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TITLE: The Role of Perceived Stress and Gender on Portion Selection Patterns

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ABSTRACT

Stress is linked to increased preferences and consumption of palatable energy dense foods, particularly among females. Despite the role of stress on potentially obesogenic eating habits, its effect on pre-meal planning, such as the selection of portion sizes, remain unknown. Here, we investigated the relationship between perceived stress, gender, and intended portion sizes for diverse foods. Across two studies, increased perceived stress predicted larger (higher energy) intended portion sizes across a variety of food items among females, but not males. Additionally, for females, increased perceived stress was associated with lowered expectations of the satiety of foods presented, suggesting a potential mechanism by which stress may influence decisions about portion size. These findings reveal that the potentially obesogenic effects of stress on food judgments and behaviors (particularly among females) are not only expressed within meals, but also during more deliberate stages of planning that precedes meals.

Keywords: Stress, Portion Selection, Pre-Meal Planning, Eating Behaviour

1. INTRODUCTION

Prior findings from human and animal studies suggest contributions of stress to unhealthy eating behaviours, such as increased preference for palatable higher energy foods^{1,2} and consumption of a higher fat diet^{3,4}. Yet, much of this research has focused on the influence of stress on food choice, actual food intake, or retrospective reports of eating habits^{1,5}. As such, there is limited understanding about the influence of stress on pre-meal planning behaviour, such as judgments or intentions about portion size, a process considered essential for dietary control of energy intake^{6,7}. Recent studies have suggested that insecurities regarding social and economic resources may increase energy from self-selected portion sizes and contribute to reduced satiety after food intake⁸⁻¹⁰, but these studies did not directly examine the role of stress. Nevertheless, the notion that increased levels of stress² or biomarkers related to stress¹¹ stimulate appetite provides support that one might increase intended food portions for consumption when stressed.

While the mechanism behind the influence of stress on eating has not been fully understood due to inconsistent evidence arising from the relationship between stress and food intake¹², we propose that stress may influence individuals' expectations about satiety. Increasing consumption when stressed may reflect increased quantities of food or energy necessary to achieve sufficient satisfaction or satiety. Following this, during premeal planning, individuals experiencing elevated stress may select larger portion sizes, given that expectations of satiety delivered from a food is one of the strongest predictors of portion size⁶. Another factor of consideration is the indirect effect of stress on eating behaviour, through an individual's ability to exhibit self-control in eating¹, which may extend to pre-meal planning. With research suggesting that stress disrupts self-regulation or control in food intake¹³, an individual may also exercise less self-control in restricting or restraining portion sizes during not only food intake,

but also at premeal planning. Importantly, these potential explanations for how stress can influence pre-meal planning are not mutually exclusive, and could be jointly operating with another, highlighting the benefits of studying the different factors together. In summary, it remains unclear if stress may influence energy intake by exclusively affecting psychological or behavioural processes *during* food intake, such as disrupting self-monitoring and self-control, or if stress may modulate relatively more deliberate pre-meal planning behaviour and intentions, such as selection of portion sizes. Given that people consume almost all of the portions they serve themselves¹⁴, the downstream consequences of stress on portion selection patterns remains an important, yet unanswered question.

In two studies, we investigated if perceived stress predicts intended self-selected portion sizes for a diversity of foods varying in energy density. We hypothesized that higher perceived stress would predict larger self-served portions sizes (H1). We also conducted an exploratory analysis (in Study 1) along with a confirmatory test of the hypothesis (in Study 2) that this pattern would be stronger among females (H2), given prior indications that females may be more susceptible to the effects of stress on food intake¹⁵.

2. Study 1

The purpose of study 1 was to investigate the relationship between perceived stress and self-served portions (through an ad-libitum meal), as well as pre-meal planning behaviour (through selection of portion sizes of various foods in a computerised task) across genders. In addition to our primary hypotheses (H1 and H2), we also predicted that perceived stress would be positively associated with energy consumed from an ad libitum meal (H3). Given that prior studies have suggested that the effect of stress on food preferences and eating behavior may be especially

pronounced for palatable, high energy foods¹⁻³, our analyses also examined the relationship between perceived stress and portion selection patterns separately for low and high energy-dense foods.

Study 1 Methods

2.1. Participants

The target effect size of .30 was determined based on Cohen's (1988) guidelines that consider the effect size to be a small-medium sized effect¹⁶. Based on alpha level of .05, power of .80, and a target correlation coefficient threshold of .30, we estimated approximately 82 participants would be required for the study¹⁷. Study 1 recruited 95 participants, but excluded active dieters (n=16)^{*} and participants with missing/incomplete data (n=29), leading to a final sample size of 50 non-dieting participants (Age: 20.9±2.4 years[†]; 26 males; BMI:21.3±3.1 kg/m²). Prior studies have shown differences between restrained eaters (i.e., dieters) and non-restrained eaters in eating behaviour^{13,18}. In the present study, active dieters were excluded as stress may be associated with greater motivation or intentions to consume larger portions among dieters, but this effect may be suppressed by the selection of a smaller portion that is consistent with their diet. The research was approved by the university's institutional review board (IRB) and written consent was obtained from all participants.

2.2. Procedure and Materials

* Analysis on the interaction between gender and perceived stress on portion selection patterns with the inclusion of active dieters whilst controlling for covariates yielded similar results to our main analysis, $F(5,53) = 3.73$, $p = .006$, $R^2 = .26$. There was a significant main effect of gender, $b = -302.20$, $SE = 140.61$, $p = .04$, but no main effect of stress, $b = -11.70$, $SE = 9.31$, $p = .21$. Although the interaction was not significant, $b = 12.84$, $SE = 6.91$, $p = .07$, higher levels of stress predicted the selection of larger portions exclusively for females ($b = 13.98$, $SE = 6.05$, $p = .02$), but not males ($b = 1.14$, $SE = 3.73$, $p = .76$).

[†] Data for the age of 1 female participant was excluded due to typographical error

109 This study was part of a larger project examining social and contextual influences on eating
110 behaviour, which consisted of variety of brief measures related to eating habits, psychosocial
111 variables (including perceived stress), and general demographics (ethnicity, gender,
112 socioeconomic variables). These additional measures were collected to examine other
113 relationships with and potential influences on eating behavior, unrelated to the role of stress on
114 portion selection. Participants were briefed on the procedures and provided informed consent
115 before beginning the study. Pertaining to this study, participants completed assessments of their
116 baseline appetite ratings¹⁹, and a computerized portion selection task (PST) to assess intended
117 quantity of energy intake from a series of diverse foods (Figure 1). Modelled on previous
118 computerized food portion selection tasks²⁰, the PST in Study 1 measured participants' ideal
119 portion sizes for 15 commonly found food items (meals and snacks) in Singapore (e.g. Fried
120 Rice, Mixed Salad, M&Ms). Each food item consisted of 50 images with portions that ranged
121 from 20 to 1000 Kcals, with a 20 Kcal increment difference between each successive image.
122 Participants were instructed to select their ideal portion size for each of the 15 randomly
123 presented food items. For each participant, portion size selected for all food items were averaged
124 to create a composite measure of an average ideal portion size (in Kcals). Food items were also
125 categorized into approximately equal-sized groups of relatively lower and higher energy-dense
126 foods(Kcal/100 g). As there were 15 food items, the energy density of the 8th food item was
127 compared against the 7th and 9th food item, and was subsequently categorised in the low energy
128 dense foods category given greater similarity in energy to the 7th food item. Following the
129 portion selection task, participants completed the Perceived Stress Scale²¹, which assesses the
130 degree of stress the respondent has experienced or perceived over the last two weeks.
131 Participants then completed the cognitive restraint subscale of Three Factor Eating Questionnaire

(TFEQ)²². Finally, participants were asked to rate their liking towards each of the foods presented in the portion selection task, in which a fixed portion of the food item was individually presented to participants in a random order. Participants were asked “How much do you like the pictured food item in general?”, and were instructed to place a mark along a 100-point Visual Analogue Scale (VAS), ranging from “not at all” (0) “very much” (100), to indicate the extent to which they liked the food item.

Participants then proceeded to consume an ad-libitum lunch meal after completing the assessments, in which they served themselves Yang Chow fried rice (1.57kcal/g) from a buffet tray. The weight of the food was covertly recorded before and after the meal to determine the amount of food and energy consumed. Finally, body mass index (BMI) was calculated from height and weight measurements taken at the end of the session.

3. Study 1 Results

Multiple regression analyses without adjusting for key covariates were conducted using model #1 of the Process SPSS macro²³ to test an interaction with simple slopes analyses between perceived stress and gender on average selected portion sizes for all foods, $F(3,46) = 3.44$, $p = .02$, $R^2 = .18$. There was a marginally significant main effect of gender such that males selected larger portions, $b = -284.12$, $SE = 140.26$, $p = .05$, but no significant main effect of stress, $b = -8.94$, $SE = 9.47$, $p = .35$. The interaction was not significant, $b = 9.90$, $SE = 6.85$, $p = .15$, and higher levels of stress did not predict the selection of larger portions for females ($b = 10.86$, $SE = 5.72$, $p = .06$), and males ($b = .96$, $SE = 3.77$, $p = .80$).

All further analyses involving the PST were adjusted for participants’ average reported liking for the food items presented in the PST given that hedonic factors (i.e. liking²⁴ and palatability²⁵)

have been demonstrated to be important predictors of food preference, selection and intake. Further, given the wide variety of foods presented in the portion selection tasks for both studies, controlling for “liking of foods” sought to account for the potential variability of “liking” across the various food items. Additionally cognitive restraint differed between males ($M = 1.96$, $SD = .57$) and females ($M = 2.33$, $SD = .58$), $t(48) = 2.27$, $p = .03$. Thus, liking of foods and cognitive restraint were entered as covariates in analyses comparing gender.

Multiple regression using model #1 of the Process SPSS macro²³ was used to test an interaction with simple slopes analyses between perceived stress and gender on average selected portion sizes for all foods, while adjusting for control variables, $F(5,44) = 3.31$, $p = .01$, $R^2 = .27$. There was a marginal main effect of gender such that males selected larger portions, $b = -277.92$, $SE = 135.52$, $p = .048$, but no main effect of stress, $b = -7.30$, $SE = 9.22$, $p = .43$. Although the interaction was not significant, $b = 9.78$, $SE = 6.61$, $p = .15$, higher levels of stress predicted the selection of larger portions exclusively for females ($b = 12.26$, $SE = 5.72$, $p = .04$), but not males ($b = 2.48$, $SE = 3.89$, $p = .53$) (Figure 2A). To investigate if higher perceived stress predicted the selection of greater portion sizes of food as a function of their energy density, we tested the interaction of perceived stress and gender on portion sizes for foods classified as high and low energy density. The analysis for low-energy dense foods, $F(5,44) = 3.41$, $p = .01$, $R^2 = .28$, revealed a marginal main effect for gender, $b = -251.65$, $SE = 139.56$, $p = .08$, such that males selected larger portions. There was no significant main effect of stress, $b = -5.50$, $SE = 9.51$, $p = .57$, or interaction between stress and gender, $b = 8.93$, $SE = 6.81$, $p = .20$. Yet, a trend was observed such that higher levels of stress predicted the selection of larger portions for females ($b = 12.36$, $SE = 5.90$, $p = .04$), but not males ($b = 3.43$, $SE = 4.03$, $p = .40$) (Figure 2B). For high-energy foods, $F(5,44) = 2.61$, $p = .04$, $R^2 = .23$, there was a significant main effect for gender, b ,

= -308.26, $SE = 145.48$, $p = .04$, such that males selected larger portions, but no significant main effect of stress, $b = -9.53$, $SE = 9.90$, $p = .34$. Although no significant interaction between gender and stress was observed for high-energy dense foods, $b = 10.98$, $SE = 7.10$, $p = .13$, a trend was again observed such that higher levels of stress predicted greater portion sizes only for females ($b = 12.44$, $SE = 6.12$, $p = .05$), but not males ($b = 1.45$, $SE = 4.15$, $p = .73$) (Figure 2C).

Similar multiple regression analyses were also used to test an interaction between perceived stress and gender on ad-libitum intake, while adjusting for cognitive restraint, $F(4,45) = 2.39$, $p = .06$, $R^2 = .18$. There were no significant main effects of gender, $b = -62.88$, $SE = 122.64$, $p = .61$, stress, $b = 5.72$, $SE = 8.34$, $p = .50$, nor interaction between gender and stress, $b = -.71$, $p = .91$ (Figure 2D).

Multiple regression was also used to test for an interaction between perceived stress and gender on liking of the foods presented in the PST, while adjusting for cognitive restraint. No significant effects of gender, $b = 2.77$, $SE = 14.24$, $p = .85$, stress, $b = .21$, $SE = .97$, $p = .83$, or their interaction were observed, $b = .11$, $SE = .69$, $p = .87$. The effect of stress and gender on the liking of foods was then examined separately for high-energy foods and low-energy foods (Table 1). No significant interaction between stress and gender was observed for both high, $b = .20$, $SE = .77$, $p = .80$, and low, $b = .04$, $SE = .77$, $p = .96$, energy dense foods, such that higher levels of stress was not predictive of liking for females ($b_{LOW-ENERGY} = .54$, $SE_{LOW-ENERGY} = .66$, $p_{LOW-ENERGY} = .42$; $b_{HIGH-ENERGY} = .31$, $SE_{HIGH-ENERGY} = .66$, $p_{HIGH-ENERGY} = .64$), and males ($b_{LOW-ENERGY} = .50$, $SE_{LOW-ENERGY} = .45$, $p_{LOW-ENERGY} = .27$; $b_{HIGH-ENERGY} = .11$, $SE_{HIGH-ENERGY} = .45$, $p_{HIGH-ENERGY} = .80$). For both low- and high-energy dense foods, no main effects of gender, $b_{LOW-ENERGY} = 3.71$, $SE_{LOW-ENERGY} = .15.79$, $p_{LOW-ENERGY} = .82$; $b_{HIGH-ENERGY} = 1.70$, $SE_{HIGH-ENERGY} = .15.74$, $p_{HIGH-ENERGY} = .91$, and stress, $b_{LOW-ENERGY} = .46$, $SE_{LOW-ENERGY} = 1.07$, $p_{LOW-ENERGY} = .67$; $b_{HIGH-ENERGY} = .46$, $SE_{HIGH-ENERGY} = 1.07$, $p_{HIGH-ENERGY} = .67$.

$ENERGY = -.08$, $SE_{HIGH-ENERGY} = .1.07$, $p_{HIGH-ENERGY} = .94$, were observed for liking of low- or high-energy foods.

4. Study 1 Discussion

Results from Study 1 partially supported our hypotheses. Although higher levels of perceived stress was not associated with increased self-selected portion sizes across the entire sample (H1 unsupported), perceived stress was selectively predictive of larger portion sizes among females (H2 supported), suggesting a trend that females may be more susceptible to the effects of stress during pre-meal planning. Nevertheless, this result from Study 1 should be interpreted with caution as the overall interaction between stress and gender did not reach significance. Finally, contrary to past research suggesting that stress may heighten preference for palatable high-energy foods¹⁻³, portion selection patterns for low and high energy-dense foods in response to stress exhibited similar patterns. These results imply that the effect of perceived stress on increased portion sizes among women appeared independent of the energy-density of foods. Furthermore, no significant associations were observed between stress and actual food intake for both genders (H3 unsupported), suggesting that the effects of stress on pre-meal planning are not necessary translating to increased energy intake.

5. Study 2 Methods

The objectives of Study 2 were to replicate the findings of Study 1 over a wider variety of food items, to recruit a larger sample to overcome the issues presented in Study 1 related to the statistical power, and to provide further insights into the potential mechanism in which stress may influence judgments about portion sizes. Because past studies have shown that expectations of satiety delivered by foods influences subsequent energy intake and portion selection^{6,7}, an

additional task was included in Study 2 to measure participants' expected satiety delivered by the foods presented in the PST.

5.1. Participants

Similar to Study 1, a sample size of at least 82 participants was estimated for Study 2 according to an alpha level of .05, power of .80, and a target correlation coefficient threshold of .30¹⁷. Study 2 consisted of 199 non-dieting participants (73 males; Age:21.6±2.09 years; BMI:21.4±3.4 kg/m²) after excluding dieters[‡] (n=36), and participants with missing/incomplete data (n=28) or reported major medical conditions[§] (n=11) from a Singaporean university. The research was approved by the university's institutional review board (IRB) and written consent was obtained from all participants.

5.2. Procedure and materials

As with Study 1, Study 2 was conducted as part of a larger study on the influence of social and contextual factors on eating behaviors, and consisted of additional measures pertaining to eating and lifestyle habits (e.g., meal times, sleep quality), psychosocial factors (including stress), and participant background/demographic variables. Study 2 was similar in design to Study 1, except: 1) the use of 25 food items on the PST (instead of 15) to compute the ideal portion size composite, 2) the inclusion of food-related measures to account for potential confounding

[‡] Analysis with the inclusion of active dieters whilst controlling for covariates yielded similar results as our main analyses, $F(6,242) = 4.43, p < .001, R^2 = .10$. There was a significant main effect of gender, $b = -203.34, SE = 62.29, p = .001$, and stress, $b = -14.75, SE = 5.92, p = .01$. A significant interaction was also observed, $b = 10.97, SE = 3.36, p = .001$, where higher levels of stress predicted the selection of larger portions exclusively for females ($b = 7.20, SE = 1.83, p < .001$), but not males ($b = -3.78, SE = 2.81, p = .18$).

[§] Analysis with the inclusion of participants reporting major medical conditions whilst controlling for covariates yielded similar results as our main analyses, $F(6,203) = 3.45, p = .003, R^2 = .09$. A significant main effect of gender, $b = -198.36, p < .01$, and stress was observed, $b = -15.45, p = .02$, such that males and participants reporting lower stress selected larger portions. A significant interaction was also observed, $b = 10.88, p = .004$, such that higher levels of stress was predictive of the selection of higher calories for females, $b = 6.32, p < .01$, but not males, $b = -4.56, p = .14$.

influences, like frequency of consumption and general desire to consume (wanting) the food items presented in the PST, 3) the absence of an ad libitum meal, and 4) the inclusion of the measurement of participants' expected satiety of the food items. This expected satiety task was similar to the PST which was designed to assess participants' ideal portion size. However, instead of instructing participants to select portions according to their ideal portion size, participants were instructed to select a portion size of the food they would need to consume for lunch to stay full until dinner. Larger portion sizes selected on the expected satiety task indicated that participants required larger quantities of the food to feel satiated (lower expected satiety). Responses across all food items were averaged to derive a composite measure of the average expected satiety of foods (in Kcals). As per Study 1, the foods presented in Study 2 were also divided into relatively higher or lower energy-dense (kcal/100 g) food categories.

6. Study 2 Results

Multiple regression using model #1 of the Process SPSS macro²³ was used to test an interaction with simple slopes analyses between perceived stress and gender on average selected portion sizes for all foods without controlling for key covariates, $F(3,195) = 2.33$, $p = .08$, $R^2 = .04$. There was a significant main effect of gender, $b = -.161.93$, $SE = 71.34$, $p = .02$, but non-significant main effect of stress, $b = -11.54$, $SE = 6.56$, $p = .08$. The interaction was significant, $b = 8.40$, $SE = 3.78$, $p = .03$, higher levels of stress predicted the selection of larger portions for females ($b = 5.25$, $SE = 2.16$, $p = .02$), but not males ($b = -3.10$, $SE = 3.10$, $p = .31$).

As per Study 1, all analyses involving the PST were adjusted for participants' average reported liking for the food items presented in the PST. Analyses were similarly adjusted for appetite and eating behaviour associated variables that significantly differed across the two genders. Notably,

baseline appetite ratings (AR) and BMI significantly differed between males ($M_{AR} = 50.06$, $SD_{AR} = 23.74$; $M_{BMI} = 22.07$, $SD_{BMI} = 3.04$) and females ($M_{AR} = 42.35$, $SD_{AR} = 26.44$; $M_{BMI} = 20.98$, $SD_{BMI} = 3.61$), $t_{AR}(197) = 2.06$, $p = .04$, $t_{BMI}(197) = 2.16$, $p = .03$, while ratings of the subscales of the TFEQ²² did not. Consequently, liking of foods, appetite ratings, and BMI were entered as covariates in the analyses comparing gender. Additionally, a summary of correlations of the variables (i.e., stress, portion selection, food judgments, covariates) included in the two studies can be found in Table S2 of the supplementary materials.

Multiple regression using model #1 of the Process SPSS macro²³ was used to test an interaction between perceived stress and gender on ideal portion sizes for the foods presented in the PST, while adjusting for control variables (discussed above), $F(6,192) = 3.08$, $p = .007$, $R^2 = .09$. A significant main effect of gender, $b = -179.61$, $p = .01$, and stress was observed, $b = -14.12$, $p = .03$, such that males and participants reporting lower stress selected larger portions^{**}. A significant interaction was also observed, $b = 9.84$, $p = .009$, such that higher levels of stress was predictive of the selection of higher calories for females, $b = 5.57$, $p = .01$, but not males, $b = -4.28$, $p = .17$ (Figure 3A). Notably, the use of the additional food-related measures assessed in Study 2 (the frequency of consumption and the general desire to consume the food item) as covariates also yielded similar outcomes to analyses that only controlled for the liking of foods (see Table S1 of Supplementary Materials).

As in Study 1, the effect of stress and gender on portion selection was examined separately for high energy foods, $F(6,192) = 3.72$, $p = .002$, $R^2 = .10$, and low energy foods, $F(6,192) = 3.49$, p

^{**} Although the main effect of stress on portion sizes is negative in this model, this is due to the adjustment of gender and the other control variables in the model. Correlation analyses without control variables demonstrate an overall positive (yet non-significant) association between stress and ideal portion size, $r = .10$, $p = .18$.

= .003, $R^2 = .10$. A significant interaction between stress and gender was observed for both high, $b = 10.49$, $SE = 4.37$, $p = .02$, and low, $b = 9.48$, $SE = 3.56$, $p = .008$, energy dense foods, such that higher levels of stress was predictive of greater portions selected for females ($b_{LOW-ENERGY} = 4.83$, $SE_{LOW-ENERGY} = 2.03$, $p_{LOW-ENERGY} = .02$; $b_{HIGH-ENERGY} = 6.58$, $SE_{HIGH-ENERGY} = 2.49$, $p_{HIGH-ENERGY} = .009$), but not males ($b_{LOW-ENERGY} = -4.65$, $SE_{LOW-ENERGY} = 2.93$, $p_{LOW-ENERGY} = .11$; $b_{HIGH-ENERGY} = -3.91$, $SE_{HIGH-ENERGY} = 3.58$, $p_{HIGH-ENERGY} = .28$) (Figure 3B & 3C). For both low- and high-energy dense foods, main effects of gender, $b_{LOW-ENERGY} = -162.72$, $SE_{LOW-ENERGY} = 66.94$, $p_{LOW-ENERGY} = .02$; $b_{HIGH-ENERGY} = -199.07$, $SE_{HIGH-ENERGY} = 81.96$, $p_{HIGH-ENERGY} = .02$, and stress were observed, $b_{LOW-ENERGY} = -14.13$, $SE_{LOW-ENERGY} = 6.19$, $p_{LOW-ENERGY} = .02$; $b_{HIGH-ENERGY} = -14.39$, $SE_{HIGH-ENERGY} = 7.59$, $p_{HIGH-ENERGY} = .06$, such that males and participants experiencing lower stress selected larger portions.

Multiple regression was used to test for an interaction between perceived stress and gender on liking of the foods presented in the PST, while adjusting for control variables (AR and BMI), $F(5,193) = 1.47$, $p = .20$, $R^2 = .04$. A non-significant main effect of gender, $b = 6.28$, $SE = 4.90$, $p = .20$, and marginal effect of stress was observed, $b = .82$, $SE = .45$, $p = .07$, such participants experiencing greater stress reported greater liking for foods. No interaction between stress and gender was observed, $b = -.40$, $SE = .26$, $p = .13$, but there was a trend that stress was predictive of liking for males, $b = .42$, $SE = .21$, $p = .05$, but not females, $b = .02$, $SE = .15$, $p = .87$. As in Study 1, the effect of stress and gender on the liking of foods was then examined separately for high and low- energy foods (Table 1). Overall, there were no significant main effects or interactions of stress on liking of high- or low-energy foods.

Multiple regression was also used to test an interaction between perceived stress and gender on expected satiety of the foods presented in the PST, while adjusting for control variables, $F(6,192)$

= 10.06, $p < .001$, $R^2 = .24$. A significant main effect of gender, $b = -136.96$, $SE = 67.25$, $p = .04$
 (males selecting greater amounts of food on the expected satiety PST), but no main effect of
 stress was observed, $b = -3.51$, $SE = 6.24$, $p = .57$. While there was no interaction between stress
 and gender, $b = 3.54$, $SE = 3.58$, $p = .32$, a trend emerged such that stress was marginally
 predictive of decreased expected satiety (requiring larger portions to stay full from lunch to
 dinner) of foods for females, $b = 3.57$, $SE = 2.04$, $p = .08$, but not males, $b = .03$, $SE = 2.95$, p
 = .99. The effect of stress and gender on expected satiety of foods was then examined separately
 for high-energy foods, and low-energy foods (Table 1). A trend was observed such that higher
 levels of stress predicted lower expected satiety (selecting greater amounts of food on the
 expected satiety PST) for high energy foods exclusively among females ($b = 4.79$, $SE = 2.42$, p
 = .049), but not males ($b = .39$, $SE = 3.50$, $p = .91$). However, this relationship was not observed
 for low energy foods for both females ($b = 2.74$, $SE = 1.93$, $p = .16$) and males ($b = 1.38$, $SE =$
 2.79, $p = .62$).

7. Study 2 Discussion

Study 2 involved a larger sample size (vs. Study 1), providing more power to identify a
 significant interaction of stress and gender that did not reach significance in Study 1, as well as
 inclusion of a wider and more diverse range of food items were used in the PST for Study 2.
 Replicating findings from Study 1, females who reported higher levels of perceived stress were
 more likely to select increased portion sizes for the variety of foods presented in the portion
 selection task. As in Study 1, this relationship was not observed among males, providing further
 support for the prediction that females might be more susceptible to the effects of stress on
 premeal planning behaviour (supporting H2). Additionally, results from Study 2 also suggest that

females who have been experiencing higher levels of stress may perceive foods to have lower expected satiety, which may have partially contributed to the selection of larger portion sizes.

8. General Discussion

We demonstrate across two studies, that the influence of stress on food selection and intake patterns also includes premeal planning. Although perceived stress had inconsistent contributions to increased portion sizes across the whole sample (lack of support for H1), the effect of perceived stress on increased portion sizes was consistently observed among females (supporting H2). While the effect of stress and gender on portion selection was observed across diverse foods, both studies revealed this pattern for both low and high energy foods, suggesting that this effect may operate independently of the energy density of foods.

Analyses of the effect of stress on food preferences and expected satiety of foods suggest that the relationship between stress and increased portion sizes among females could be partially attributed to a tendency for female (but not male) participants to expect lower satiety delivered from foods resulting from perceived stress rather than stress-related changes in preferences for foods (i.e., liking). Although not directly examining or manipulating stress, prior research has suggested that food consumption during a state of perceived insecurity regarding socioeconomic resources may be associated with lower reports of subsequent satiety²⁶. However, given that the results showed an overall non-significant trend, it should be noted that expected satiety might not be the only factor driving the differences in stress-sensitivity of portion selection patterns between genders. Further research is needed to better understand the processes and mechanisms by which heightened stress may alter expectation or concerns that females may have about the satiating properties of foods.

A notable limitation presented by this study relates to the total number of male participants being involved in the two studies, which may have made the analyses with males more susceptible to issues pertaining to reduced power to detect effects. However, this may not account for the stronger effects of stress observed for females, as the direction of effects suggests (non-significantly) that males exhibit lower portion selection sizes in response to stress, instead of simple weaker positive relationships between stress and portion size, a result supported by a previously conducted study²⁷. Another potential limitation relates to the method of analysis of the foods according to their energy density in the portion selection tasks in the two studies. As discussed above, the relatively modest sample size (for males) could have contributed to a reduced sensitivity in detecting effects. Future studies should utilize adequately powered sample sizes to directly test potential interactions between stress, gender, and energy density of evaluated foods to examine if the effects of stress and gender on portion selection patterns are indeed insensitive to energy density of the foods, as opposed to research suggesting otherwise for actual food intake⁵.

Contrary to prior studies suggesting increased energy intake in the face of stress¹, results from the ad-libitum meal in Study 1 revealed no significant relationship between higher stress levels and an increase in actual food intake across both genders. One explanation may be that the ad-libitum meal consisted of only of a specific food item (fried rice), which participants may have varied preferences toward, and is thus not as robust or sensitive as the diverse range of foods presented in the PST. Additionally, the lack of relationship between stress and actual food intake may be attributed to the test food (fried rice) being relatively low in energy density (1.57 Kcal/grams). Past studies have shown that preferences shift towards high-energy density foods when higher stress levels are reported⁵.

371 While the present study provides initial support towards the use of the PST to investigate
372 premeal planning behaviours, the cross-sectional nature of this study serves as a limitation since
373 the causal role of perceived stress on premeal planning remains unknown. Yet, it should be noted
374 that this limitation is due to a lack of practical or ethical means of experimentally assigning
375 human participants to chronically or dispositionally perceive stress. Subsequent studies could
376 experimentally induce acute or momentary stress to ascertain whether it has similar effects on
377 premeal planning as observed with relatively more chronic perceived stress assessed in the
378 current study. Additionally, given the mixed effects that stress may sometimes have on appetite
379 and food intake patterns (stress hyper- and hypo-phagia)^{5,28}, identifying individual differences
380 that determine whether stress may produce selection of increased or decreased portion sizes
381 would be an important avenue for future research. Finally, although foods presented varied in
382 actual energy density in this study, an additional measure of an individual's expectations of
383 satiety from the foods presented might add value to the study of the relationship between stress
384 and eating behaviours (premeal planning and actual food intake). Gauging the ability of
385 participants to discriminate between foods based on their satiating properties would enhance an
386 understanding of the potential mechanism underpinning the effect of stress on energy selection.
387 This would make it possible to observe whether people in a stressed state have heightened
388 sensitivity to subtle differences in satiating properties across available food or by contrast,
389 consistently de-value the satiating properties of foods, leading to the perception that they will
390 need more food (larger portions) to remain full. Less explored, we propose that stressful events
391 inherently involve potential threats or loss to such critical aspects of the self like social standing,
392 self-image, loss or frustration of acquiring rewards and opportunities. Given that prior studies
393 showed that insecurity of critical resources (e.g., economic and social) can increase people's

appetite and blunt their experience of satiety^{9,26}, stressful events may likewise lead to a potential dampening in the experience of satiety. Although the present study did not investigate the type of stressor faced by the individual, participants' stress levels may reflect the presence of these subjective insecurities that may blunt the experience or expectations of satiety.

9. CONCLUSION

The present findings provide preliminary support that suggest that among females, perceived stress may promote selection and consumption of larger portion sizes, and that the effects of stress on judgments and behaviors towards food extend to premeal planning. While adequately powered pre-registered replications of these findings are required, a promising avenue for future investigation would be to identify potential interventions targeting the stage of premeal planning of portion sizes to mitigate the effects of stress on obesogenic dietary behaviours.

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487 **Figure 1.** Sample food item (Singaporean Bee Hoon Noodles) from the portion selection task
488 used in Studies 1 and 2. Portion sizes for each food item ranged from 20 to 1000 kcal (in 20 kcal
489 increments), such that each food item consisted of 50 images of increasing/decreasing portion
490 sizes that participants could select from.

491

492

Figure 2. Interaction of gender and perceived stress on selected portion sizes across all foods (A), low-energy dense foods (B), high-energy dense foods (C), and amount of test meal consumed ad libitum (D) in Study 1 ($n = 50$ * $p \leq .05$).

Figure 3. Interaction of gender and perceived stress on selected portion sizes across all foods (A), low-energy dense foods (B), and high-energy dense foods (C) in Study 2 ($n = 199$; $*p < .05$, $**p < .01$).

507 **Table 1.** Multiple regression results for the effect of perceived stress, gender, and their
508 interaction on: (A) liking (Study 1 and 2), and (B) expected satiety of low- and high-energy
509 foods (Study 2) presented in the portion selection task.

Study 1

	<i>Liking for Low-Energy Foods</i>	<i>Liking for High-Energy Foods</i>
Model	$F(4,45) = .84, p = .51, R^2 = .07$	$F(4,45) = .78, p = .54, R^2 = .07$
Gender	$b = 3.71, p = .82$	$b = 1.70, p = .91$
Stress	$b = .46, p = .67$	$b = -.08, p = .94$
Gender x Stress	$b = .04, p = .96$	$b = .20, p = .80$

Study 2

	<i>Liking for Low-Energy Foods</i>	<i>Liking for High-Energy Foods</i>
Model	$F(5,193) = 1.81, p = .11, R^2 = .04$	$F(5,193) = .72, p = .61, R^2 = .02$
Gender	$b = 7.73, p = .16$	$b = 5.24, p = .41$
Stress	$b = .82, p = .11$	$b = .77, p = .19$
Gender x Stress	$b = -.37, p = .21$	$b = -.42, p = .22$
	<i>Expected Satiety for Low-Energy Foods</i>	<i>Expected Satiety for High-Energy Foods</i>
Model	$F(6,191) = 10.91, p < .001, R^2 = .26$	$F(6,191) = 8.20, p < .001, R^2 = .20$
Gender	$b = -101.17, p = .11$	$b = -148.32, p = .07$
Stress	$b = .006, p = 1.0$	$b = -4.01, p = .59$
Gender x Stress	$b = 1.37, p = .69$	$b = 4.40, p = .30$

510

Table S1. Multiple regression results for the effect of perceived stress, gender, and their interaction on ideal portion size of the food items presented in the portion selection task for Study 2, controlling for baseline appetite ratings, BMI, and general attitudes towards the foods presented on the portion selection task: (A) liking of foods, (B) general desire to consume (wanting) the foods, and (C) frequency of consumption of the foods.

Study 2	
	<i>Covariate: Liking of foods, Baseline appetite ratings, BMI</i>
Model	$F(6,192) = 3.08, p = .007, R^2 = .09$
Gender	$b = -179.61, p = .01$
Stress	$b = -14.12, p = .03$
Gender x Stress	$b = 9.84, p = .009$
	<i>Covariate: Desire to eat, Baseline appetite ratings, BMI</i>
Model	$F(6,192) = 3.28, p = .004, R^2 = .09$
Gender	$b = -171.27, p = .01$
Stress	$b = -13.76, p = .03$
Gender x Stress	$b = 9.51, p = .01$
	<i>Covariate: Frequency of consumption, Baseline appetite ratings, BMI</i>
Model	$F(6,192) = 3.01, p = .008, R^2 = .09$
Gender	$b = -156.66, p = .03$
Stress	$b = -11.43, p = .08$
Gender x Stress	$b = 8.31, p = .03$

Table S2. Correlations between perceived stress and ideal portion size selection (Studies 1 & 2), expected satiety portion size selection (Study 2), ad libitum intake (Study 1), and additional measures that may influence eating behaviour: cognitive restraint subscale from Three Factor Eating Questionnaire (Studies 1 & 2), attitudes towards food items presented in portion selection tasks (Studies 1 & 2), Body Mass Index (Studies 1 & 2), baseline appetite ratings (Studies 1 & 2), and uncontrolled and emotional eating subscale from Three Factor Eating Questionnaire (Study 2).

Study	Gender	Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1	Male	1. Ad Libitum Intake		.22	.29	.37	-.24	-.06	-.30	.14				
		2. Average Ideal Portion Size (PST)			.05	-.06	.43*	.14	.22	-.009				
		3. Perceived Stress				.46*	.15	.15	-.13	.08				
		4. Cognitive Restraint					.07	-.05	.05	.16				
		5. Average Liking for foods (PST)						.36	.27	-.01				
		6. Average Familiarity for foods (PST)							-.13	.08				
		7. BMI								-.01				
		8. Baseline Appetite Composite Ratings												
	Female	1. Ad Libitum Intake		.41*	.20	-.18	.08	-.05	.12	.09				
		2. Average Ideal Portion Size (PST)			.41*	-.25	.11	-.08	.06	.06				
		3. Perceived Stress				.33	.12	.10	.41*	.21				
		4. Cognitive Restraint					-.10	.38	.41*	.24				
		5. Average Liking for foods (PST)						.31	.26	-.07				
		6. Average Familiarity for foods (PST)							.05	.06				
		7. BMI								-.02				
		8. Baseline Appetite Composite Ratings												
2	Male	1. Average Ideal Portion Size (PST)		.19	0.12	.10	.03	.01	.15	-.03	.21	-.15	-.10	.04
		2. Expected Satiety Portion Size (PST)			.10	-.19	-.02	.06	.50**	.06	.47**	.15	-.07	.31**

Female	3. Perceived Stress			.13	.32**	.44**	.24*	-.10	.20	.18	.14	.11
	4. Cognitive Restraint (TFEQ)				.27*	.009	-.18	.25*	-.16	.08	.24	-.04
	5. Emotional Eating (TFEQ)					.55**	-.25*	-.03	-.15	-.10	.30*	-.04
	6. Uncontrolled Eating (TFEQ)						-.02	-.009	.02	-.07	.06	.16
	7. Average Liking for foods (PST)							.13	.85**	.27*	-.07	.18
	8. Average Fillingness for foods (PST)								.05	.10	.12	-.05
	9. Average Wanting to Eat for foods (PST)									.20	-.22	.17
	10. Frequency of Consumption (PST)										.09	.11
	11. BMI											.008
	12. Baseline Appetite Composite Ratings											
	1. Average Ideal Portion Size (PST)	.29**	.22*	-.06	.03	.15	.11	.07	.16	-.12	.006	.26
	2. Expected Satiety Portion Size (PST)		.13	-.16	.03	.19*	.23*	.02	.32**	-.19*	.04	.26**
	3. Perceived Stress			-.01	.16	.22*	.006	.007	.09	-.16	.02	-.07
	4. Cognitive Restraint (TFEQ)				.13	-.03	-.17	.00	-.24*	-.15	.12	-.09
	5. Emotional Eating (TFEQ)					.64**	-.05	-.07	-.02	.04	.10	.04
	6. Uncontrolled Eating (TFEQ)						-.03	-.10	.07	.08	.05	.21*
	7. Average Liking for foods (PST)							.34**	.68**	.09	.01	.09
	8. Average Fillingness for foods (PST)								.28*	.04	.06	-.15
	9. Average Wanting to Eat for foods (PST)									.09	.06	.23*
	10. Frequency of Consumption (PST)										.001	-.05

11. BMI
12. Baseline
Appetite Composite
Ratings

.02

13 *Note: ** $p < .01$, * $p < .05$*