Mere experience of low subjective socioeconomic status stimulates appetite and food intake

Bobby K. Cheon[a,b,1] **and Ying-Yi Hong**[c]

[a]Division of Psychology, Nanyang Technological University, Singapore 637332, Singapore; [b]Clinical Nutrition Research Centre, Singapore Institute for Clinical Sciences, Agency for Science, Technology and Research (A*STAR), Singapore 117609, Singapore; and [c]Department of Marketing, Chinese University of Hong Kong, Sha Tin, Hong Kong

Edited by Richard E. Nisbett, University of Michigan, Ann Arbor, MI, and approved November 14, 2016 (received for review May 9, 2016)

Among social animals, subordinate status or low social rank is associated with increased caloric intake and weight gain. This may reflect an adaptive behavioral pattern that promotes acquisition of caloric resources to compensate for low social resources that may otherwise serve as a buffer against environmental demands. Similarly, diet-related health risks like obesity and diabetes are disproportionately more prevalent among people of low socioeconomic resources. Whereas this relationship may be associated with reduced financial and material resources to support healthier lifestyles, it remains unclear whether the subjective experience of low socioeconomic status may alone be sufficient to stimulate consumption of greater calories. Here we show that the mere feeling of lower socioeconomic status relative to others stimulates appetite and food intake. Across four studies, we found that participants who were experimentally induced to feel low (vs. high or neutral) socioeconomic status subsequently exhibited greater automatic preferences for high-calorie foods (e.g., pizza, hamburgers), as well as intake of greater calories from snack and meal contexts. Moreover, these results were observed even in the absence of differences in access to financial resources. Our results demonstrate that among humans, the experience of low social class may contribute to preferences and behaviors that risk excess energy intake. These findings suggest that psychological and physiological systems regulating appetite may also be sensitive to subjective feelings of deprivation for critical nonfood resources (e.g., social standing). Importantly, efforts to mitigate the socioeconomic gradient in obesity may also need to address the psychological experience of low social status.

subjective socioeconomic status | social class | appetite | eating behavior | food preferences

Obesity and diabetes have been climbing to pandemic levels across societies around the world, inciting calls for urgent action (1, 2).Within industrialized societies, the burden of these widespread risks to health and well-being are disproportionately shouldered by people of lower socioeconomic status (SES) (3–7). Such socioeconomic gradients in metabolic health risks may generally be attributed to inexpensive, processed, and calorie-dense diets of lower SES groups (5, 8). However, interventions designed to alleviate financial burden and access to healthier food items have surprisingly been associated with increased body mass and caloric intake (9, 10), suggesting the role of other critical mechanisms besides actual economic deprivation.

One factor that has received limited attention in the study of SES gradients in diet-related health is subjective socioeconomic status. Unlike objective indicators of socioeconomic status, such as actual income, education, or occupational status, subjective socioeconomic status reflects one's perception of his or her social standing or rank relative to others. This subjective social standing or class is largely based on perceived relative possession of material and social resources (wealth, education, occupational prestige) compared with others, given the role of such resources in signifying and reifying status. Cross-sectional investigations and metaanalysis on the relationship between subjective socioeconomic status and health outcomes have suggested that individuals who report lower levels of subjective socioeconomic status and rank are more likely to be at risk for weight gain, adiposity, diabetes, and overweight/obesity even when controlling for objective indicators of socioeconomic status (11–14). One pilot feasibility study using a small sample has implied that people placed into disadvantaged social roles subsequently consume more calories, but under circumstances where those in disadvantaged roles are exposed to greater stress and potential aggression from those in dominant roles (15). However, no studies to date have experimentally tested whether the mere psychological experience of low subjective socioeconomic status actually stimulates appetite and caloric intake independent of other risk factors associated with low SES (e.g., low economic/material resources, heightened stress). Experimental confirmation of a causal link between subjective feelings of SES and appetite is important given its theoretical significance in implying a functional overlap between the regulation of hunger and status-relevant resources, as well as critical health policy implications of elucidating the psychological nature of socioeconomic gradients in overweight/obesity.

We propose that low subjective socioeconomic status may be sufficient to stimulate appetite and consumption of greater calories by potentially increasing salience of perceived deprivation independent of actual economic and resource deprivation. Heightened appetite and caloric intake in the face of low socioeconomic status and associated feelings of relative deprivation may have served critically adaptive functions. Both material and social resources, which contribute to and underlie the experience of subjective social status, act as buffers or insurance against pressures and insecurities of the environment (16, 17). When deprived of such buffers and left naked in the face of environmental demands, an adaptive response may be to seize and exploit other key resources for survival that may be available, such as food. Given that access to sufficient nutrients and energy intake is among the most conserved survival pressures across species,

Significance

Lower socioeconomic status (SES) has been linked to increased risk of obesity. This relationship is generally assumed to be a product of low financial resources or greater stress associated with low SES that promotes unhealthy diets and lifestyles. We demonstrate here that the mere subjective experience of being lower in SES relative to others is alone sufficient to causally elicit behaviors that may risk obesity (e.g., preference, selection, and intake of greater calories), independent of actual economic deprivation or stress from being subordinated. Among social species, the physiological/psychological systems regulating hunger may have been adapted to be sensitive to perceived deprivation of critical social, material, and symbolic resources that underlie social class in addition to caloric deprivation.

Author contributions: B.K.C. and Y.-Y.H. designed research; B.K.C. performed research; B.K.C. analyzed data; and B.K.C. and Y.-Y.H. wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

[1]To whom correspondence should be addressed. Email: bkcheon@ntu.edu.sg.

increasing the intake of nutrients and promoting the storage of energy (e.g., adiposity) may serve as an important long-term behavioral adaptation to compensate for perceived deprivations in essential nonfood (material and social) resources. However, whereas this proposed tendency for increased food intake may have been adaptive in ancestral contexts where energy-dense foods were scarce, the same process may increase health-related risks and morbidity (e.g., obesity, diabetes, cardiovascular disease) in our modern obesogenic environment in which palatable high-fat/energy foods are readily available.

Consistent with this notion, research using animal models have indicated that low social resources or subordinate status may predispose increased caloric intake and adiposity across diverse species (18, 19). Among species as diverse as great tit birds, rats, hamsters, and monkeys, subordinate social status has been identified as a predictor of hyperphagic meal patterns, increased adiposity, and total caloric intake, especially in presence of high fat and sugar diets (18, 20–23). Importantly, fat reserves are an especially sensitive predictor of survival rates for low ranking animals when environmental conditions are harsh (22). Even acute and intermittent experiences of subordination and lowered status have been identified to increase energy intake and adiposity over time (21), suggesting that the experience of subordinate status itself may alter appetite independent of other stressors associated with low status (e.g., obstruction of food, harassment and aggression from dominants). Paralleling findings from animal models, research on humans has also suggested that inequality and reminders of potential deprivation of material, social, and symbolic resources may contribute to increased valuation and intake of calories (24–27). These outcomes may typically be attributed to disinhibitory effects of ego and self-concept threats or stress. However, similar patterns observed among animals suggest that the mechanisms linking experience of low status to increased caloric intake may be conserved across social species and that higher-order self-relevant or ego-defensive processes may not be necessary.

The current investigation is among the first to directly examine the causal role of the experience of low subjective socioeconomic status (SSES) on diverse manifestations of appetite by experimentally manipulating SSES. Importantly, we test the causal role of SSES in a manner that is not confounded with other risks associated with actual low SES or subordinate status (e.g., stress, salient ego threats, reminders of actual resource deprivation, aggression from dominant others). Results supporting this mechanism would have important theoretical and practical impacts. In regards to theory, such findings along with prior animal studies would suggest that perceived deprivation or scarcity of critical nonfood resources (e.g., wealth, respect) may functionally overlap with subjective deprivation of caloric resources (e.g., hunger). Practically, the present studies would demonstrate that the mere mindset or subjective feeling of lower socioeconomic status and standing compared with others may uniquely contribute to socioeconomic gradients in obesity and metabolic disease independent of actual economic deprivation or stress associated with low economic means. As such, our findings may shed light on potential interventions to curb the obesity pandemic.

Results

Study 1. As an initial test of these hypotheses, 101 participants (65 females; age $M = 20.35$, $SD = 1.17$) were recruited in Singapore to identify whether low SSES may contribute to intentions to consume meals of higher caloric density. Participants were randomly assigned to complete a low or high SSES manipulation (28, 29), in which they were shown an image of a ladder consisting of 10 rungs and asked to either make a direct comparison between themselves and people who are relatively better off (low SSES condition) or worse off (high SSES condition). Participants were provided the following instructions:

> Think of this ladder as representing where people stand in Singapore. Now, please compare yourself to the people at the very bottom (top) of the ladder. These are the people who are the worst (best) off—those who have the least (most) money, least (most) education, and least (most) respected jobs. In particular, we'd like you to think about how YOU ARE DIFFERENT FROM THESE PEOPLE in terms of your own income, educational history, and job status. Where would you place yourself on this ladder relative to these people at the very bottom (top)? Please select the number that corresponds to the rung where you think you stand in relation to these people.

After selecting a rung, participants were then instructed to write a description of what it would be like to have an interaction with the person they had just compared themselves with:

> Now imagine yourself in a getting acquainted interaction with one of the people you just thought about from the very bottom (top) of the ladder. Think about how the DIFFERENCES BETWEEN YOU might impact what you would talk about, how the interaction is likely to go, and what you and the other person might say to each other. Please write a brief description about how you think this interaction would go.

This manipulation of SSES was selected given its relatively minimal and implied nature, and because it does not involve an actual experience of subordination or status loss (thus having low risk of producing profound ego threats or stress).

Following the SSES manipulation, participants selected what they would eat for their next meal from a hypothetical buffet. Total selected calories from the hypothetical buffet meals were estimated based on calorie density (kilocalorie per gram or unit) of the quantity of selected foods. Multiple regression with simple slopes analysis (30) was used to test for an interaction between subjective social status and cognitively restrained eating style (proxy for dieting status) (31), while controlling for participant gender, given systematic differences in quantity of food typically selected and consumed by men and women. A marginal interaction was observed, $F(4, 96) = 4.48$, $R^2 = 0.16$, $P = 0.002$, $b = 711.28$, $P = 0.08$, such that lower levels of cognitive restraint toward food was predictive of a trend toward selection of greater calories exclusively among those experiencing low SSES, $b = -927.62$, $P = 0.002$, but not those experiencing high SSES, $b = -216.34$, $P > 0.10$ (Fig. 1). This finding suggests that low SSES may increase motivation and intention to consume meals consisting of greater quantities of food or larger calorie densities, especially among individuals who are relatively unrestrained eaters (e.g., nondieters). To the extent that participants who report high levels of cognitive restraint toward food

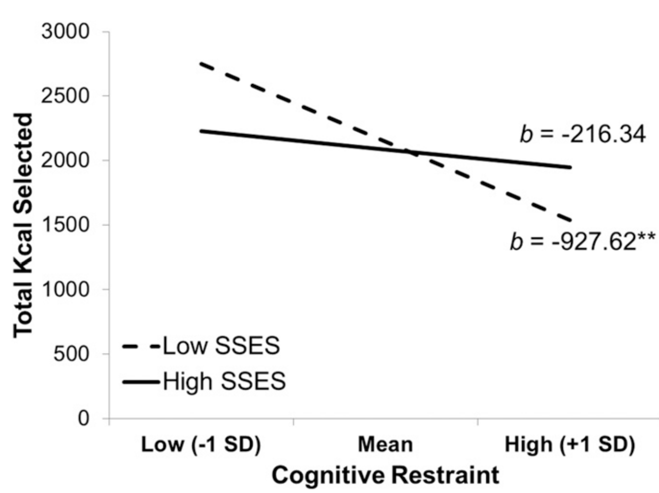

Fig. 1. Interaction of subjective socioeconomic status and cognitive restraint on food and portion selection from a hypothetical buffet in study 1. Lower level of cognitively restrained eating style is predictive of greater amounts of calories selected for consumption from a hypothetical buffet, but only among participants experiencing low subjective socioeconomic status. $^{**}P < 0.005$.

PSYCHOLOGICAL AND COGNITIVE SCIENCES

are also likely to be dieting or otherwise systematically restricting their food intake, perceived SSES may impact on nondieters only. Based on these findings, only nondieters (i.e., those who reported no restriction of food intake) were included in our subsequent studies.

Study 2. To identify whether feelings of low SSES (relative to high SSES) heightens appetitive automatic associations for calorie-dense foods, 167 nondieting participants (102 females; age $M = 35.56$, $SD = 12.13$) were recruited for study 2. Following the same manipulation of SSES used in study 1, participants completed an implicit association task (IAT) (32) in which they categorized images of high-calorie foods (e.g., pizza, hamburger, fried chicken) and low calorie foods (e.g., fruits and vegetables) into categories using words with pleasant (e.g., tasty, delicious, wonderful) and unpleasant (e.g., disgusting, nasty, awful) connotations that were descriptive of food. A 2 (SSES: low or high) × 2 (gender) ANOVA demonstrated only a marginally significant main effect of SSES, $F(1, 163) = 3.22$, $P = 0.07$, $\eta_p^2 = 0.02$, but no significant main effects of gender or interaction between gender and SSES condition. Participants in the low subjective status condition ($M = 0.51$, $SD = 0.75$) exhibited a trend for stronger implicit preferences for calorie-dense foods over fruits/vegetables compared with those in the high SSES condition ($M = 0.27$, $SD = 0.70$), suggesting that feelings of low SSES may alter the motivational relevance or perceived appetitiveness of calorie-dense foods at an automatic level.

Study 3. Study 3 examined whether the experience of low SSES stimulates actual food intake from snacks during a fixed time interval. Eighty-three nondieting participants (41 female, age $M = 20.29$, $SD = 1.38$) completed the SSES manipulation from studies 1 and 2, then viewed a short documentary video while freely eating three snacks (potato chips, M&M candies, and California raisins) from separate bowls. A 2 (SSES: low or high) × 2 (gender) ANOVA revealed only a significant main effect of SSES on caloric intake, $F(1, 79) = 4.92$, $P = 0.03$, $\eta_p^2 = 0.06$, but no significant main effects of gender or interaction between gender and SSES condition. Participants in the low SSES condition ($n = 47$) consumed significantly greater calories ($M = 88.24$, $SD = 75.32$) compared with those in the high SSES condition ($n = 36$) ($M = 53.62$, $SD = 63.66$). Consistent with the results of study 2, which demonstrated increased automatic preferences for high calorie foods (over fruits and vegetables) as a result of low SSES, increased caloric intake following low SSES in study 3 was attributed to greater intake of potato chips, $F(1, 79) = 3.17$, $p = 0.08$, $\eta_p^2 = 0.04$, and M&Ms, $F(1, 79) = 3.42$, $p = 0.07$, $\eta_p^2 = 0.04$, but not raisins, $F(1, 79) = 1.11$ $p = 0.30$, $\eta_p^2 = 0.01$, which were the least calorie dense of the three snack foods. Furthermore, when total calories consumed from the potato chips and M&Ms were summed, participants in the low SSES condition ($M = 76.91$, $SD = 69.33$) consumed significantly greater calories from these relatively higher calorie snacks than participants in the high SSES condition ($M = 46.22$, $SD = 58.48$), $F(1, 79) = 4.62$, $p = 0.04$. There were no significant interactions between SSES condition and gender on calories consumed specifically from each snack food.

Study 4. To examine whether low SSES also stimulates food intake when larger portions are provided in a meal context, study 4 presented participants with an ad libitum meal. Study 4 also introduced a neutral control condition to determine whether low SSES stimulates appetite or high SSES suppresses appetite. One hundred forty-eight nondieting participants completed the SSES manipulation used in studies 1–3, with the inclusion of a third control condition without manipulation of SSES. The control condition involved rating one's place on the 10-rung ladder representing one's society, but participants were simply asked to indicate their place on the ladder without comparing their social standing with anyone else (people on the top or bottom). Then, participants in the control condition were asked to write a description of what it would be like to have a getting acquainted interaction with a fellow student at their university that they were meeting for the first time. Participants were then provided 300 grams of chasoba noodles (a green tea flavored Japanese noodle, which is typically served without soup base) and 240 grams of water to be consumed ad libitum.

A 2 (SSES: low or high) × 2 (gender) ANOVA revealed a significant main effect of gender, $F(1, 142) = 4.47$, $P = 0.04$, $\eta_p^2 = 0.03$, on food intake, such that males ($M_{grams} = 204.82$, $SD_{grams} = 113.57$; $M_{kcal} = 282.65$, $SD_{kcal} = 156.73$) consumed more food than females ($M_{grams} = 167.80$, $SD_{grams} = 92.89$; $M_{kcal} = 231.56$, $SD_{kcal} = 128.19$). Importantly, a significant main effect of SSES was also observed, $F(2, 142) = 3.26$, $P = 0.04$, $\eta_p^2 = 0.04$, on total amount of noodles consumed (in grams and kilocalories) (Fig. 2). Those in the low SSES condition ($n = 56$, $M_{grams} = 201.30$, $SD_{grams} = 96.59$; $M_{kcal} = 277.79$, $SD_{kcal} = 133.29$) consumed significantly more noodles than did those in the high SSES condition ($n = 50$, $M_{grams} = 169.18$, $SD_{grams} = 96.77$; $M_{kcal} = 233.45$, $SD_{kcal} = 133.54$), $t(104) = 2.53$, $P = 0.01$, $d = 0.33$, and control condition ($n = 42$, $M_{grams} = 166.45$, $SD_{grams} = 111.31$; $M_{kcal} = 229.70$, $SD_{kcal} = 184.29$), $t(96) = 2.16$, $P = 0.03$, $d = 0.33$. There was no significant difference between the amount of noodles consumed in the high SSES and control conditions $t(90) = 0.28$, $P = 0.78$, $d = 0.03$, confirming that the experience of low SSES stimulates appetite and food intake. There was no significant interaction between gender and SSES.

Discussion

Across four studies, we find consistent and converging support for our hypothesis that the mere experience of low subjective socioeconomic status stimulates appetite. Although negative affect or threats to one's self-concept may elicit coping through eating, we observed no consistent effects of our subjective status manipulation on negative affect or self-concept (*Materials and Methods*), suggesting that subjective socioeconomic status influences appetite independent of these mechanisms. Furthermore, we used a relatively minimal manipulation of subjective socioeconomic status and social standing based on perceived relative access to critical material and social resources without systematic introduction of negative affect typically associated with stress or actual loss of status. As such, our findings also contribute the perspective that increased appetite and caloric intake associated with lower socioeconomic status may not be driven by stress per se; even without displaying more stress-related responses, participants in the low SSES condition still consumed more calories than did those in the high SSES condition.

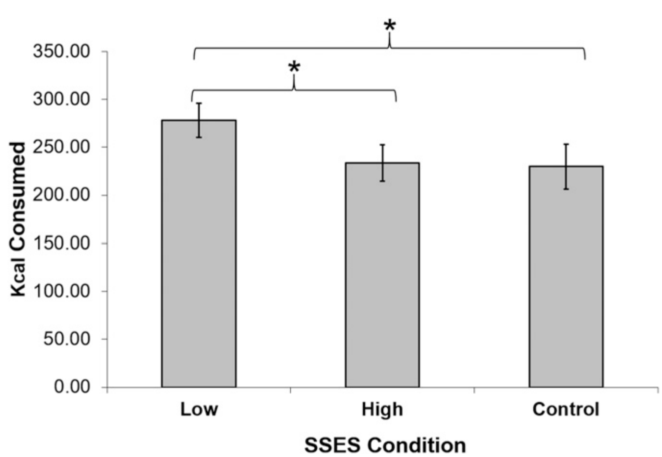

Fig. 2. Ad libitum consumption of a meal in study 4. Participants in the low subjective socioeconomic status condition consumed significantly greater quantities of noodles for a meal than participants in both the high subjective socioeconomic status and control conditions. *$P < 0.05$.

Given that diverse species also increase food intake and adiposity following social subordination (18, 21, 22), the mechanisms underlying the relationship between subjective socioeconomic status and appetite may be conserved across humans and other species. One explanation is that the existing motivational and physiological architecture of appetite regulation may have served as a preadaptation that was coopted or extended in function to regulate maintenance of other resources critical for survival and reproduction (e.g., mates, social standing, economic/symbolic resources), which contribute to the subjective experience of status. Consequently, perceived deprivation of these critical, yet nonfood resources may directly coactivate an overlapping motivation for caloric intake independent of stress or negative affect. Other existing physiological and neurological systems associated with food selection and intake have also been proposed to have served as preadaptations for higher-order social functions. For instance, the food-rejection system may have served as a basis for human disgust and morality (33, 34). Future studies that investigate whether subjective social status may also modulate physiological systems regulating appetite would provide direct support for this framework. Another promising avenue of future investigation would be identifying specific adaptive advantages conferred by this proposed relationship between perceived deprivation in status-related resources and motivation for caloric resources (e.g., accrual of somatic capital, preparation for future status competition).

The present findings also suggest the unique contribution of the subjective experience of low status to socioeconomic gradients in diet-related health risks, such as obesity and diabetes. Whereas our findings demonstrate consistent effects of acute and incidental experiences of subjective socioeconomic status on food preference, appetite, and caloric intake, chronic and prolonged feelings of low social rank associated with actual poverty may promote development of eating habits that risk obesity and diabetes independent of other material barriers to healthier diets (e.g., affordability of fresh and healthy foods). Whereas access to financial resources to pursue healthier diets and lifestyles are important contributors to socioeconomic disparities in health, these findings suggest that mindsets of deprivation and low social standing may be critically linked to obesity risk via increased intake of calories. Accordingly, interventions focused on reducing such material and financial barriers may alone be insufficient to alleviate socioeconomic gradients in obesity and diabetes without addressing the subjective experience of low socioeconomic status (9, 10).

Materials and Methods

All studies were approved by the institutional review board of Nanyang Technological University.

Study 1.

Participants. Participants included 101 (65 females; age $M = 20.35$, SD = 1.17) participants recruited from a university in Singapore.

Procedure. Participants completed the experiment alone on computers in a small soundproof room of a laboratory. After providing informed consent, participants rated their current state of hunger on a six-point Likert scale. There was no significant difference in hunger between participants in the low SSES ($M = 2.86$, SD = 1.40) and high SSES ($M = 2.82$, SD = 1.44) conditions, $t(99) = 0.15$, $P = 0.88$. This was followed by the three factor eating questionnaire (TFEQ) (31) to assess participants' level of cognitive restraint toward food intake. Participants in the low SSES condition ($M = 2.29$, SD = 0.64) and high SSES condition ($M = 2.23$, SD = 0.67) did not differ on their levels of cognitive restraint, $t(99) = 0.49$, $P = 0.62$. Participants from the two conditions also did not differ in uncontrolled eating [low SSES: $M = 2.35$, SD = 0.42; high SSES: $M = 2.35$, SD = 0.49; $t(99) = 0.08$, $P = 0.94$] or emotional eating [low SSES: $M = 2.18$, SD = 0.82; high SSES: $M = 2.13$, $SD = 0.58$, $t(99) = 0.30$, $P = 0.76$].

Next, participants completed the experimental manipulation of SSES, followed by the positive and negative affect schedule (PANAS) (35). Participants in the two conditions did not significantly differ on reported positive affect [low SSES: $M = 22.59$, SD = 6.97; high SSES: $M = 22.04$, SD = 7.93, $t(99) = 0.37$, $P = 0.71$] or negative affect [low SSES: $M = 16.73$, SD = 6.63; high SSES: $M = 16.28$, SD = 6.82, $t(99) = 0.33$, $P = 0.74$].

Next, following a filler decision-making task unrelated to food, participants completed the hypothetical buffet task. In this task, participants were shown 20 foods that are common to Singapore and provided the following instructions:

> In this section, you will be presented a list of different foods. Suppose that all of these options are available to you for your next meal (like at a buffet). We would like you to design your ideal next meal based on these options. Based on the available choices, please indicate what you would choose to eat for your next meal (select all the items that apply). For each item you select to be part of your next meal, please enter the quantity you would put on your plate(s) (e.g., number of pieces, or weight of the serving you wish to eat for that food item).

For each of the foods, participants could tick a check box to indicate their desire to select the food for their hypothetical meal and specify the amount of the food they would serve themselves (in grams or units). Each food that did not involve discrete units (e.g., stir-fried mixed vegetables) was accompanied by a description of a typical portion serving size in grams derived from Nutrition.com.sg, a nutrition education website for Singaporeans sponsored by a Singapore-based nutrition consulting company. Estimates of calorie density (calories per gram) for each of the foods were derived from Nutrition.com.sg and multiplied with grams of each food selected to produce an index of total intended calories for consumption selected by each participant. Following this, participants completed a series of filler tasks before completing general demographics.

A 2 (SSES: low or high) × 2 (gender) ANOVA revealed no significant main effect of SSES condition, $F(1, 97) = 0.001$, $p = 0.97$, or interaction between SSES and gender, $F(1, 97) = 0.05$, $p = 0.82$, on total calorie selected from the hypothetical buffet. Only a significant main effect of gender was observed, $F(1, 97) = 6.08$, $p = 0.02$, $\eta_p^2 = 0.06$, such that males ($M = 2553.30$, SD = 1439.85) selected a greater amount of calories than females ($M = 1855.21$, SD = 1274.46).

Pertaining to our main hypothesis, there was a significant interaction effect of SSES manipulation and cognitive restraint toward food, such that among participants with lower levels of cognitive restraint toward food, those experiencing low SSES selected greater calories than did those experiencing high SSES (see results in study 1). This effect was reversed for participants with higher levels of cognitive restraint toward food. Based on this finding, we recruited only nondieters, who presumably have lower levels of cognitive restraint toward food in subsequent studies.

Study 2.

Participants. Participants included 167 (102 females; age $M = 35.56$, SD = 12.13) nondieters recruited from Amazon Mechanical Turk—an online platform in which workers (i.e., participants) can be recruited to complete various tasks, such as online surveys. All participants were recruited from the United States of America.

Procedure. After providing informed consent, participants rated their current state of hunger on a six-point Likert scale. Participants in the low SSES condition ($M = 2.41$, SD = 1.34) and high SSES condition ($M = 2.39$, SD = 1.40) did not significantly differ in their ratings of hunger at the start of the experiment, $t(165) = 0.12$, $P = 0.90$. Following hunger ratings, participants completed the TFEQ. On the subscales of the TFEQ, participants in the low and high SSES condition did not significantly differ in cognitive restraint [low SSES: $M = 2.15$, SD = 0.65; high SSES: $M = 2.13$, SD = 0.64; $t(165) = 0.20$, $P = 0.84$]. However, there was a significant difference observed between conditions on the uncontrolled eating subscale [low SSES: $M = 2.16$, SD = 0.63; high SSES: $M = 1.93$, SD = 0.61; $t(165) = 2.37$, $P = 0.02$, $d = 0.37$] and emotional eating subscale [low SSES: $M = 2.22$, SD = 0.95; high SSES: $M = 1.85$, SD = 0.84; $t(165) = 2.69$, $P = 0.008$, $d = 0.41$]. Marginally significant main effects of SSES condition were still observed on automatic IAT bias favoring high-calorie foods over low-calorie foods even when scores for uncontrolled eating, $F(1, 162) = 3.63$, $p = 0.06$, $\eta_p^2 = 0.02$, and emotional eating, $F(1, 162) = 2.91$, $p = 0.09$, $\eta_p^2 = 0.02$, were entered as covariates in SSES condition × gender ANCOVAs (see results section).

After the SSES manipulation used in study 1 (which was adapted for American respondents), participants then completed the PANAS. Participants in the low SSES condition ($M = 13.18$, SD = 5.05) reported significantly more negative affect after the manipulation than participants in the high SSES condition ($M = 11.50$, SD = 3.34), $t(165) = 2.52$, $P = 0.01$, $d = 0.39$, yet the two groups did not differ in ratings of positive affect (low SSES: $M = 27.86$, SD = 8.31; high SSES: $M = 27.54$, SD = 9.14), $t(165) = 0.24$, $P = 0.81$. A significant main effect of SSES condition was observed on automatic IAT bias favoring high-calorie foods over low-calorie foods even when negative affect score, $F(1, 162) = 4.33$, $p = 0.04$, $\eta_p^2 = 0.03$, was entered as a covariate in a SSES × gender ANCOVA (see results section).

PSYCHOLOGICAL AND COGNITIVE SCIENCES

Following a filler decision-making task unrelated to food, participants completed an IAT assessing automatic preferences for high-calorie foods relative to low-calorie foods (fruits and vegetables). The IAT was programmed and completed online via the Inquisit software platform. Prior studies comparing IAT data collected through web-based methods versus in laboratory contexts have demonstrated the robustness and reliability of web-based IATs (36). The IAT was scored according to the improved scoring algorithm (37).

After a series of filler tasks, participants' general demographics and self-reported financial socioeconomic status (SES) was measured using a measure of perceived personal insecurity of financial resources with the following three statements: "I have enough money to buy things I want," "I don't need to worry too much about paying my bills," and "I don't think I'll have to worry too much about money in the future." (38). These three items were averaged to create a composite index of financial SES. Participants in the low SSES (M = 3.56, SD = 1.71) and high SSES (M = 3.76, SD = 1.88) conditions did not significantly differ in their financial SES, $t(165) = -0.72$, $P = 0.47$.

Study 3.

Participants. Study 3 involved 83 nondieting participants (41 female, age M = 20.29, SD = 1.38) recruited from a university in Singapore.

Procedure. Participants completed the experiment alone in a small soundproof room of a laboratory. Following informed consent, participants completed the same measure of current hunger used in studies 1 and 2, followed by the TFEQ. There was no difference in hunger ratings between participants in the low (M = 3.11, SD = 1.51) and high (M = 3.47, SD = 1.50) SSES conditions, $t(81) = 1.10$, $P = 0.28$. Likewise, there were no differences between groups on TFEQ subscales of cognitive restraint (low SSES: M = 2.10, SD = 0.49; high SSES: M = 2.02, SD = 0.48; $t(81) = 0.75$, $P = 0.46$), uncontrolled eating (low SSES: M = 2.51, SD = 0.42; high SSES: M = 2.47, SD = 0.39; $t(81) = 0.52$, P = 0.61), and emotional eating (low SSES: M = 2.23, SD = 0.73; high SSES: M = 2.10, SD = 0.64; $t(81) = 1.46$, $P = 0.15$). Also, as in studies 1 and 2, participants completed the PANAS scale, which revealed no differences in positive [low SSES: M = 24.32, SD = 7.81; high SSES: M = 24.42, SD = 7.30; $t(81) = 0.06$, P = 0.95] or negative affect [low SSES: M = 16.98, SD = 6.79; high SSES: M = 16.69, SD = 6.62; $t(81) = 0.19$, $P = 0.85$] across the two conditions.

After a brief filler task unrelated to food, the experimenter informed the participants that they would be watching a video. Participants were instructed to watch the video and pay attention to the content, because they would be asked questions about the video at a later time. At this time, the experimenter (blind to experimental condition) also served the participants three bowls containing 25 grams each of potato chips, M&M candies, and California raisins, and indicated that the participant could help him/herself to the snacks while watching the video. The experimenter then started the video and left the room. The video was 7 minutes and 5 seconds long and consisted of a documentary on telescopes. After the completion of the video, the experimenter returned to the room, removed the bowls of snacks, and instructed participants to continue working on the remaining surveys (ratings of general frequency of consuming each snack, financial SES questions from study 1, and demographics). The bowls of snacks were then weighed, and total estimated caloric intake from the snacks was calculated based on the manufacturers' nutrition labels (e.g., calories per gram) for each of the snacks.

Next, to test if participants in the two SSES conditions differ in their usual preferences for chips and raisins, participants completed questions on their frequency of typically consuming each test food on a seven-point Likert scale. There were no significant differences observed between participants in the low and high SSES condition on the frequency of consumption for chips [low SSES: M = 2.57, SD = 1.26; high SSES: M = 2.89, SD = 1.45; $t(81) = 1.05$, p = 0.30], M&Ms [low SSES: M = 2.36, SD = 1.01; high SSES: M = 2.64, SD = 1.36; $t(81) = 1.07$, $p = 0.29$], and raisins [low SSES: M = 2.04, SD = 1.18; high SSES: M = 1.69, SD = 1.06; $t(81) = 1.39$, $p = 0.17$]. Participants also completed demographic measures and the financial SES measure from study 2. No significant differences were observed between participants in the low (M = 4.45, SD = 1.19) and high (M = 4.36, SD = 1.52) SSES conditions on financial SES, $t(81) = 0.29$, $p = 0.77$.

Study 4.

Participants. One hundred forty-eight nondieting participants (97 female, age M = 21.51, SD = 1.77) were recruited from a Singaporean university. Participants were informed on the recruitment materials that they would be served a meal of chasoba noodles (green tea Japanese noodles) during the experiment.

Procedure. Participants completed the experiment alone in a small soundproof room of a laboratory. Following informed consent, current hunger was assessed through the use of three visual analog scales (VASs) with the following questions: "How hungry are you?" "How full are you?" How strong is your desire to eat?" Each VAS was anchored at "not at all" and "extremely." Ratings for the three VASs were averaged to produce a composite index of hunger. There was no significant difference between participants in the low SSES (M = 63.20, SD = 19.62), high SSES (M = 58.61, SD = 22.18), and control (M = 56.70, SD = 22.17) conditions on this composite index of hunger, $F(2, 145) = 1.25$, $P = 0.29$. Participants then completed the TFEQ. No significant differences were observed between SSES groups on cognitive restraint [low SSES: M = 2.07, SD = 0.55; high SSES: M = 2.03, SD = 0.49; control: M = 2.17, SD = 0.56, $F(2, 145) = 0.82$, $P = 0.44$], uncontrolled eating [low SSES: M = 2.43, SD = 0.51; high SSES: M = 2.52, SD = 0.52; control: M = 2.48, SD = 0.46; $F(2, 145) = 0.46$, $P = 0.64$], and emotional eating [low SSES: M = 2.26, SD = 0.70; high SSES: M = 2.22, SD = 0.74; control: M = 2.21, SD = 0.73; $F(2, 145) = 0.06$, $P = 0.94$].

Participants then completed one of three manipulations (low SSES, high SSES, control). To assess changes in self-concept as a result of the manipulation that may influence subsequent eating behavior, participants completed a series of questions assessing threatened self-concept and psychological needs. Participants rated on five-point Likert scales (1 = not at all, 5 = extremely) the extent to which they currently felt secure about themselves across various domains: high self-esteem, liked, insecure, satisfied, invisible, meaningless, nonexistent, important, useful, powerful, in control, able to alter events, unable to influence actions of others, and that others were controlling their outcomes (39). There were no differences observed between low and high SSES groups and the control group in any of these items (p's > 0.10) except on feeling important [low SSES: M = 3.07, SD = 0.89; high SSES: M = 3.36, SD = 0.80; control: M = 2.81, SD = 0.97; $F(2, 145) = 4.44$, $P = 0.01$], and powerful [low SSES: M = 2.57, SD = 0.83; high SSES: M = 2.96, SD = 0.95; control: M = 2.57, SD = 0.97; $F(2, 145) = 3.02$, P = 0.05]. Main effects of SSES condition were still observed on quantity of noodles consumed even when feelings of importance, $F(1, 141) = 3.23$, p = 0.04, $\eta_p^2 = 0.04$, and power, $F(1, 141) = 3.01$, $p = 0.05$, $\eta_p^2 = 0.04$, were entered as covariates in SSES $\times$ gender ANCOVAs (see results section).

After completing a brief filler task unrelated to food, participants were served by an experimenter blind to the experimental condition an ad libitum lunch of 300 g of chasoba noodles (which are typically served cold and without soup base) with one cup containing 240 g of water. Participants were instructed to eat until they were comfortably full and that they could signal the experimenter when they were finished with their meal or desired more food. Participants were instructed to refrain from using their phones or computers during their meal. After the completion of their meal, remaining food and water were cleared by the experimenter and weighed in another room. Participants then completed another set of VASs on hunger, desire to eat, and ability to consume more food that were identical to the questions asked at the beginning of the study. Participants were also presented a list of potential reasons to rate for terminating the meal (fullness, boredom with food, time concerns, dislike of food, consumed all of the food served, unfamiliar with the food). A repeated measures ANOVA on these ratings indicated that "feeling full" was the most highly endorsed reason for meal termination across the sample compared with any other reason [$F(5, 915)$ = 22.62, $P < 0.001$, all pairwise comparisons $P < 0.001$]. There was no significant interaction between endorsement of reasons for meal termination and SSES condition, $F(10, 915) = 1.25$, $P = 0.25$, suggesting that meal termination was primarily driven by satiation across all conditions. Finally, participants indicated how frequently they consumed the test food on a six-point Likert scale, followed by the financial SES questions from studies 2 and 3, and demographic questions. There were no significant differences between the low SSES (M = 1.68, SD = 0.90), high SSES (M = 1.88, SD = 1.02), and control (M = 1.74, SD = 1.06) conditions on frequency of consumption of the test food, $F(2, 145) = 0.57$, $p = 0.57$. Similarly, there were no significant differences between low SSES (M = 5.93, SD = 1.49), high SSES (M = 5.90, SD = 1.57), and control (M = 5.71, SD = 1.40) conditions on financial SES, $F(2, 145) = 0.28$, $p = 0.76$.

Energy density of the chasoba noodles was assessed using near infrared (NIR) spectroscopy via Calorie Answer manufactured by Joy World Pacific Co. (Japan) (40). The meal was blended and separated into three portions, which were each subjected to three trials of NIR spectroscopy. Measurements across each portion and each trial of NIR spectroscopy were averaged to produce a composite estimate of energy density of 1.38 kcal per gram.

ACKNOWLEDGMENTS. We thank Fan Xuan Chen, Zhi Qiang Chew, Natalie Chua, Sheeling Neo, Amelia Teo, and Ting Xuan Leng for their help with data collection in experiments 3 and 4; Aaron Sim, Elizabeth Lim, and Li-Ling Lee for analysis of calorie density of noodles in study 4; and Ciaran Forde, Christiani Jeyakumar Henry, and Judith Swain for helpful discussion and feedback. This research was supported by Nanyang Technological University Nanyang Assistant Professorship Grant M4081643, Biomedical Science Institute Strategic Positioning Fund Grant 13-80048G-SICS Theme 1E: Nutritional Psychology (to B.K.C.), and Singapore Ministry of Education Academic Research Fund (Tier 2: MOE2012-T2-1-051) (to Y.-Y.H).

1. Ng M, et al. (2014) Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: A systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 384(9945):766–781.
2. World Health Organization (2014) *Global Status Report on Noncommunicable Diseases 2014* (World Health Organization, Geneva, Switzerland).
3. Bonney A, et al. (2015) Area-level socioeconomic gradients in overweight and obesity in a community-derived cohort of health service users: A cross-sectional study. *PLoS One* 10(8):e0137261.
4. Drewnowski A (2009) Obesity, diets, and social inequalities. *Nutr Rev* 67(Suppl 1): S36–S39.
5. Drewnowski A, Specter SE (2004) Poverty and obesity: The role of energy density and energy costs. *Am J Clin Nutr* 79(1):6–16.
6. Feng X, Wilson A (2015) Getting bigger, quicker? Gendered socioeconomic trajectories in body mass index across the adult lifecourse: A longitudinal study of 21,403 Australians. *PLoS One* 10(10):e0141499.
7. McLaren L (2007) Socioeconomic status and obesity. *Epidemiol Rev* 29(1):29–48.
8. Darmon N, Drewnowski A (2008) Does social class predict diet quality? *Am J Clin Nutr* 87(5):1107–1117.
9. Fernald LC, Gertler PJ, Hou X (2008) Cash component of conditional cash transfer program is associated with higher body mass index and blood pressure in adults. *J Nutr* 138(11):2250–2257.
10. Leroy JL, Gadsden P, González de Cossío T, Gertler P (2013) Cash and in-kind transfers lead to excess weight gain in a population of women with a high prevalence of overweight in rural Mexico. *J Nutr* 143(3):378–383.
11. Adler NE, Epel ES, Castellazzo G, Ickovics JR (2000) Relationship of subjective and objective social status with psychological and physiological functioning: Preliminary data in healthy white women. *Health Psychol* 19(6):586–592.
12. Goodman E, et al. (2003) Impact of objective and subjective social status on obesity in a biracial cohort of adolescents. *Obes Res* 11(8):1018–1026.
13. Lemeshow AR, et al. (2008) Subjective social status in the school and change in adiposity in female adolescents: Findings from a prospective cohort study. *Arch Pediatr Adolesc Med* 162(1):23–28.
14. Tang KL, Rashid R, Godley J, Ghali WA (2016) Association between subjective social status and cardiovascular disease and cardiovascular risk factors: A systematic review and meta-analysis. *BMJ Open* 6(3):e010137.
15. Cardel MI, et al. (2016) The effects of experimentally manipulated social status on acute eating behavior: A randomized, crossover pilot study. *Physiol Behav* 162: 93–101.
16. Brewer MB (2004) Taking the social origins of human nature seriously: Toward a more imperialist social psychology. *Pers Soc Psychol Rev* 8(2):107–113.
17. Van de Vliert E (2008) *Climate, Affluence, and Culture* (Cambridge Univ Press, Cambridge, UK).
18. Tamashiro KL, et al. (2007) Social stress and recovery: Implications for body weight and body composition. *Am J Physiol Regul Integr Comp Physiol* 293(5):R1864–R1874.
19. Melhorn SJ, et al. (2010) Meal patterns and hypothalamic NPY expression during chronic social stress and recovery. *Am J Physiol Regul Integr Comp Physiol* 299(3): R813–R822.
20. Arce M, Michopoulos V, Shepard KN, Ha Q-C, Wilson ME (2010) Diet choice, cortisol reactivity, and emotional feeding in socially housed rhesus monkeys. *Physiol Behav* 101(4):446–455.
21. Foster MT, Solomon MB, Huhman KL, Bartness TJ (2006) Social defeat increases food intake, body mass, and adiposity in Syrian hamsters. *Am J Physiol Regul Integr Comp Physiol* 290(5):R1284–R1293.
22. Gosler AG (1996) Environmental and social determinants of winter fat storage in the great tit Parus major. *J Anim Ecol* 65:1–17.
23. Wilson ME, et al. (2008) Quantifying food intake in socially housed monkeys: Social status effects on caloric consumption. *Physiol Behav* 94(4):586–594.
24. Briers B, Laporte S (2013) A wallet full of calories: The effect of financial dissatisfaction on the desire for food energy. *J Mark Res* 50(6):767–781.
25. Cornil Y, Chandon P (2013) From fan to fat? Vicarious losing increases unhealthy eating, but self-affirmation is an effective remedy. *Psychol Sci* 24(10):1936–1946.
26. Dubois D, Rucker DD, Galinsky AD (2012) Super size me: Product size as a signal of status. *J Consum Res* 38(6):1047–1062.
27. Pickett KE, Kelly S, Brunner E, Lobstein T, Wilkinson RG (2005) Wider income gaps, wider waistbands? An ecological study of obesity and income inequality. *J Epidemiol Community Health* 59(8):670–674.
28. Kraus MW, Côté S, Keltner D (2010) Social class, contextualism, and empathic accuracy. *Psychol Sci* 21(11):1716–1723.
29. Piff PK, Stancato DM, Côté S, Mendoza-Denton R, Keltner D (2012) Higher social class predicts increased unethical behavior. *Proc Natl Acad Sci USA* 109(11):4086–4091.
30. Aiken LS, West SG, Reno RR (1991) *Multiple Regression: Testing and Interpreting Interactions* (Sage, Los Angeles, CA).
31. Stunkard AJ, Messick S (1985) The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *J Psychosom Res* 29(1):71–83.
32. Greenwald AG, McGhee DE, Schwartz JL (1998) Measuring individual differences in implicit cognition: The implicit association test. *J Pers Soc Psychol* 74(6):1464–1480.
33. Rozin P, Haidt J, Fincher K (2009) Psychology. From oral to moral. *Science* 323(5918): 1179–1180.
34. Tybur JM, Lieberman D, Kurzban R, DeScioli P (2013) Disgust: Evolved function and structure. *Psychol Rev* 120(1):65–84.
35. Watson D, Clark LA, Tellegen A (1988) Development and validation of brief measures of positive and negative affect: The PANAS scales. *J Pers Soc Psychol* 54(6):1063–1070.
36. Houben K, Wiers RW (2008) Measuring implicit alcohol associations via the Internet: Validation of Web-based implicit association tests. *Behav Res Methods* 40(4): 1134–1143.
37. Greenwald AG, Nosek BA, Banaji MR (2003) Understanding and using the implicit association test: I. An improved scoring algorithm. *J Pers Soc Psychol* 85(2):197–216.
38. Griskevicius V, Tybur JM, Delton AW, Robertson TE (2011) The influence of mortality and socioeconomic status on risk and delayed rewards: A life history theory approach. *J Pers Soc Psychol* 100(6):1015–1026.
39. Williams KD, Cheung CK, Choi W (2000) Cyberostracism: Effects of being ignored over the Internet. *J Pers Soc Psychol* 79(5):748–762.
40. Lau E, Goh H-J, Quek R, Lim S-W, Henry J (2016) Rapid estimation of the energy content of composite foods: The application of the Calorie Answer. *Asia Pac J Clin Nutr* 25(1):18–25.