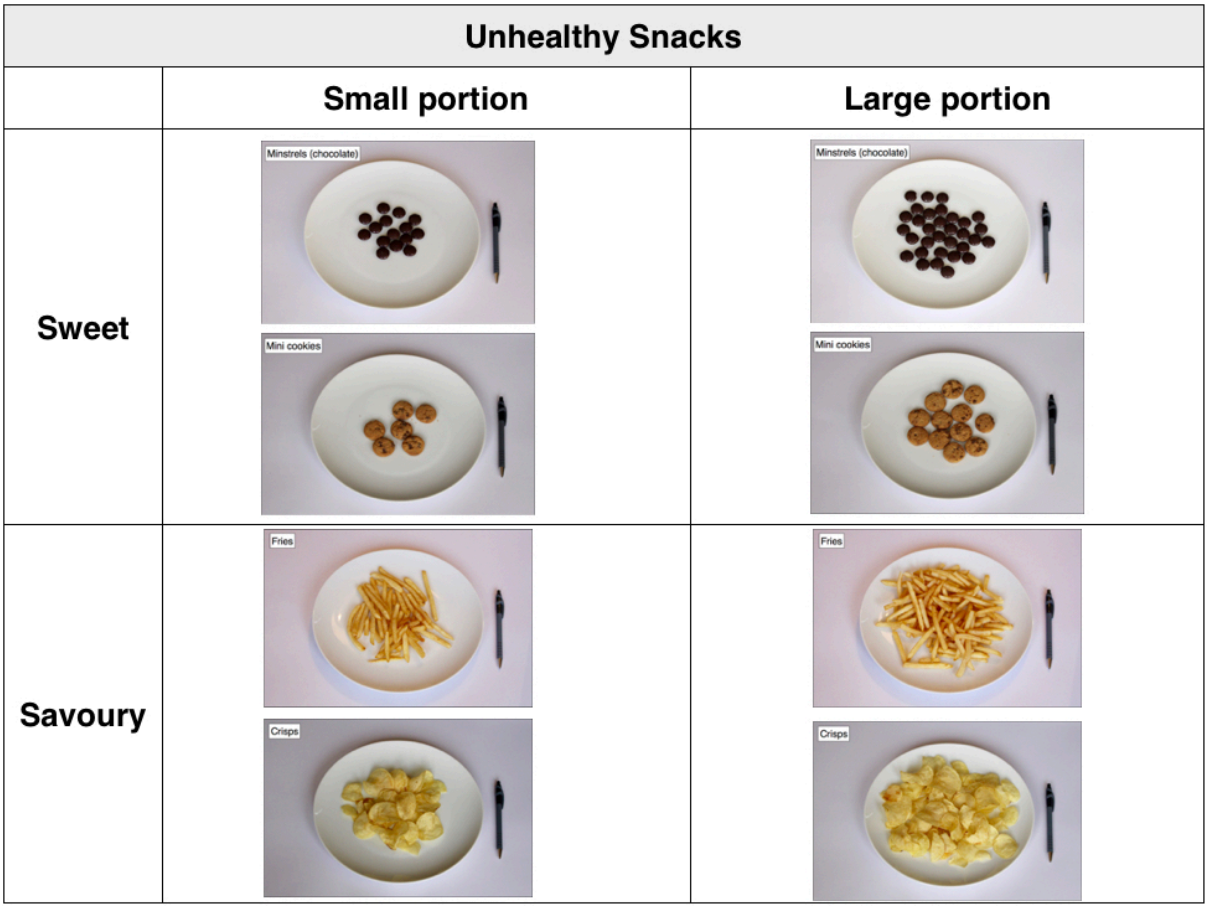

Figure S1. Images of the unhealthy snacks in the small portions (left) and large portions (right).

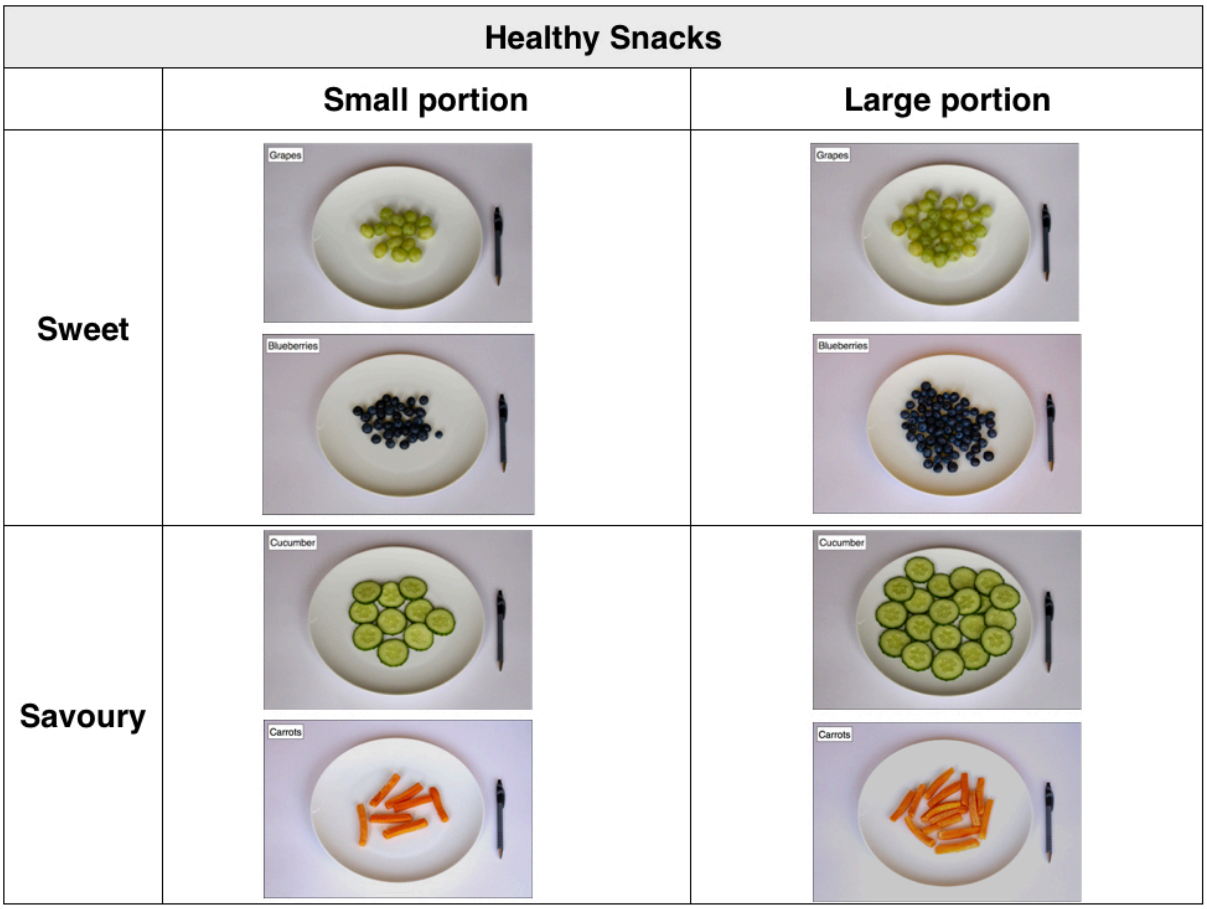

Figure S2. Images of the healthy snacks in the small portions (left) and large portions (right).

Analyses to Examine the Moderating Effects of Socioeconomic Status and Portion Size on Intended Consumption of the Unhealthy Snacks with Hunger Included as an Additional Fixed Effect

					Variance Explained	
Model	***Estimate***	***SE***	***t***	***p***	R^2m	R^2c
Model 1: Highest Educational Qualification (Baseline = Low)					0.271	0.650
(Intercept)	1.2785	0.0341	37.53	< **0.001**		
Portion size	0.5323	0.0257	20.73	< **0.001**		
Education	-0.0830	0.0291	-2.86	**0.004**		
Hunger	0.0907	0.0230	3.95	< **0.001**		
Portion size by Education	-0.0610	0.0195	-3.14	**0.002**		
Model 2: Household Income					0.277	0.648
(Intercept)	1.2824	0.0337	38.04	< **0.001**		
Portion size	0.5343	0.0248	21.54	< **0.001**		
Income	-0.1154	0.0289	-4.00	< **0.001**		
Hunger	0.0879	0.0229	3.84	**0.001**		
Portion size by Income	-0.0527	0.0196	-2.69	**0.007**		
Model 3: Neighbourhood Deprivation					0.264	0.649
(Intercept)	1.2785	0.0343	37.30	< **0.001**		
Portion size	0.5323	0.0259	20.54	< **0.001**		
Neighbourhood deprivation	0.0517	0.0291	1.77	0.077		
BMI	0.0917	0.0229	4.01	< **0.001**		
Portion size by Neighbourhood deprivation	0.0302	0.0196	1.54	0.124		
Model 4: Perceived Current Wealth					0.277	0.650
(Intercept)	1.2785	0.0341	37.54	< **0.001**		
Portion size	0.5323	0.0259	20.59	< **0.001**		
Perceived wealth	-0.1142	0.0289	-3.96	< **0.001**		
Hunger	0.0888	0.0229	3.88	< **0.001**		
Portion size by Perceived wealth	-0.0705	0.0194	-3.64	< **0.001**		

Table S2. Overview of the linear multilevel models conducted on the intended consumption of the unhealthy snacks with hunger included as an additional fixed effect. Separate models were computed for each SES indicator (highest educational level, household income, neighbourhood deprivation, perceived current wealth). Estimate is the coefficient, t and p refer to the t-value and p-value for each fixed effect, respectively. R^2m is the variance explained by the fixed effects; R^2c is the variance explained by the fixed effects plus the random effects. *Note that N = 511 for all Models, except Model 2 (Household Income) where N = 504 due to exclusions.

Analyses to Examine the Moderating Effects of Socioeconomic Status and Portion Size on Intended Consumption of the Unhealthy Snacks with BMI Included as an Additional Fixed Effect

					Variance Explained	
Model	***Estimate***	***SE***	***t***	***p***	R^2m	R^2c
Model 1: Highest Educational Qualification (Baseline = Low)					0.263	0.654
(Intercept)	1.2785	0.0348	36.71	**< 0.001**		
Portion size	0.5323	0.0252	21.10	**< 0.001**		
Education	-0.0912	0.0295	-3.09	**0.002**		
BMI	0.0477	0.0232	2.06	**0.040**		
Portion size by Education	-0.0610	0.0195	-3.13	**0.002**		
Model 2: Household Income					0.269	0.653
(Intercept)	1.2824	0.0345	37.17	**< 0.001**		
Portion size	0.5343	0.0244	21.89	**< 0.001**		
Income	-0.1178	0.0294	-4.00	**< 0.001**		
BMI	0.0463	0.0232	2.00	**0.046**		
Portion size by Income	-0.0527	0.0196	-2.68	**0.007**		
Model 3: Neighbourhood Deprivation					0.256	0.654
(Intercept)	1.2785	0.0351	36.45	**< 0.001**		
Portion size	0.5323	0.0255	20.90	**< 0.001**		
Neighbourhood deprivation	0.0536	0.0298	1.80	0.073		
BMI	0.0466	0.0233	2.00	**0.046**		
Portion size by Neighbourhood deprivation	0.0302	0.0196	1.54	0.125		
Model 4: Perceived Current Wealth					0.269	0.655
(Intercept)	1.2786	0.0348	36.71	**< 0.001**		
Portion size	0.5323	0.0254	20.94	**< 0.001**		
Perceived wealth	-0.1182	0.0295	-4.00	< **0.001**		
BMI	0.0417	0.0233	1.79	0.075		
Portion size by Perceived wealth	-0.0706	0.0194	-3.63	**< 0.001**		

Table S3. Overview of the linear multilevel models conducted on the intended consumption of the unhealthy snacks with BMI included as an additional fixed effect. Separate models were computed for each SES indicator (highest educational level, household income, neighbourhood deprivation, perceived current wealth). Estimate is the coefficient, t and p refer to the t-value and p-value for each fixed effect, respectively. R^2m is the variance explained by the fixed effects; R^2c is the variance explained by the fixed effects plus the random effects. *Note that N = 511 for all Models, except Model 2 (Household Income) where N = 504 due to exclusions.

Analyses to Examine the Moderating Effects of Socioeconomic Status and Portion Size on Intended Consumption of the Unhealthy Snacks with Gender Included as an Additional Fixed Effect

Note: This model did not converge when controlling for the random slopes (and intercepts) of portion size for each participant and food item (indicating overfitting). Hence, we removed the random slope of portion size and controlled only for the random intercepts of each participant and food item.

					Variance Explained	
Model	***Estimate***	***SE***	***t***	***p***	R^2m	R^2c
Model 1: Highest Educational Qualification (Baseline = Low)					0.262	0.532
(Intercept)	1.2784	0.0336	38.06	< **0.001**		
Portion size	0.5323	0.0161	33.01	< **0.001**		
Education	-0.0990	0.0295	-3.36	**0.001**		
Gender	-0.0390	0.0295	-1.32	0.186		
Portion size by Education	-0.0611	0.0161	-3.79	< **0.001**		
Model 2: Household Income					0.269	0.531
(Intercept)	1.2824	0.0322	39.78	< **0.001**		
Portion size	0.5343	0.0163	32.87	< **0.001**		
Income	-0.1285	0.0296	-4.35	< **0.001**		
Gender	-0.0461	0.0296	-1.56	0.119		
Portion size by Income	-0.0530	0.0163	-3.26	**0.001**		
Model 3: Neighbourhood Deprivation					0.254	0.529
(Intercept)	1.2784	0.0339	37.75	< **0.001**		
Portion size	0.5323	0.0162	32.90	< **0.001**		
Neighbourhood deprivation	0.0607	0.0295	2.05	**0.041**		
Gender	-0.0309	0.0295	-1.05	0.296		
Portion size by Neighbourhood deprivation	0.0299	0.0162	1.85	0.065		
Model 4: Perceived Current Wealth					0.270	0.534
(Intercept)	1.2784	0.0336	38.08	< **0.001**		
Portion size	0.5323	0.0161	33.06	< **0.001**		
Perceived wealth	-0.1330	0.0295	-4.51	< **0.001**		
Gender	-0.0503	0.0295	-1.71	0.088		
Portion size by Perceived wealth	-0.0703	0.0161	-4.36	< **0.001**		

Table S4. Overview of the linear multilevel models conducted on the intended consumption of the unhealthy snacks with gender included as an additional fixed effect. Separate models were computed for each SES indicator (highest educational level, household income, neighbourhood deprivation, perceived current wealth). Estimate is the coefficient, t and p refer to the t-value and p-value for each fixed effect, respectively. R^2m is the variance explained by the fixed effects; R^2c is the variance explained by the fixed effects plus the random effects. *Note that N = 511 for all Models, except Model 2 (Household Income) where N = 504 due to exclusions.

Analyses to Examine the Moderating Effects of Socioeconomic Status and Portion Size on Intended Consumption of Unhealthy Snacks with Liking Included as an Additional Fixed Effect

Note: This model did not converge when controlling for the random slopes (and intercepts) of portion size for each participant and food item (indicating overfitting). Hence, we removed the random slope of portion size and controlled only for the random intercepts of each participant and food item.

					Variance Explained	
Model	***Estimate***	***SE***	***t***	***p***	R^2m	R^2c
Model 1: Highest Educational Qualification (Baseline = Low)					0.443	0.601
(Intercept)	1.0762	0.0251	42.81	< **0.001**		
Portion size	0.5288	0.0147	36.09	< **0.001**		
Education	-0.0632	0.0236	-2.68	**0.008**		
Liking	0.5871	0.0237	24.74	< **0.001**		
Portion size by Education	-0.0587	0.0147	-4.00	< **0.001**		
Model 2: Household Income					0.451	0.600
(Intercept)	1.0787	0.0255	42.23	< **0.001**		
Portion size	0.5312	0.0148	35.98	< **0.001**		
Income	-0.0791	0.0234	-3.38	< **0.001**		
Liking	0.5893	0.0238	24.77	< **0.001**		
Portion size by Income	-0.0510	0.0148	-3.46	< **0.001**		
Model 3: Neighbourhood Deprivation					0.439	0.597
(Intercept)	1.075	0.0252	42.63	< **0.001**		
Portion size	0.529	0.0147	35.94	< **0.001**		
Neighbourhood deprivation	0.045	0.0236	1.90	0.058		
Liking	0.590	0.0238	24.80	< **0.001**		
Portion size by Neighbourhood deprivation	0.030	0.0147	2.00	**0.045**		
Model 4: Perceived Current Wealth					0.448	0.603
(Intercept)	1.0769	0.0251	42.98	< **0.001**		
Portion size	0.5288	0.0146	36.14	< **0.001**		
Perceived wealth	-0.0890	0.0234	-3.80	< **0.001**		
Liking	0.5850	0.0237	24.71	< **0.001**		
Portion size by Perceived wealth	-0.0663	0.0146	-4.53	< **0.001**		

Table S5. Overview of the linear multilevel models conducted on the intended consumption of the unhealthy snacks with liking included as an additional fixed effect. Separate models were computed for each SES indicator (highest educational level, household income, neighbourhood deprivation, perceived current wealth). Estimate is the coefficient, t and p refer to the t-value and p-value for each fixed effect, respectively. R^2m is the variance explained by the fixed effects; R^2c is the variance explained by the fixed effects plus the random effects. *Note that N = 511 for all Models, except Model 2 (Household Income) where N = 504 due to exclusions.

Analyses to Examine the Moderating Effects of Socioeconomic Status and Portion Size on Intended Consumption of Unhealthy Snacks with Consumption Frequency Included as an Additional Fixed Effect

					Variance Explained	
Model	***Estimate***	***SE***	***t***	***p***	R^2m	R^2c
Model 1: Highest Educational Qualification (Baseline = Low)					0.333	0.682
(Intercept)	1.2286	0.0435	28.25	< **0.001**		
Portion size	0.5307	0.0229	23.20	< **0.001**		
Education	-0.0615	0.0272	-2.26	**0.024**		
Frequency	0.2951	0.0183	16.10	< **0.001**		
Portion size by Education	-0.0570	0.0188	-3.03	**0.003**		
Model 2: Household Income					0.340	0.680
(Intercept)	1.2322	0.0424	29.06	< **0.001**		
Portion size	0.5323	0.0222	24.03	< **0.001**		
Income	-0.0946	0.0271	-3.50	**0.001**		
Frequency	0.2946	0.0184	16.00	< **0.001**		
Portion size by Income	-0.0530	0.0189	-2.80	**0.005**		
Model 3: Neighbourhood deprivation					0.328	0.681
(Intercept)	1.2285	0.0437	28.09	< **0.001**		
Portion size	0.5307	0.0230	23.05	< **0.001**		
Neighbourhood deprivation	0.0377	0.0272	1.39	0.166		
Frequency	0.2956	0.0183	16.15	< **0.001**		
Portion size by Neighbourhood deprivation	0.0283	0.0190	1.49	0.136		
Model 4: Perceived Current Wealth					0.341	0.682
(Intercept)	1.2288	0.0435	28.25	< **0.001**		
Portion size	0.5307	0.0230	23.10	< **0.001**		
Perceived wealth	-0.0992	0.0269	-3.68	< **0.001**		
Frequency	0.2941	0.0183	16.08	< **0.001**		
Portion size by Perceived wealth	-0.0675	0.0188	-3.60	< **0.001**		

Table S6. Overview of the linear multilevel models conducted on the intended consumption of the unhealthy snacks with consumption included as an additional fixed effect. Separate models were computed for each SES indicator (highest educational level, household income, neighbourhood deprivation, perceived current wealth). Estimate is the coefficient, t and p refer to the t-value and p-value for each fixed effect, respectively. R^2m is the variance explained by the fixed effects; R^2c is the variance explained by the fixed effects plus the random effects. *Note that N = 511 for all Models, except Model 2 (Household Income) where N = 504 due to exclusions.

Analyses to Examine the Effects of (1) Household Income and Portion Size on Intended Consumption with Perceived Current Wealth Included as an Additional Fixed Effect and (2) Perceived Current Wealth and Portion Size on Intended Consumption with Household Income Included as an Additional Fixed Effect

					Variance Explained	
Model	***Estimate***	***SE***	***t***	***p***	***R^2m***	***R^2c***
Model 1: Household Income (with Perceived Current Wealth)					0.268	0.652
(Intercept)	1.2824	0.0344	37.30	< **0.001**		
Portion size	0.5343	0.0246	21.74	< **0.001**		
Household Income	-0.1071	0.0312	-3.43	**0.001**		
Perceived Current Wealth	-0.0335	0.0254	-1,32	0.187		
Portion size by Household Income	-0.0527	0.0196	-2.69	**0.007**		
Model 2: Perceived Current Wealth (with Household Income)					0.272	0.653
(Intercept)	1.2824	0.0347	36.94	< **0.001**		
Portion size	0.5343	0.0247	21.64	< **0.001**		
Perceived Current Wealth	-0.0980	0.0312	-3.12	**0.002**		
Household Income	-0.0584	0.0254	-2.30	**0.022**		
Portion size by Perceived Current Wealth	-0.0697	0.0195	-3.57	< **0.001**		

Table S7. Overview of the linear multilevel models conducted on the intended consumption of the high energy-dense snacks to examine the effects of (1) Portion size and Household Income, with Perceived Current Wealth included as an additional fixed effect; and (2) Portion size and Perceived Current Wealth, with Household Income included as an additional fixed effect. Estimate is the coefficient, t and p refer to the t-value and p-value for each fixed effect, respectively. R^2m is the variance explained by the fixed effects; R^2c is the variance explained by the fixed effects plus the random effects. Note that N = 504 due to exclusions.

Exploratory Analyses

We conducted separate frequentist and Bayesian mediation analyses for each socioeconomic status indicator with present time perspective as a mediator, following the same procedures implemented in the confirmatory mediation analyses (see main text).

Present time perspective. Present time perspective was positively correlated with impulsivity (r = 0.532, $p < 0.001$) and the frequency of consuming the unhealthy snacks (r = -0.295, $p < 0.001$). Differences in present time perspective partially mediated the effect of highest educational level, and fully mediated the effect of neighbourhood deprivation on the portion-size effect for the unhealthy snacks (Table S8), although the total model and proportion mediation for the latter result were not reliable. Bayesian mediation analyses revealed ‘anecdotal’ support for the indirect effect of present time perspective for highest educational level (BF = 2.05) and ‘moderate’ evidence for the indirect effect of present time perspective for neighbourhood deprivation (BF = 6.82). The effects of household income and perceived current wealth on the portion-size effect for the unhealthy snacks were not reliably mediated by present time perspective (Table S8), and there was ‘anecdotal’ support for the null hypothesis of no mediation across both indicators ($BFs \leq 0.80$).

	Standardised Estimate	*95% CI lower*	*95% CI upper*	*p*
Highest Educational Level (Baseline = Low)				
Indirect effect	-0.0208	-0.0405	-0.01	**0.003**
Direct effect	-0.1016	-0.1739	-0.03	**0.006**
Total effect	-0.1224	-0.1938	-0.05	**0.001**
Proportion mediated	0.1701	0.0442	0.46	**0.004**
Household Income				
Indirect effect	-0.0083	-0.0211	0.00	0.080
Direct effect	-0.0982	-0.1690	-0.03	**0.006**
Total effect	-0.1065	-0.1779	-0.04	**0.003**
Proportion mediated	0.0724	-0.0078	0.29	0.082
Neighbourhood Deprivation				
Indirect effect	0.0215	0.0076	0.04	**0.002**
Direct effect	0.0382	-0.0340	0.11	0.302
Total effect	0.0597	-0.0122	0.13	0.102
Proportion mediated	0.3604	-1.6411	2.88	0.103
Perceived Current Wealth				
Indirect effect	-0.0004	-0.0010	0.00	0.063
Direct effect	-0.0061	-0.0094	0.00	**0.001**
Total effect	-0.0065	-0.0099	0.00	**< 0.001**
Proportion mediated	0.0653	-0.0042	0.18	0.063

Table S8. Overview of the causal mediation analyses to examine the indirect effect of present time perspective. Separate mediation analyses were conducted for each of the SES indicators on the portion-size effect for the unhealthy snacks. *p* refers to the p-valence; CI refers to the confidence interval.