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Exploring the effects of daily hassles and uplifts on eating behaviour in young adults: The role of daily cortisol levels

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ABSTRACT

Existing stress-eating research has shown that daily hassles are associated with increases in food intake and that cortisol reactivity to stress has been found to influence the stress-eating relationship. However, the moderating effects of daily cortisol levels (e.g., the cortisol awakening response, CAR) remain unknown. Moreover, recent evidence has shown that daily uplifts, as well as daily hassles, are important in understanding daily influences on eating behaviour. Therefore, in the same study, the current investigation explored the effects of daily hassles and uplifts on eating behaviour and whether these relationships were moderated by mean daily cortisol levels in young female adults. Forty-nine female participants (M age: 19.13 years) recorded the daily hassles and uplifts that they experienced over a 4-day period, together with the between-meal snacks they consumed each day, using an online daily diary. Cortisol samples were provided daily immediately upon waking, at +30 minutes and +12 hours. Mean CAR and mean cortisol levels were calculated across the 4 days. Using multi-level modeling, daily hassles and uplifts were both significantly associated with greater unhealthy snacking. Daily uplifts, but not daily hassles, were also associated with lower healthy snack intake. Higher levels of mean CAR were associated with lower daily healthy snack intake. Moreover, the effects of daily uplifts on healthy snacking were found to be moderated by mean daily cortisol levels, such that participants with the highest levels of mean cortisol consumed less healthy snacks on days when they experienced uplifts. The current study provides novel evidence that mean daily cortisol levels, as well as daily hassles and uplifts, are implicated in daily snack consumption in young female adults. The role of hypothalamic-pituitary adrenal axis activity should be explored further in the context of the daily hassles/uplifts and eating behaviours relationship, in men and in individuals from lower socio-economic status and minority groups.

Keywords: Stress, daily hassles, cortisol, snacking, positive emotion, HPA axis, cortisol awakening response

1. INTRODUCTION

It is well established that stress influences a range of eating behaviours. These stress-related eating behaviours have been linked to both hyperphagic (increased) and hypophagic (decreased) responses to food consumption (Hill et al., 2018; 2021; Macht, 2008; O'Connor & Conner, 2011). For example, O'Connor et al. (2008) have shown that many individuals consume more between-meal snacks, less fruit and vegetables and are less likely to have a main meal on days when they encounter stress. However, the majority of research has focussed on hyperphagic responses to stress due to the health implications of being overweight and obese (Araiza & Lobel, 2018; O'Connor & Conner, 2011). Moreover, considerable evidence now indicates that the impact of stress on eating behaviour is an important pathway through which stress impacts on health outcomes (O'Connor, Thayer & Vedhara, 2021). There are also a growing number of studies that have highlighted the key role played by positive daily events (also known as daily uplifts) and emotions for understanding eating behaviour. For example, positive emotion has been shown to initiate the consumption of healthier food (e.g., fruit, Macht, 2008) as well as unhealthy foods (e.g., high caloric foods, Evers et al., 2013). More recently, an ecological momentary assessment study found the presence of daily positive emotion was related to increased food consumption (Richenberger et al., 2018) and others have argued that positive emotions, or daily uplifts, are a neglected trigger for food intake (e.g., Evers et al, 2013; Moss et al., 2020a).

Furthermore, understanding the stress-eating behaviour relationship is complicated by the presence of various important moderating variables (Araiza & Lobel, 2018; O'Connor & Conner, 2011). Cumulative evidence suggests that stress-eating relationships are strongest among individuals who are female, high in restraint, disinhibition, external eating and emotional eating. However, one group of moderating variables that has received much less attention relate to individual differences in daily cortisol dynamics and cortisol responses to stress. One of the central functions of cortisol (in times of stress) is to increase access to energy stores, increase protein and fat mobilization, and decrease inflammation. Marked increases in cortisol trigger the release of excess energy stored in the muscle and liver as glycogen, which is then broken down into glucose ready for utilization by the

muscles and the brain. In addition, it has also been argued, that glucocorticoids (GC), with cortisol being the most important GC in humans, promote food intake (Dallman, 2010). In humans, the administration of GC has been shown to increase energy consumption, especially carbohydrates and proteins (Tataranni et al., 1996). In addition, a number of potential mechanisms have been suggested that link cortisol to food intake. For example, one possibility is that cortisol initiates the release of neuropeptide Y, a known appetite stimulant or that cortisol protects against the hypophagic effects of leptin. Moreover, in their model of Reward Based Stress Eating, Adam and Epel (2007) emphasise the role of cortisol and brain reward circuitry in motivating calorically dense food intake. These authors suggest that "repeated stimulation of the reward pathways through either stress induced hypothalamic pituitary adrenal (HPA) axis stimulation, intake of highly palatable food or both, may lead to neurobiological adaptations that promote compulsive overeating. Cortisol may influence the reward value of food via neuroendocrine/peptide mediators such as leptin, insulin and neuropeptide Y" (p. 449).

To date, a small number of studies have shown that individual differences in cortisol reactivity to stress moderate stress-eating relationships in adults (e.g., Epel et al., 2001; Newman et al., 2007) and in children (Moss et al., 2020b). An important early study found that individuals who exhibited high cortisol reactivity to stress consumed more snacks when given the opportunity to do so in a laboratory setting (Epel et al., 2001). Newman et al. (2007) extended this finding into naturalistic settings by showing that individuals who released more cortisol in response to stress in the laboratory reported eating more between-meal snacks on days when they encountered stress in the real world. More recently, Moss et al. (2020b) replicated these results in children as young as 8-11 years old.

There is a growing, but limited evidence-base that has investigated the relationship between naturally fluctuating cortisol levels (i.e., the cortisol awakening response (CAR) and daily cortisol levels across the day) and eating behaviours. For example, a study by Heaney, Phillips and Carroll (2012) in young adults and older adults found mixed evidence that diurnal cortisol levels (across one day) were associated with aspects of food intake. Specifically, they found a significant interaction between age, cortisol, and diet such that younger adults with higher fat and lower fruit and vegetable intake exhibited a lower cortisol awakening response and a flatter diurnal profile. Another study by

Therrien et al. (2008) in a sample of men and women, found a number of negative associations between the cortisol awakening response and eating behaviour measures (e.g., disinhibition, restraint behaviours etc.) such that lower cortisol levels in the morning were linked to more negative eating behaviours.

Taken together, the limited available evidence linking daily cortisol levels to eating behaviour is mixed and a number of factors may account for the inconsistencies. For example, diurnal cortisol levels and eating behaviours were only assessed once or over a couple of days. The need to assess cortisol (in particular, the CAR) over multiple consecutive days in order to gain a more reliable trait-like estimate is well established (cf., O'Connor et al., 2009; 2020; Stalder et al., 2016). Similarly, it is important to monitor stress and eating relationships dynamically in naturalistic settings. O'Connor et al. (2008) emphasised the importance of daily diary designs because of their ability to capture 'day-to-day' events as opposed to one-off indices of life stress and as well as stress-sensitive aspects of eating behaviour such as between-meal snacking. In the current study, there were three main reasons for focussing on between-meal snacking and not meal consumption. First, self-report measures of meal intake are challenging, fraught with measurement issues and are very burdensome for participants. Second, it has been argued that snacking behaviour may be more sensitive to stress-related influences due to greater variability compared to meal intake (O'Connor et al., 2008). Third, snacking may also be more under individual control than meal intake and it has been used successfully as a 'discrete' form of eating behaviour in a large number of directly related studies (e.g., Conner et al., 1999; O'Connor et al., 2005; O'Connor, Armitage & Ferguson, 2015). Finally, daily diary designs also allow the modeling of day-to-day within-person effects *together* with the impact of between-person (trait-like) factors and the data gathered using daily diaries has also been found to improve the validity of individuals' responses (Almeida, 2005; Hsu & Raposa, 2020; O'Connor et al., 2020).

The effect of stress on eating behaviour appears to influence women and men differently. Research has indicated that females are more likely to change their normal eating behaviours when experiencing stress compared to males (Klatkzin et al., 2019; Mikolajczyk et al., 2009; Sims et al., 2008; Stone & Brownell, 1994; Weinstein, Shide, & Rolls, 1997), in particular, by increasing intake of between-meal snacking, sweet foods and comfort eating (Gibson, 2012; O'Connor & Conner,

2011; O'Connor et al., 2008). However, there are fewer studies that have investigated men only and interpretation of these findings is further complicated by the fact that gender is correlated with important eating style variables such as restrained and emotional eating (i.e., women generally show higher levels of restraint). Moreover, differences have been shown in how males and females respond to stressors (e.g., Allen et al., 2017; Kudielka & Kirschbaum, 2005). For example, men have been found to release significantly higher levels of cortisol in response to stressors compared to females (Allen et al., 2017) and women are more likely to experience stress-related disorders such as generalised anxiety disorder (Baxter et al., 2013). Therefore, it is clear that gender is likely to play a role in understanding stress and eating behaviour relationships.

To summarise, the aim of the current study was to explore the effects of daily hassles *and* uplifts on eating behaviour and whether these relationships were moderated by mean daily cortisol levels (i.e., mean CAR and mean cortisol levels across the day) in young adults over 4 days.

2. METHODS

2.1. Design and participants

This study used a repeated measures daily diary design over 4 days. Participants were recruited from the School of Psychology at the University of Leeds using the School's participant pool scheme. This was a convenience sample that consisted mostly of healthy, non-overweight individuals. In total, 52 undergraduate students took part, although the data from 2 students was removed (one because of severe illness and the other because of a lack of appropriate saliva sample storage), leaving 50 participants in total. The sample consisted of 49 females and one male. However, given the imbalance and the gender differences relating to stress and eating (outlined above), the male participant was removed from the analyses. The current study and sample size were directly informed by the design and findings of Newman, O'Connor and Conner (2007). This earlier study employed a comparable daily diary design to explore the role of cortisol reactivity in the context of daily hassles and eating behaviour. This study recruited 50 female participants; therefore, given their observed cortisol effects, the current study aimed to recruit 50 participants. Participants' mean age was 19.13

years (SD = 0.87, range = 18 – 21 years) and they identified with the following ethnic groups: 40 identified as being White, 3 identified as belonging to mixed/multiple ethnic groups and 6 identified as being Asian/Asian British. The mean body mass index (BMI) for the sample was 21.32. Ethical approval from the School of Psychology's Research Ethics Committee was granted (reference number: 17-0252).

2.2. Study materials and procedure

Screening session

Participants were asked to complete a screening questionnaire to determine their eligibility for the study. If eligible (i.e., if they were happy to take part, were in good health, and had not taken any recreational drugs or steroid containing medication in the recent past), participants were asked to complete a baseline questionnaire which asked questions on their age, gender, ethnicity, medication-taking behaviour. During this session, participants' height and weight were also measured. At the end of the session, participants were informed of the remaining study elements (described below).

2.2.1. Online daily diaries

Participants were asked to complete 4 online daily diaries, one each evening of the 4-day study. The diaries asked participants to record any experience they encountered that day that they believed to be either a hassle or an uplift (definitions and example experiences were given). Participants were given space to report up to 5 daily hassles and 5 daily uplifts on any one given day. We utilised a more open-ended approach by allowing participants to freely report any experience that they believed was a daily hassle (defined as, "Hassles are events, thoughts or situations which, when they occur produce negative feelings such as annoyance, irritation, worry or frustration, and/or make you aware that your goals and plans will be more difficult or impossible to achieve", O'Connor et al., 2008; p. S20) or a daily uplifts (defined as "being the opposite to a daily hassle – a positive experience such as the joy derived from manifestations of love, relief at hearing good news, the pleasure of a good night's rest and so on"). This approach mirrors the approach used originally by Conner et al. (1999) and has the advantage of not constraining respondents to a limited number of

different types of events, helps reduce participant burden and is easy to administer on a daily basis (O'Connor & Ferguson, 2016). Moreover, a pilot study showed that scores using the current open-ended, free response measure of daily hassles and daily uplifts were each significantly associated with the much longer (53-item) Daily Hassles and Uplifts Scale (DeLongis, Folkman, & Lazarus, 1988) measure of hassles and uplifts. This confirms the concurrent validity of our open-ended measure of both hassles and uplifts. It is also worth noting that a separate 2 week pilot study showed that when participants were not restricted on the number of daily hassles entries they could make, no participant reported more than 5 per day. A daily hassles and uplifts score (respectively) was created by summing the total number of daily hassles or uplifts that had been reported.

In addition, participants were asked to report any between-meal snacks that were consumed that day, and the questionnaire provided space to record up to 5 snacks per day. The between-meal snacks were coded into total number of unhealthy or healthy snacks based on whether they contained high levels of sugar and/or fat. These categorisations were made using food composition tables from the work of McCance and Widdowson (2014). If a snack contained either high levels of sugar and/or fat, it was deemed unhealthy (e.g., chocolate), if a snack contained low levels of sugar and fat, it was deemed healthy (e.g., carrot and cucumber sticks). For example, a food was classified as being high in (total) fat if it consisted of more than 17.5 grams of fat per 100 grams of food. For sugar, a food classified as being high in sugar if it contained over 22.5 grams of sugar per 100 grams of food. The snacks were initially all coded by the primary researcher (RM). However, a colleague also independently coded 10% of the total between-meal snacks reported (n = 36) to determine the inter-rater reliability of the coding process. This resulted in inter-rater reliability scores that reflected substantial agreement ($k = 0.78$ and $k = 0.85$).

Participants were asked to complete each questionnaire as close to their bed time as possible and received an email reminder each day of the study at 5pm. The online survey system (Jisc Online Surveys) recorded the completion time and date of each questionnaire entry (allowing back dated completions to be removed). If a questionnaire was completed after 3am the day after which it was required, it was removed from further analysis and was treated as a missing entry (of which there

were 11/192). When accounting for and removing missing and back-filled diary entries, there was a final total of 181 diary entries.

2.2.2. Diurnal cortisol samples

Across the 4-day study, participants were asked to provide 12 saliva samples. More specifically, 3 samples each day: the first upon waking, the second 30 minutes post-waking, and the last, 12 hours post-waking. Participants were given a test sample during the screening session to familiarise themselves with the procedure and to enable them to ask any questions about the process. To provide a saliva sample, individuals were asked to place a cotton swab under their tongue for 2 minutes. After this duration, individuals put their cotton swab into a salivette tube (Stratech, UK). Participants were instructed to refrain from eating, drinking caffeine, alcohol, acidic drinks, smoking, and brushing their teeth immediately before and during sample taking. Participants were instructed to place each sample in their freezer until the samples were to be returned to the primary researcher. The primary researcher stored individuals' samples in a departmental laboratory freezer set to -20°C. After all participants' samples were gathered, samples were packaged using dry ice and were couriered to an external laboratory for assaying. Cortisol levels were determined by using a competitive enzyme-linked immunosorbent assay kit (ELISA) designed for analysing saliva. Intraassay and weighted interassay coefficients of variation (CV) of the assay in the current study were 5.71% and 5.98% respectively.

2.2.3. Operationalising cortisol measures

In order to obtain more reliable, trait-like estimates (as recommended by Stalder et al., 2016) mean daily cortisol measures over the 4-day study period were calculated to capture the mean CAR and the mean total cortisol output per day. Including these measures allowed us to capture the two distinctive aspects of daily cortisol production: the CAR and an indicator of total cortisol secretion across the day (mean cortisol). Specifically, CAR was calculated as the mean difference between the waking sample and the 30 minutes post-waking sample across the 4 days. Similarly, the total cortisol measure was calculated as the mean of all 3 samples across each of the 4 days.

2.2.4. Treatment of cortisol data

In total, 600 saliva samples were sent off for assay, however, 33 samples (5.5%) were returned without a reading. Within these missing samples, 25 (4.17%) contained insufficient content so could not be assayed (this could have been due to an absence of/or insufficient amount of saliva within each sample). In addition, 8 further samples gave readings that the laboratory advised we treat with caution. Five of these eight samples had low levels of cortisol (very close to or below the lower limits of assay reading) and 3 had exceptionally high readings (and were likely due to contamination).

To treat these missing sample readings, 2 different strategies were employed. For the 25 insufficient samples, the appropriate column mean values were inserted. Roth (1994) stated that this approach of 'mean substitution' is suitable because it reduces the influence of 'variance estimations' that can arise if a different strategy for treating missing data is chosen. The remaining 8 samples that were deemed either too low or too high for use were treated by truncating the sample using the formula 'column mean +/- 2.5x SD'. For the 5 samples that were too low for assay, the truncation subtracted 2.5 times the (sample) SD value, however, for the last 3 samples that contained samples that were too high, the truncation added 2.5 times the (sample) SD value on to the sample mean. This strategy was chosen to avoid the need to remove these specific data points, and to reduce the negative effect such small/large values would have had on the dataset as a whole.

The CAR is heavily influenced by the timing of the first sample upon awakening and whether participants are adherent to the study protocol. Thorn et al. (2006) have argued that it is possible to detect potentially non-adherent participants in non-clinical samples by identifying individuals who show no rise in cortisol following awakening. Therefore, we probed for participant non-adherence and found 43 samples (from 600; 7.17%) that exhibited no increase between first and second samples. Therefore, these samples were removed from the analyses and not included in the calculations for the mean CAR or mean cortisol levels (described above). Moreover, the importance of the sample times was impressed on participants: it was made clear that it would be apparent from the cortisol levels if they had failed to adhere to the protocol. In addition, all participants received an accelerometer (GeneActiv) device to wear on their wrist during the study day. This was also to improve adherence to

the cortisol sampling protocol as the participants were aware that we were monitoring their wake and sleep times (though, these data were not analysed due to technical reasons). Inspection of the cortisol variable before analyses revealed they were skewed. Therefore, mean CAR and mean cortisol levels were log transformed, however, the untransformed values are reported in the descriptive statistics table (Table 1) for ease of interpretation.

2.2.5. Study duration

The study spanned across 5 days. On day 1, participants were invited to a screening session, where their suitability was confirmed. If participants met the inclusion criteria, they were given information about the study, and were asked to complete a screening and demographics questionnaire. The study started the following day (day 2) and took place over the next four days (days 2 - 5).

2.3. Statistical Analysis

Multi-level modeling was conducted using the Hierarchical Linear Modeling (HLM) Student Version 7 software. This analysis enables both within and between subject level variables to be compared simultaneously in the same model. The data was considered to have a two-level hierarchical structure. Level 1 variables (e.g., daily hassles, between-meal snacking) were group mean centred (i.e., to subtract the individual's group mean from the individual's score) and modelled as random as it was assumed that each of the within-person variables would vary from day to day. The level 2 variables (mean CAR and mean total cortisol) were grand mean centred (i.e., to subtract the grand mean of the predictor using the mean from the full sample) and assumed to be fixed. The main analyses consisted of two HLM models, one run for daily healthy snack intake and one for daily unhealthy snack intake. In each model, daily hassles and uplifts were entered as level 1 variables and mean CAR and mean cortisol as level 2 variables. BMI was entered as a covariate in both models. Each model allowed us to: i) investigate the effects of daily hassles and uplifts on snack intake, ii) the main effects of mean CAR and mean cortisol levels on snack intake, and iii) whether the daily hassles/uplifts – snacking relationships were moderated by mean CAR or mean cortisol levels. Significant cross-level interactions were decomposed using Preacher and colleagues' online simple

slopes procedures based on mean-centred scores (Preacher, Curran & Bauer, 2018). In addition, in order to tease apart any within-person and between-person effects of daily hassles and uplifts on the eating behaviour outcomes, we also created person-level variables by averaging these across the 4-day time window. In these analyses, we re-ran the two main HLM models with the within-person variable (e.g., daily hassles/uplifts) at level 1 together with the between-person variables (e.g., person-level average of daily hassles and uplifts at level 2).

3. RESULTS

3.1. Descriptive Statistics

Table 1 provides a summary of main study variables. The mean number of daily hassles and daily uplifts experienced by participants was around 2 with a range from 0 to 5. There was wide variety of daily stressors and uplifts reported by participants. For the stressors, these included university related stressors (e.g., "having to finish the practical report and submit it before tomorrow" and "one difficult lecture went a bit too fast for me"), family/relationship stressors (e.g., "argument with friend" and "family conflict") and some physical stressors (e.g., "becoming poorly with flu"). For the uplifts, these included things like: "doing well in a presentation", "buying new shoes", "friend surprising me with pancakes".

The mean number of snacks consumed per day was a marginally higher for unhealthy snacks (mean 2.20; range 0-6) compared to healthy snacks (mean 1.55; range 0-6). These figures are comparable with other daily diary studies of stress and eating (e.g., Newman et al., 2007; O'Connor et al., 2008). The participant's salivary cortisol levels were within the normal range for adults (O'Connor et al., 2009; Pruessner et al., 2003). Table 1 shows that participants' mean cortisol levels were lowest 12 hours after waking, a pattern that has been frequently identified within existing literature (e.g., Dowd et al., 2010; Šupe-Domić et al., 2016).

3.2. Effects of daily hassles, daily uplifts and cortisol levels on daily healthy snack intake

HLM results (Table 2) showed there was a significant main effect of mean CAR on daily healthy snack intake (β = -0.94, p = 0.016) such that high levels of mean CAR were associated with lower daily healthy snack intake. Daily uplifts (β = -0.25, p = 0.03), but not daily hassles (β = 0.13, p =0.23), were significantly associated with lower healthy snack intake. Moreover, the effects of daily uplifts on healthy snacking were found to be moderated by mean daily cortisol levels (β = -1.72, p =0.006). This interaction was decomposed using simple slopes (see Figure 1). These analyses showed that total uplifts were negatively associated with healthy snack consumption at high (β = -0.55, p = 0.001), and moderate levels of mean cortisol (β = -0.19, p = 0.052) but not at low levels of mean cortisol (β = 0.18, p = 0.159) indicating that participants with the highest levels of mean cortisol consumed less healthy snacks on days when they experienced uplifts. BMI was unrelated to healthy and unhealthy snack intake.

3.3. Effects of daily hassles, daily uplifts and cortisol levels on daily unhealthy snack intake

In contrast to healthy snack intake, the results showed there were no significant main effects of mean CAR (β = 0.22, p = 0.60) or mean cortisol levels (β = -0.54, p = 0.56) on daily unhealthy snack intake (Table 2). However, the analyses found that daily hassles (β = 0.41, p = 0.004) and daily uplifts (β = 0.46, p =0.005) were both significantly associated with higher unhealthy snack intake. In terms of the cross-level interactions, mean CAR did not moderate the daily hassles - unhealthy snacking (β = -0.36, p = 0.41) or the daily uplifts – unhealthy snacking relationship (β = 0.12, p = 0.80). Similarly, mean cortisol levels did not moderate the daily hassles - unhealthy snacking (β = -0.32, p = 0.60) or the daily uplifts – unhealthy snacking relationship (β = -0.12, p = 0.86).

As outlined earlier, we also explored the effects of the within person daily hassles and uplifts on healthy and unhealthy snack intake while including the person-level version of the daily hassles and uplifts variables in order to tease apart any potential within-person and between-person effects. However, none of the person-level variables was statistically significant and the results for within-person variables remained unchanged (data not shown).

4. DISCUSSION

Three main findings emerged from the current study. First, daily hassles *and* uplifts were associated with a greater intake of unhealthy snacks, but only daily uplifts were associated with lower healthy snack intake. Second, a higher mean CAR was associated with lower healthy snack intake. Third, mean cortisol levels moderated the daily uplifts - healthy snacking relationship, such that participants with the highest levels of mean cortisol consumed less healthy snacks on days when they experienced uplifts.

It is well established that daily hassles and stressors are associated with increased unhealthy food intake and that these effects are often stronger and more robust in females (Araiza & Lobel, 2018; O'Connor & Conner, 2011). Numerous studies have shown that daily stressors can disrupt habitual eating behaviours. O'Connor et al. (2008), in a large daily diary investigation over 28 days, showed that daily hassles were associated with increased consumption of high fat, energy dense snacks together with a reduction in vegetable intake and main meals. Similar patterns have been observed in children and adolescents (Hsu & Raposa, 2020; Moss et al., 2020b;). For example, Hsu and Raposa (2020) showed in a daily diary investigation that on days with high perceived stress and more daily negative life events, adolescents reported elevated rates of craving tasty foods and trouble stopping the consumption of tasty foods. However, the findings here that daily uplifts are also key determinants of higher unhealthy snack consumption *and* lower healthy snack consumption are important and noteworthy. The findings for unhealthy snacking are consistent with earlier work in mixed samples of men and women that has shown that positive emotion (as well as negative mood) can trigger unhealthy food consumption (Evers et al., 2013; Moss et al., 2020a; Richenberger et al., 2018). Interestingly, Evers et al. (2013) found that higher caloric snack intake in a daily life study was reported to result more often following positive emotions than following negative emotions. However, our finding that daily uplifts are associated with lower healthy snack intake is particularly novel and suggest that positive emotions have the capacity to disrupt the intake of healthier foods, such as fruit and vegetables, that form the basis of a balanced diet. Therefore, as Evers and colleagues (2013) have argued, there is a need to understand the extent to which food consumption is triggered by emotional arousal in general, or by emotional valence specifically. The current findings suggest that general

arousal may be key and they also highlight the importance of future research including assessment of healthy as well as unhealthy food consumption.

This study also found, for the first time, using a daily diary design that aspects of HPA axis functioning, as indicated by mean CAR levels, were associated with lower healthy snack consumption. It also showed that mean daily cortisol levels interacted with positive daily events to predict lower healthy snack intake. Surprisingly, mean CAR and mean cortisol were not found to be significantly related to unhealthy snacking or to moderate the daily hassles/uplifts – unhealthy snacking relationship. Taken together, we feel these results are noteworthy, novel and warrant replication and further investigation. Moreover, the differential effects of hassles/uplifts and daily cortisol levels on healthy and unhealthy snacking may be explained, in part, by Adam and Epel's (2007) Reward Based Stress Eating model. As outlined earlier, the latter model suggests that cortisol may influence the reward value of food (via neuroendocrine/peptide mediators such as leptin, insulin and neuropeptide Y), and as such, higher levels of daily cortisol may *promote* glucocorticoid-induced and insulin-delineated palatable food intake, which at the same time may *demote* the reward value of healthy foods. That is, over time this process may lead to the formation of stronger associations between "feeling stressed" (hassle) or "feeling happy" (uplift) following consumption of high energy dense, palatable food, such that hassles and uplifts become more reliable triggers of unhealthy foods (cf., Dallman, 2010). In contrast, over time, higher levels of cortisol may become less associated with the consumption of healthy foods and/or simply inhibit the motivation to consume more healthy, less energy-dense palatable foods. Therefore, the current findings open up the possibility, that when daily hassles and uplifts are considered together with healthy and unhealthy snacks in the same investigation (which few, if any, previous studies have examined), that the effects of general arousal triggered by daily hassles and uplifts are pre-imminent for unhealthy snacking (possibly due to the formation of stronger associations), and the effects of daily cortisol are more important for understanding healthy snack consumption. These possibilities notwithstanding, we recognise that the important next steps for research in this area is to attempt to replicate the current findings in a larger, more representative sample, over a longer period of study. This will help elucidate the precise causal relationships between daily hassles/uplifts, cortisol levels and healthy and unhealthy eating behaviour.

In addition, future research ought to utilise a signal-contingent daily diary approach (e.g., use experience sampling) to measure daily hassles and uplifts.

There are a number of shortcomings of the current study that require additional comment. First, we are aware that the sample size included in this study might be considered small in relation to other large scale investigations of stress and eating. However, it is worth noting that the current study design and sample size were directly informed by the approach and findings of Newman, O'Connor and Conner (2007). This earlier study also employed a comparable daily diary design to explore the role of cortisol reactivity in the context of daily hassles and eating behaviour with a similarly sized sample. In addition, the current study also includes all the strengths of adopting a within-participant, daily diary design (e.g., multiple observations, using each participant as their own control etc.). Nevertheless, it is clearly important that future studies attempt to replicate the effects observed here before firm conclusions can be drawn. We also recognise that there was some evidence of participant suspected non-adherence to protocol, despite participants receiving clear instructions, wearing an accelerometer and a briefing that the experimenter would be able to identify non-compliance by inspecting their cortisol profiles. We are also aware that using the suspected non-adherence analysis does not eliminate potential issues with participants who only partially adhere to the sampling instructions. That said, it is important to highlight that the suspected non-adherence rate was only 7% and these data were not included in the analyses, therefore, the impact of protocol non-compliance is likely to be negligible. We are also aware that the between-meal snacking data were self-reported and that we did not utilize a more objective measure such as a detailed daily dietary assessment method such as '24-h recall' or use smartphones to photograph snack intake. The primary reason for this approach was that we were concerned that using such methods might impact negatively on recruitment and also that detailed daily assessment can be considered burdensome and may influence participants' normal eating. In addition, comparable daily methods assessing discrete aspects of eating behaviour (e.g., between-meal snacking) have been found to be reliable and valid measures of food intake (e.g., Conner, Fitter & Fletcher, 1999; O'Connor et al., 2008). We are also aware that different individuals may have a tendency to report varying numbers of daily hassles/uplifts, with some reporting more and some less than others. Such between-participant factors (e.g., personality traits

such as conscientiousness) may influence the degree to which daily events are seen as a hassle/uplift (although, a strength of the current design was that each participant acts as their own control) and potentially impact on the current results. We are also mindful of the issues relating to psychological research being conducted in Western, Educated, Industrialized, Rich, Democratic (WEIRD) populations (Henrich, Heine, & Norenzayan, 2010) and that the current sample consists of healthy weight woman only. Therefore, the extent to which any of the current findings can be generalised to men, as well as to overweight or obese individuals or non-WEIRD samples is unknown. Future research should endeavour to recruit equal numbers of men and women in order to elucidate whether the effects of daily hassles and uplifts, and cortisol reactivity to stress are comparable or different in the context of stress and eating. Moreover, in the current study, it is possible that some of the observed effects of daily hassles and uplifts on between-meal snacking may be different in individuals from lower socio-economic and minority groups (e.g., 82% of current sample identified as being White). For example, Spinosa et al. (2019) have recently shown that psychological distress and subsequent emotional eating represent important pathways linking lower socio-economic status and obesity. Sims et al. (2009) found that perceived stress was associated with emotional eating in a community-based sample of African Americans. However, little is known about the precise mechanisms involved and whether daily uplifts as well as daily hassles are associated with unhealthy eating patterns in lower as well as higher socio-economic and minority groups. Therefore, future research ought to explore further the effects of these important between-participant factors using more sophisticated research designs.

To conclude, the current study found that daily hassles *and* uplifts were associated with a greater intake of unhealthy snacks and but only daily uplifts were associated with lower intake of healthy snacks. Higher levels of mean CAR were associated with lower daily healthy snack intake and the effects of daily uplifts on healthy snacking were found to be moderated by mean daily cortisol levels, such that participants with the highest levels of mean cortisol consumed less healthy snacks on days when they experienced uplifts. The current study provides novel evidence that daily cortisol levels, as well as daily hassles and uplifts, are implicated in daily snack consumption. The role of

hypothalamic-pituitary adrenal axis activity should be explored further in the context of the daily hassles/uplifts and eating behaviours relationship.

Author Contributions

RM, DO and MC identified a gap in the literature and designed this study. RM recruited participants and undertook data collection. RM conducted data analysis with supervision from DO and MC. DO, RM and MC wrote this manuscript and all authors are willing to be accountable for this piece.

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Conflict of interest

None

Ethical standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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Table 1. Descriptive statistics for main study variables (n = 49)

	Mean	SD
Daily measures		
Total daily hassles	1.82	1.13
Total daily uplifts	1.91	1.07
Healthy snacks	1.55	1.59
Unhealthy snacks	2.20	1.80
Cortisol measures		
Mean cortisol (nmol/L)*	8.04	3.18
Mean CAR (nmol/L)**	6.45	5.42
Waking (nmol/L)	7.63	3.95
+ 30 minutes (nmol/L)	14.08	6.24
+ 12 hours (nmol/L)	2.59	2.28

Note. * = mean of all three daily samples; ** CAR = cortisol awakening response (change in cortisol between waking and + 30 minutes)

Table 2. Hierarchical linear modeling results: effects of mean CAR, mean cortisol and daily hassles/uplifts on healthy and unhealthy snack intake (n = 49)

	Healthy snacks				**Unhealthy snacks**			
	Symbol	**Coefficient**	**SE**	**P**	**Symbol**	**Coefficient**	**SE**	**P**
Intercept	β_{00}	1.64	0.17	<.001	β_{00}	2.17	0.17	<.001
BMI	β_{01}	0.05	0.05	0.276	β_{01}	0.01	0.04	0.938
Mean CAR	β_{02}	-0.94	0.38	0.016	β_{02}	0.22	0.43	0.603
Mean cortisol	β_{03}	-0.28	0.96	0.775	β_{03}	-0.54	0.91	0.558
Hassles-snack intake slope	β_{10}	0.13	0.10	0.230	β_{10}	0.41	0.14	0.004
Mean CAR	β_{11}	-0.64	0.34	0.064	β_{11}	-0.36	0.43	0.412
Mean cortisol	β_{12}	-0.19	0.48	0.700	β_{12}	-0.32	0.60	0.601
Uplifts-snack intake slope	β_{20}	-0.25	0.11	0.033	β_{20}	0.46	0.16	0.005
Mean CAR	β_{21}	0.24	0.37	0.525	β_{21}	0.12	0.49	0.801
Mean cortisol	β_{22}	-1.72	0.59	0.006	β_{22}	-0.12	0.66	0.861

Figure 1. The relationship between total uplifts and healthy snack intake at different levels of mean cortisol levels.