Food insecurity moderates the acute effect of subjective socioeconomic status on food consumption

Sarah Godsell§, Michael Randle§, Melissa Bateson and Daniel Nettle*

Centre for Behaviour and Evolution & Institute of Neuroscience, Newcastle University, Newcastle, UK

§ Joint first authors

Corresponding author:
Daniel Nettle, Henry Wellcome Building, Newcastle University, Newcastle NE2 4HH, UK. Email address: daniel.nettle@ncl.ac.uk

Word length: 3500, 2 tables, 2 figures
Abstract

Experimentally inducing low subjective socioeconomic status (SSES) increases food consumption in standardized eating opportunities. Separately, food insecurity (FI) has also been shown to be associated with increased opportunistic food consumption. Here, we assigned 123 adult volunteers to a low-SSES manipulation or a control condition, followed by an opportunity to consume snack foods. We measured FI prior to the experiment. Thus, our experiment served to replicate the effects of SSES and of FI on consumption, and also to establish whether these effects combine additively or interactively. The low-SSES manipulation increased food consumption, but only among participants who were food-secure at baseline. Amongst food-insecure participants, the effect was reversed. This interaction was not predicted a priori and is presented as an exploratory finding. We also found evidence that both SSES and FI affected the hedonic evaluation of the snack foods. Our findings suggest that both FI and low SSES affect the consumption and evaluation of food. Their combined effects on consumption may be complex.

Keywords: Food insecurity; socioeconomic status; obesity; eating; energy intake
Introduction

Low socioeconomic status is a predictor of obesity and overweight in developed countries, especially amongst women (McLaren, 2007; Newton et al., 2017; Sobal and Stunkard, 1989). Subjective socioeconomic status (SSES; the self-assessed appraisal of one’s position within society) explains variation in obesity above and beyond more socioeconomic objective variables (Goodman et al., 2001, 2003). Recently, researchers have begun to manipulate SSES experimentally, using tasks that cause participants to compare their lot favourably or unfavourably to others. Such manipulations increase intended or actual food consumption in their immediate aftermath (Bratanova et al., 2016; Cardel et al., 2015; Cheon and Hong, 2016; Sim et al., 2018a), and increase secretion of the hormone ghrelin (Sim et al., 2018b), lending support to the idea that the relationship between SSES and body weight may be causal, and mediated by energy intake.

Food insecurity (FI)—the limited or uncertain ability to procure adequate food—also predicts obesity and overweight amongst women (Nettle et al., 2017; Townsend et al., 2001). In two recent studies, food-insecure participants consumed more calories when given free eating opportunities (Nettle et al., 2019; Stinson et al., 2018). Thus, two factors appear to predict how much a person will eat when given a staged opportunity: their (experimentally manipulated) SSES; and their (baseline) FI. As these factors have only recently been documented, they require replication. It is currently unknown how they combine. It is plausible that they would be additive: people who are food-insecure consume more than those who are food-secure, and both consumption of both groups is increased by the same amount by manipulation of low SSES. Alternatively, there could be interactions between the manipulation and FI. Food-insecure participants might show a larger response to the experimental SSES manipulation; this would be a form of sensitization to acute cues indicative of shortfall or stress. Equally, food-insecure participants might show a smaller response to the SSES manipulation, because their calorie consumption in the control condition would be higher anyway.

As well as finding that food-insecure women consumed more than food-secure women, Nettle et al. (2019) found that food-insecure women rated one of the foods (chocolate) more highly when asked to evaluate it. Thus, an important proximate psychological effect of FI may be to increase the hedonic value of foods, leading to greater consumption, as suggested by Anselme and Güntürkün (2018). Just as FI might lead to changes in the hedonic value of foods, so might SSES. That is, the increased consumption seen following SSES manipulations might be due to changes in the perception of the hedonic value of the foods on offer. This possibility has not been tested in previous studies.

The present study is a conceptual replication of Nettle et al. (2019), in which we measured baseline FI in a community sample, and then presented a mock ‘taste test’ of snack foods, and measured energy intake. The innovation of the present study was that we also included an SSES manipulation (following the methods of Cheon and Hong, 2016). Hence, our study also provides a replication of the acute experimental effect of SSES on consumption. Based on prior findings, we made the following confirmatory predictions: there will be an interaction between sex and FI in predicting consumption, with food-insecure women consuming more than food-secure women, but no difference by FI amongst men; and participants receiving the low-SSES manipulation will consume more than participants in a control condition. We investigated the possibility of interactions between FI and manipulated SSES, but without directional prediction. We also predicted that both FI and SSES would affect the hedonic value of the foods on offer, as reflected in participant ratings.

Materials and Methods
Ethics statement

Ethical approval for this study was granted by the Faculty of Medical Sciences ethics committee at Newcastle University, approval number 1400/15594/2017. All participants gave written informed consent to participate and were debriefed as to the true nature of the study on completion.

Data availability

The raw data from this study, along with R code used for analysis, are freely available via the Zenodo repository at: https://doi.org/10.5281/zenodo.2580973.

Participants

We recruited an opportunity sample of 125 adult participants (36 males, 89 females; 84 students) via flyers, online advertisement and registers held at Newcastle University. Two male participants did not complete key parts of the study, leaving 123 (34 males, 89 females). This gave a power of 0.96 to detect the SSES effect size in Cheon and Hong (2016)’s study 3, and 0.75 to detect the effect size in their study 4. Participants were asked to disclose any food allergies or intolerances that might affect their participation in the taste test, and none were excluded for this reason. The study was presented as an investigation of how individual characteristics and eating patterns relate to food preferences.

Food insecurity

Participants completed an online questionnaire prior to attending the laboratory, including two measures of FI: the AFI questionnaire (Nettle et al., 2019), and the USDA Food Insecurity scale (Bickel et al., 2000). The USDA scale is the standard FI measure, but in general populations, most people score zero. The AFI was designed to produce a more satisfactory distribution in general population studies. It focuses on all experiences of food insecurity and irregularity, regardless of their cause, whereas the USDA questionnaire focuses exclusively on food insecurity due to financial constraints. The questionnaire also contained a number of measures of early-life experience that are not analysed here.

Procedure

Participants were tested singly by one of two experimenters (SG and MR). Assignment to condition was an alternate sign-up basis.

*Cola pre-task.* On arrival, participants consumed two cups containing 75g of Coca-Cola® Classic (31.5kcal) and 75g of Pepsi (33kcal), then completed a 10-minute filler task in which they watched video advertisements of the two brands and answered questions on their cola preferences. This is a previously used method of equalising satiety levels prior to the taste test (Nettle et al., 2019; Wang and Dvorak, 2010). Participants then rated their hunger, fullness and desire to eat on 7-point scales.

*SSES manipulation.* Participants next completed the experimental manipulation, based on Cheon and Hong (2016). Each participant was shown an image of a ladder with rungs numbered 1 – 10, representing UK society. In the low status condition, an adjacent body of text asked the participant to compare herself to the people at the very top of the latter, think about how she was different from those people, and then place herself on the ladder relative to them. Following this, the participant was asked to imagine an interaction with a stranger from the top of the ladder. In the control condition, participants placed themselves on the ladder without first comparing themselves to the people at the top and no ladder position for the stranger in the imagined interaction was specified. After finishing
this, participants completed the PANAS measures of positive and negative affect (Watson et al.,
1988).

Taste test. Next, four standard pre-weighed plates of food were simultaneously presented by drawing
back curtains. The plates were positioned in a row and contained: milk chocolate buttons (69g,
516kcal/100g); cheese crackers (48g, 529kcal/100g); ready salted potato crisps (50g, 539kcal/100g);
and sweet popcorn (35g, 463kcal/100g). The quantities were chosen to balance available calories from
sweet food (518kcal) and savoury food (523kcal). Water was also presented.

For five minutes, participants were asked to evaluate each food on a 7-point scale, adding short
qualitative comments indicating what they liked and disliked about it. Once the five minutes had passed,
we distributed an additional packet of questionnaires, saying: ‘Please feel free to eat as much as you’d
like as we have to throw the food away between participants.’ The experimenter then withdrew for 10
minutes. Height (stadiometer, 0.5 cm precision) and weight (digital scales, 0.1 kg precision) were
recorded on conclusion of the session. Food plates were weighed following the session. Food weights
were converted to kilocalories using the nutritional information on the packaging.

Data analysis

For consumption, we had four outcome variables (kcals consumed of each of the four foods). We
therefore used multivariate analysis of variance (MANOVA) to examine whether FI, experimental
SSES condition, sex, and their interactions predicted the set of four consumption outcomes. Sex and
its interactions were included as previous studies have found sex differences in the response to FI. For
evaluation of the foods, we performed a parallel MANOVA with the four ratings of the foods as the
outcomes in place of the kcals consumed. Significant MANOVA findings were followed up with
single-outcome general linear models where appropriate. All analyses were carried out in R (R Core
Development Team, 2018), with an α level of 0.05 and two-sided tests throughout. The consumption
variables had positively skewed distributions and were log-transformed for analysis. Figures are based
on untransformed data.

The three hunger ratings prior to the taste test (rated hunger, rated fullness and rated desire to eat)
were after appropriate reversal all highly inter-correlated (Cronbach’s α = 0.82). Henceforth they were
summed to provide a single variable referred to as current hunger.

We had two measures of FI, the AFI and USDA scores. These were correlated (r = 0.57, with USDA
score log transformed), but had very different distributions. For AFI score, only 5 participants scored
zero, and the central tendency was in the middle of the range. For USDA score, 90 participants (73%)
scored zero. We retained both measures for analysis, as they may carry somewhat different
information: AFI score as a continuous measure of the experience of food irregularity and
unpredictability in daily life; and USDA (which we dichotomised as ‘Secure’ (score of 0) or
‘Insecure’ (score > 0)) as the standard marker of serious economically-driven FI. We therefore repeat
all models first using USDA FI, and then using AFI FI. Retaining two measures of FI increases
multiple testing and hence the false positive rate. We hence interpret significant results involving FI
with caution (see Discussion).

Results

Descriptive statistics
Descriptive statistics for the final study sample are shown in Table 1. The amounts consumed of the different foods were all moderately positively correlated (Cronbach’s $\alpha = 0.73$), as were the evaluations of the foods (Cronbach’s $\alpha = 0.45$). The evaluation of the food was moderately correlated with the amount consumed in all cases (chocolate: $r = 0.37$, $p < 0.001$; crackers: $r = 0.42$, $p < 0.001$; crisps: $r = 0.22$, $p = 0.01$; popcorn: $r = 0.46$, $p < 0.001$). Current hunger weakly or negligibly predicted consumption of the foods (chocolate: $r = 0.12$, $p = 0.18$; crackers: $r = 0.27$, $p = 0.002$; crisps: $r = 0.20$, $p = 0.03$; popcorn: $r = 0.16$, $p = 0.08$). Inclusion of current hunger as an additional predictor variable does not affect any of the results presented below.

**Calorie consumption**

Table 1 shows MANOVA results. For calorie consumption, using USDA as the FI measure, there was a significant interaction between SSES condition and FI in predicting consumption. To investigate the interaction, we split the data into food-secure and food-insecure participants, and performed separate MANOVAs with condition as the predictor. Amongst food-secure participants, there was a significant effect of condition ($F_{4, 85} = 3.84$, $p = 0.006$), with those in the low SSES condition consuming more than those in the control condition (Figure 1). Amongst food-insecure participants, there was also a significant effect of condition ($F_{4, 28} = 2.85$, $p = 0.04$), but the difference was in the opposite direction (Figure 1). Splitting into separate MANOVAs by condition instead of FI, in the control condition, there was a significant main effect of FI ($F_{4, 55} = 2.80$, $p = 0.03$), with food-insecure participants consuming more; whereas in the low SSES condition, the difference between food-secure and food-insecure participants was near-significantly in the opposite direction ($F_{4, 58} = 2.40$, $p = 0.06$).

The interaction between SSES condition and FI was not restricted to any one of the foods. In separate analyses of each outcome variable, the interaction term was significant or near-significant in all four cases (Chocolate: $B = 0.93$, 95% CI -0.01 – 1.87, $t = 1.95$, $p = 0.05$; Crackers: $B = 1.22$, 95% CI 0.35 - 2.09, $t = 2.78$, $p = 0.006$; Crisps: $B = 1.43$, 95% CI 0.57 – 2.28, $t = 3.31$, $p = 0.001$; Popcorn: $B = 1.25$, 95% CI 0.29 – 2.21, $t = 2.58$, $p = 0.01$). Using continuous AFI score instead of USDA as the FI measure, the significant interaction of FI and SSES condition was not found (Table 1). The main effect of condition was however significant.

**Evaluation of foods**

For evaluation of foods, results were similar whether USDA or AFI was used as the FI measure: there were significant main effects of both condition and FI on the set of ratings, and no interaction (Table 2). The pattern across the individual foods was complex (Figure 2). The overall condition effect was driven by low SSES producing individually non-significant increases in the ratings of chocolate ($B = 0.44$, 95% CI -0.18 – 1.06, $t = 1.41$, $p = 0.16$), crackers ($B = 0.26$, 95% CI -0.28 – 0.80, $t = 0.94$, $p = 0.38$), and crisps ($B = 0.33$, 95% CI -0.11 – 0.77, $t = 1.48$, $p = 0.14$), but a significant decrease in the rating of popcorn ($B = -0.78$, 95% CI -1.32 – 0.24, $t = -2.83$, $p = 0.005$). The FI effect (results shown for USDA) was driven by food-insecure participants giving significantly higher ratings to crisps ($B = 0.62$, 95% CI 0.11 – 1.11, $t = 2.44$, $p = 0.01$), non-significantly higher ratings to crackers ($B = 0.19$, 95% CI -0.42 – 0.81, $t = 0.63$, $p = 0.53$) and popcorn ($B = 0.42$, 95% CI -0.19 – 1.03, $t = 1.37$, $p = 0.17$), but non-significantly lower ratings to chocolate ($B = -0.34$, 95% CI -1.03 – 0.35, $t = -0.97$, $p = 0.33$).

**Discussion**
We measured opportunistic snack food consumption, and the evaluation of snack foods, in a sample of participants where baseline FI was known, and SSES was experimentally manipulated using a recently published method. Our first goal was to replicate the finding that experimental SSES manipulation affects consumption. We confirmed that it did. For the food-secure participants (who constituted the majority of the sample), the effect was as described in previous studies (Bratanova et al., 2016; Cardel et al., 2015; Cheon and Hong, 2016; Sim et al., 2018a): consumption was higher across the range of foods in the low status than the control condition. Our second goal was to replicate the finding that food-insecure participants consume more when given an opportunity to do so freely (Nettle et al., 2019; Stinson et al., 2018). Here, the replication was partial. In the control condition, food-insecure participants did indeed consume significantly more than food-secure participants. However, our prediction was that this would be true for the female but not male participants, and we found no interaction by sex. This could be a power issue given the unbalanced sex composition of the sample. Moreover, the effects involving FI were only significant using the USDA measure, not AFI. In our previous comparable study (Nettle et al., 2019), the significant FI effects were found using AFI rather than USDA (though see Stinson et al., 2018 for significant FI effects using the USDA measure). However, even correcting for two rounds of multiple testing given our two FI measures, the effects involving FI would be deemed significant by conventional criteria.

Our most striking finding, however, was that FI and experimentally-induced low SSES interacted strongly. It was not just that evoking SSES produced a smaller increase in consumption amongst food-insecure participants, as might be expected through a ceiling effect given that consumption by food-insecure participants was already high in the control condition. Rather, in food-insecure participants, consumption across the range of foods was significantly reduced in the low SSES condition compared to control. We did not predict the reversal a priori; there is the multiple-FI-measure issue mentioned above; and the number of USDA food-insecure participants was small (33). We therefore consider the finding exploratory and as requiring further investigation. As well as determining whether the interaction is robust, such investigation would need to explore why it occurs.

It is possible that food-insecure participants are self-conscious about eating and weight, so that when faced with a negative status manipulation, respond by over-riding an automatic tendency to increase eating, producing a deliberate over-compensation in the opposite direction. However, this remains a speculation on our part, since we had no measure of eating restraint or self-consciousness about eating and weight. We did measure negative and positive affect, but the only relationships of these measures to other study variables was that baseline food-insecure participants had higher levels of negative affect (full analyses not shown).

FI and low SSES were associated with differences in the evaluation of foods. This lends partial support to the hypothesis that the psychological mechanisms underlying FI and SSES effects on consumption involve changes in the hedonic value of food. However, the effects were small and hard to interpret. Although the average rating across all four foods was higher in the low SSES condition than the control condition, and higher amongst food-insecure than food-secure participants, there was heterogeneity across the foods, with one food showing the reversed pattern in each case. Moreover, the effects on evaluations were additive, rather than the interaction seen for consumption. Thus, the precise changes in hedonic properties of food that are associated with low SSES and FI, as well as their roles in mediating changes in consumption, require further investigation.

**Author contributions**
All four authors conceived and designed the study collaboratively. SG and MR conducted the experimental sessions and collated the data. SG, MR and DN performed the data analysis. SG and MR wrote first drafts of the paper. DN and MB revised the paper for content.

Conflicts of interests

The authors declare that they have no conflicts of interests.

References

Anselme, P., and Güntürkün, O. (2018). How foraging works: uncertainty magnifies food-seeking motivation. *Behav. Brain Sci.*, 1–106. doi:DOI: 10.1017/S0140525X18000948.

Bickel, G., Nord, M., Price, C., Hamilton, W., and Cook, J. (2000). Measuring food security in the United States: Guide to measuring household food security. *Washington. USDA*.

Bratanova, B., Loughnan, S., Klein, O., Claassen, A., and Wood, R. (2016). Poverty, inequality, and increased consumption of high calorie food: Experimental evidence for a causal link. *Appetite* 100, 162–171. doi:10.1016/j.appet.2016.01.028.

Cardel, M. I., Johnson, S. L., Beck, J., Dhurandhar, E., Keita, A. D., Tomczik, A. C., et al. (2015). The effects of experimentally manipulated social status on acute eating behavior: A randomized, crossover pilot study. *Physiol. Behav.* 162, 93–101. doi:10.1016/j.physbeh.2016.04.024.

Cheon, B. K., and Hong, Y.-Y. (2016). Mere experience of low subjective socioeconomic status stimulates appetite and food intake. *Proc. Natl. Acad. Sci.*, 201607330. doi:10.1073/pnas.1607330114.

Goodman, E., Adler, N. E., Daniels, S. R., Morrison, J. A., Slap, G. B., and Dolan, L. M. (2003). Impact of objective and subjective social status on obesity in a biracial cohort of adolescents. *Obes. Res.* 11, 1018–1026. doi:10.1038/oby.2003.140.

Goodman, E., Adler, N. E., Kawachi, I., Frazier, a L., Huang, B., Colditz, G. a, et al. (2001). Adolescents’ perceptions of social status: Development and evolution of a new indicator. *Pediatrics* 108, 1–8. doi:10.1542/peds.108.2.e31.

McLaren, L. (2007). Socioeconomic status and obesity. *Epidemiol. Rev.* 29, 29–48. doi:10.1093/epirev/mxm001.

Nettle, D., Andrews, C., and Bateson, M. (2017). Food insecurity as a driver of obesity in humans: The insurance hypothesis. *Behav. Brain Sci.* 40, e105. doi:10.1017/S0140525X16000947.

Nettle, D., Joly, M., Broadbent, E., Smith, C., Tittle, E., and Bateson, M. (2019). Opportunistic food consumption in relation to childhood and adult food insecurity: An exploratory correlational study. *Appetite* 132, 222–229. doi:10.1016/j.appet.2018.07.018.

Newton, S., Braithwaite, D., and Akinyemiju, T. F. (2017). Socio-economic status over the life course and obesity: Systematic review and meta-analysis. *PLoS One* 12, 1–15. doi:10.1371/journal.pone.0177151.

R Core Development Team (2018). R: A Language and Environment for Statistical Computing.

Sim, A. Y., Lim, E. X., Forde, C. G., and Cheon, B. K. (2018a). Personal relative deprivation
increases self-selected portion sizes and food intake. *Appetite* 121, 268–274. doi:10.1016/j.appet.2017.11.100.

Sim, A. Y., Lim, E. X., Leow, M. K., and Cheon, B. K. (2018b). Low subjective socioeconomic status stimulates orexigenic hormone ghrelin – A randomised trial. *Psychoneuroendocrinology* 89, 103–112. doi:10.1016/j.psyneuen.2018.01.006.

Sobal, J., and Stunkard, A. J. (1989). Socioeconomic status and obesity: a review of the literature. *Psychol. Bull.* 105, 260–275. doi:10.1037/0033-2909.105.2.260.

Stinson, E. J., Votruba, S. B., Venti, C., Perez, M., Krakoff, J., and Gluck, M. E. (2018). Food Insecurity is Associated with Maladaptive Eating Behaviors and Objectively Measured Overeating. *Obesity* 26, 1841–1848. doi:10.1002/oby.22305.

Townsend, M. S., Peerson, J., Love, B., Achterberg, C., and Murphy, S. P. (2001). Food insecurity is positively related to overweight in women. *J. Nutr.* 131, 1738–1745.

Wang, X. T., and Dvorak, R. D. (2010). Sweet future: Fluctuating blood glucose levels affect future discounting. *Psychol. Sci.* 21, 183–188. doi:10.1177/0956797609358096.

Watson, D., Clark, L. A., and Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS Scales. *J. Pers. Soc. Psychol.* 47, 1063–70.
Table 1. Descriptive statistics for the main study variables.

| Variable                      | Mean   | Standard deviation |
|-------------------------------|--------|--------------------|
| Age                           | 30.66  | 16.66              |
| FI (USDA)                     | Secure 90    | Insecure 33       |
| FI (AFI score)                | 6.05   | 4.11               |
| Current hunger                | 10.71  | 4.01               |
| Chocolate consumption (kcals) | 88.34  | 84.93              |
| Cracker consumption (kcals)   | 51.92  | 56.06              |
| Crisp consumption (kcals)     | 46.26  | 51                 |
| Popcorn consumption (kcals)   | 24.78  | 33.05              |
| Evaluation of chocolate       | 5.21   | 1.72               |
| Evaluation of crackers        | 5.07   | 1.47               |
| Evaluation of crisps          | 5.11   | 1.27               |
| Evaluation of popcorn         | 4.96   | 1.56               |
### Table 2. MANOVA results.

#### Calorie consumption

| Predictor         | Using USDA FI status |           | p-value | F   | df   | p-value |
|-------------------|----------------------|-----------|---------|-----|------|---------|
| Condition         | 3.74                 | 4, 112    | 0.007*  | 3.67| 4, 112| 0.008*  |
| FI                | 1.15                 | 4, 112    | 0.33    | 0.96| 4, 112| 0.43    |
| Sex               | 0.32                 | 4, 112    | 0.87    | 0.28| 4, 112| 0.89    |
| Condition * FI    | 3.46                 | 4, 112    | 0.01*   | 0.54| 4, 112| 0.71    |
| Condition * Sex   | 2.10                 | 4, 112    | 0.09    | 1.88| 4, 112| 0.12    |
| Sex * FI          | 0.99                 | 4, 112    | 0.42    | 1.01| 4, 112| 0.41    |
| Condition * Sex * FI | 2.01  | 4, 112    | 0.10    | 0.86| 4, 112| 0.49    |

#### Evaluation of foods

| Predictor         | Using USDA FI status |           | p-value | F   | df   | p-value |
|-------------------|----------------------|-----------|---------|-----|------|---------|
| Condition         | 2.62                 | 4, 105    | 0.04*   | 2.61| 4, 105| 0.04*   |
| FI                | 2.56                 | 4, 105    | 0.04*   | 2.49| 4, 105| 0.048*  |
| Sex               | 0.54                 | 4, 105    | 0.71    | 0.52| 4, 105| 0.72    |
| Condition * FI    | 1.25                 | 4, 105    | 0.29    | 0.50| 4, 105| 0.73    |
| Condition * Sex   | 0.97                 | 4, 105    | 0.43    | 1.04| 4, 105| 0.39    |
| Sex * FI          | 1.26                 | 4, 105    | 0.29    | 1.81| 4, 105| 0.13    |
| Condition * Sex * FI | 2.09 | 4, 105    | 0.09    | 1.34| 4, 105| 0.26    |
Figure 1. Calorie consumption by food insecurity status (USDA) and experimental SSES condition. Bars are broken into consumption of the four constituent foods. Error bars represent one ± 1 standard error of total consumption.
Figure 2. Mean evaluations of the foods: (A) by SSES condition; (B) by USDA food insecurity status. Error bars represent ± 1 standard error.