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Low craving control predicts increased high energy density food intake during the COVID-19 lockdown: Result replicated in an Australian sample.

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Abstract

This research aimed to replicate a previous UK-based finding that low craving control predicts increased intake of high energy density foods (HED) during the COVID-19 lockdown, and extend this finding to adults living in Victoria, Australia. The study also assessed whether acceptance coping moderates the relationship between craving control and increased HED food intake, and examined the associations between trait disinhibition, perceived stress and changes to HED food intake. An online survey completed by 124 adults living in Victoria, Australia (total eligible n = 147; 38.5 ± 12.9 years) during the COVID-19 lockdown showed that 49% of participants reported increased overall food intake, and 21-29% reported increased intake of HED sweet and savoury foods during the COVID-19 lockdown. Of the eating behaviour traits assessed, low craving control was the only significant predictor of increased HED sweet and savoury food intake (cognitive restraint, disinhibition and emotional eating were non-significant predictors). Perceived stress was associated with reported increases in overall savoury and sweet snack intake, but was not significantly associated with changes to specific HED food groups (sweet and savoury). In this sample, acceptance coping did not significantly moderate the relationship between craving control and increased HED food intake. Based on these replicated findings, further trials should now consider interventions targeting craving control to promote controlled food intake in individuals at-risk of weight gain during the current COVID-19 and future potential lockdowns.

Keywords: COVID-19 lockdown, craving control, eating behaviour traits, food intake, high energy density foods, acceptance coping, replication.

1.1 Introduction

Studies from multiple countries have identified the COVID-19 lockdowns as a risky time period for some individuals to increase food intake (e.g. Ammar et al., 2020; Buckland et al., 2021; Deschasaux-Tanguy et al., 2020; Herle, Smith, Bu, Steptoe, & Fancourt, 2021; Sidor & Rzymski, 2020). In a predominant UK sample, Buckland et al., (2021) found that 48% (268 out 559) of adults reported increased food intake during the COVID-19 lockdowns, with increased intake more common for snacks than meals. In another sample of 22,374 UK adults, 28% reported increased food intake at some point during the COVID-19 lockdown (including 16% who reported persistent increased intake) (Herle et al., 2021). Such increased food intake may be due to a number of disinhibiting factors that viral lockdowns are associated with, including increased boredom, stress, loneliness and other negative emotions (Brooks et al., 2020; Cherikh et al., 2020; Herle et al., 2021).

Given that the existing evidence indicates individual variability in food intake in response to the COVID-19 lockdowns (e.g. Buckland et al., 2021; Herle et al., 2021), it is important to identify which groups of individuals are most susceptible to increased food intake. Psychometric eating behaviour traits linked with increased food intake can be targeted in future interventions to promote controlled food intake in those susceptible. Buckland et al., (2021) examined the role of several widely used eating behaviour traits in changes to high energy density (HED) food intake during the COVID-19 lockdown. Of note, in Buckland et al., (2021), the term HED was used to refer to foods that are commonly reported to be difficult to resist or control intake of, given that many of these foods are high in energy density (Christensen, 2007; Hill & Heaton-Brown, 1994; Roe & Rolls, 2020). While a number of traits were significantly associated with increased HED food intake (e.g. emotional over/undereating), craving control - the ability to resist food cravings and control food intake (Dalton, Finlayson, Hill, & Blundell, 2015), was the strongest predictor of increased HED sweet and savoury food intake. Low cognitive restraint was also a significant predictor of increased HED sweet food intake (not significant for savoury intake), and the models explained between 6 and 12% of variance in reported dietary changes. Further unplanned analysis showed that adopting an acceptance coping response attenuated the relationship between craving control and HED sweet food intake. To date, the results for these eating behaviour traits have yet to be replicated.

In recent years, within the science of Psychology (and other sciences), there has been increased recognition of the importance of replicating results (Diener & Biswas-Diener, 2020). This recognition has been driven by the replication crisis, whereby assessment of published psychological studies showed that only 36% could be replicated (Open Science Collaboration, 2015). Replicating findings in a different sample and/or contexts increases confidence that the reported results are true (Diener & Biswas-Diener, 2020), and therefore increases confidence to apply study results to inform interventions, public health, and clinical practice. While the finding that only a sub-group of individuals report increased food intake in response to the COVID-19 lockdowns has been observed across multiple studies (e.g. Buckland et al., 2021; Herle et al., 2021), no other studies have assessed craving control, and therefore none have as yet replicated Buckland et al.'s (2021) finding that craving control significantly predicts increased food intake. Replicating this finding is important to increase empirical support for testing craving control-based interventions to prevent increased food intake and ultimately increased risks of weight gain and obesity during the current and future potential pandemics (Marchitelli et al., 2020; Pellegrini et al., 2020). Additionally, while widely used traits were included in Buckland et al., trait disinhibition, the tendency to eat opportunistically (Bryant, King, & Blundell, 2008) was not assessed. Disinhibition has previously been linked to increased preferences for high-fat foods, increased food intake, increased BMI, increased body weight and poorer weight loss outcomes (Bryant et al., 2008; Bryant, Rehman, Pepper, & Walters, 2019). Therefore, trait disinhibition may have an important role in intake of HED foods during the COVID-19 lockdowns. Furthermore, although Buckland et al., (2021) suggested that stress may explain increased HED food intake, no measures of perceived stress were collected to confirm this.

This research aimed to conceptually replicate and extend the finding that craving control is an important psychometric trait that predicts increased HED food intake during COVID-19 lockdowns. Specifically, the study aimed to assess whether this finding generalises to a sample of adults living in Victoria, Australia during the COVID-19 lockdown. Additionally, this replication assessed the roles of trait disinhibition and stress in reported changes to HED food intake during the COVID-19 lockdown in Victoria, Australia. Furthermore, the study aimed to test whether adopting an acceptance coping response moderated the relationship between craving control. In line with previous research, it was hypothesised that there would be individual variability in reported changes to food intake and that most participants would report dietary changes. It was also hypothesised that low craving control, low restraint, high disinhibition, high emotional eating and high perceived stress would be significantly associated with increased intake of HED sweet and savoury HED foods, and that low craving control and low cognitive restraint would be significant predictors of increased HED sweet and savoury foods (with craving control being the strongest predictor). Finally, in line with Buckland et al., (2021) it was expected that scoring high in acceptance coping would attenuate the relationship between craving control and increased HED food intake. Hypotheses, study methods and the data analysis plan were pre-registered on Open Science Framework (https://osf.io/vc285/).

1.2 Methods

1.2.1 Participants

Recruitment strategies targeted Australian adults (≥18 years old) living in Victoria, Australia during the COVID-19 lockdown. Data was collected online via Qualtrics (Provo, UT) in August and September 2020 via an amended survey to the one used in Buckland et al., (2021) (amendments were approved by the University of Sheffield's ethics committee). In total, 206 participants accessed the survey. Of the 158 participants providing consent, 147 were eligible (excluded n = 11: not living in Victoria, AU n = 2; eating disorder n = 9) and of these, 124 completed the survey. Data was retained in the analysis up to the point that participants withdrew from the survey, therefore sample sizes reported vary depending on the variables reported. All participants completed the survey when Victoria was under strict stay-at-home orders, whereby residents were permitted to leave home only for essential purposes (care or medical reasons, shopping for essentials, physical activity and essential work e.g., doctor, nurse, care worker). Under lockdown orders, non-essentials shops closed and only essential shops (e.g. supermarkets and pharmacies) remained open. Most participants were female (n = 98; male n = 41; non-binary n = 3; other and prefer not to say n = 1) and lived in Melbourne, the capital of Victoria (n = 128; other n = 16). Table 1 shows additional participant characteristics. Of note, most participants were white, reported having a healthy weight, had at least a Bachelor's degree and earned over $91,000.

The recruited sample size was lower than the *a priori* power calculations which estimated that 154 participants were needed to detect a conservative small-to-medium effect of $f^2 = 0.09$ (based on Buckland et al., 2021, where effect sizes ranged between $f^2 = 0.06$ to 0.13) with five predictors (habitual food intake, craving control, cognitive restraint, disinhibition and emotional eating). Of note, while the final sample size fell short of the targeted estimated sample, it was within the required range for the least conservative power calculations based on Buckland et al., (2021; using the largest effect size of $f^2 = 0.13$ yielded an estimated required sample size of 108 participants).

1.2.2 Measures

A summary of measures used will be reported in brief, as the study measures were identical to those used in Buckland et al., (2021) with the exception of cultural adaptations and removal and additions of psychometric eating behaviour trait questionnaires as detailed below.

1.2.2.1 Reported changes to food intake and habitual food intake

Overall changes to food intake ('Has the amount of food you have eaten changed since the lockdown?'), snack intake [overall snack intake, sweet food intake and savoury snack food intake;

e.g. 'Has the amount of sweet snack foods (e.g. chocolate, cakes, pastries, biscuits, lollies etc.) that you have eaten changed since the lockdown?')] and meal intake ['Has the amount you have eaten at meals (e.g. breakfast, lunch, dinner) changed since the lockdown?'] were measured with the questions developed and reported in Buckland et al., (2021).

For changes to HED sweet and savoury food groups, and habitual food intake [assessed with an adapted version of the Food Frequency Questionnaire (FFQ) (Mulligan et al., 2014)], participants reported changes to specific food items that were culturally adapted from Buckland et al., for an Australian sample. For the cultural adaptation, the foods remained the same but the naming or branding of foods changed where relevant, for instance, 'sweets e.g. jellies, hard boiled, toffees, mints' was changed to 'lollies, e.g. jellies, hard boiled, toffees, mints'; 'Crisps or other packet savoury snacks, e.g. Wotsits' was changed to 'Crisps or other packet savoury snacks, e.g. Cheezels'). In line with Buckland et al. (2021), scores for individual food items were averaged to compute overall scores for HED food groups (HED sweet snacks, HED savoury snacks and HED savoury meal foods; both for reported changes and for habitual food intake). A full list of the food items is shown in Supplementary Materials, Table 1. All food groups showed good internal reliability (Cronbach's α ranging from 0.66 – 0.89).

For overall intake, and HED food groups, possible scores ranged from '-50 = I eat a lot less' to '0 = no change' to '100 = I eat a lot more'. Following Buckland et al., (2021) scores ≤-6 were classified as decreased intake, scores ranging between -5 and +5 were classified as no change, and scores ≥6 were classified as increased intake. This range was chosen to allow room for response errors when participants selected no change, as a no change response still required participants to drag the cursor and position it on the rating scale). The categorising of scores allowed us to use responses to changes in HED sweet and savoury food groups both categorically (to report frequencies) and continuously (to assess associations between variables). For habitual intake, possible scores ranged from '0 = never or less than once a month' to '8 = 6+ times a day.' Of note, no pre-COVID-19 measures were collected and as such, the changes reported reflect *perceived* rather than *actual* changes in food intake.

1.2.2.2 Eating behaviour traits

In line with Buckland et al., (2021) craving control was measured with the Control of Eating Questionnaire (COEQ; (Dalton et al., 2015); current study (all internal consistencies reported refer to the current study) Cronbach's α = 0.94], and the revised Three Factor Eating Questionnaire (TFEQ; Karlsson, Persson, Sjostrom, & Sullivan, 2000) was administered to assess cognitive restraint (Cronbach's α = 0.75). Unlike Buckland et al., the full 18-item TFEQ was administered to also assess disinhibited eating (uncontrolled eating; Cronbach's α = 0.84) and emotional eating (Cronbach's α = 0.85). Responses were collected on a 4-point scale. Items were summed to give a total score per subscale with higher scores indicating higher levels of each trait. Buckland et al., (2021) also assessed food responsiveness, enjoyment of food, emotional overeating/undereating and satiety responsiveness (Hunot et al., 2016), but as these were non-significant predictors of changes to HED food intake, these traits were not assessed here.

1.2.2.3 Coping strategies and perceived stress

Acceptance coping was assessed with two items from the Brief Cope Questionnaire (Carver, 1997). Perceived stress during the COVID-19 lockdown period was assessed with the Perceived Stress Scale, with higher scores indicating greater perceived stress (S. Cohen, Kamarck, & Mermelstein, 1994).

1.2.3 Procedure

The procedure was the same as reported in Buckland et al., (2020). In brief, after providing informed consent, participants completed socio-demographic questions, indicated changes to overall food intake, changes to HED food items and habitual food intake. Participants then completed the TFEQ and COEQ, before randomly completing measures of perceived stress, acceptance coping, and other measures not reported here (physical activity levels, sleep changes, well-being and boredom). Participants then indicated final socio-demographic questions [including subjective social status (Adler & Stewart, 2007), self-reported height and weight to allow for BMI (kg/m^2) to be computed; and self-reported weight status (underweight, healthy weight, overweight, obese)], indicated survey recruitment source and were debriefed. Upon completion of the survey, participants had the opportunity to be entered into a prize draw to win one of 4 $50 Amazon vouchers. For quality control, the survey comprised of two attention check questions (e.g. "From the options below select 'Green'") which all participants answered correctly.

1.2.4 Data analysis

The analysis plan was registered prior to conducting the data analysis (https://osf.io/vc285/). To assess associations between reported changes in food intake [changes in overall intake, snack intake, meal intake and changes to HED sweet and savoury foods) and eating behaviour traits and perceived stress, bivariate correlations (Pearson's r) were conducted. Alpha was set at $p < .01$ to account for the number of associations examined. Correlation coefficients were interpreted as 0.1 small, 0.3 medium and 0.5 large (Cohen, 1988). Following bivariate correlations, three separate stepwise linear regression models were developed, whereby the dependent variable entered was either: changes in HED sweet snacks, changes in HED savoury snacks or changes in HED savoury meal foods. Each model controlled for habitual food intake (FFQ) (step 1, stepwise method), before all eating behaviour traits (craving control, restraint, disinhibition and emotional eating) were entered into each model (step 2, stepwise method). Each regression model was checked for statistical outliers as per standardised residuals and Cook's Distance (all assumptions were met). There were also no issues with multicollinearity as based on the Variance Inflation Factor (< 10), and Tolerance values (> 0.2) (Tabachnick & Fidell, 2007).

Three PROCESS (Hayes, 2017) moderation analyses were conducted to test acceptance coping as a potential moderator of the relationships between craving control and HED sweet snacks, savoury snacks and savoury meal foods. Habitual food intake was included in each model as a covariate. As a deviation from the pre-registered plan, gender was not controlled for in the moderation analyses in order to retain as large a sample size as possible (models were unable to account for participants identifying as non-binary, other or prefer not to say). For regression and moderation analyses, alpha was set at $p < .05$. All statistical analyses were performed using IBM SPSS Statistics for Windows (Version 26.0. Armonk, NY).

1.3 Results

1.3.1 Reported changes to food intake

For changes to overall food intake and overall snack intake, 49% (n = 68) reported increased intake, with the remaining sample reporting either decreased intake or no change [decreased: 26% (n = 37) for overall intake; 25% (n = 35) for snack intake; no change: 25% (n = 35) for overall intake; 26% (n = 37) for snack intake]. For changes to overall sweet snack intake, 51% (n = 71) reported increases, 24% (n = 34) reported no change and 25% (n = 35) reported decreased intake. For changes to overall savoury snack intake, 41% (n = 57) reported increases, 26% (n = 36) reported decreases and 34% (n = 47) reported no change. For changes to meal intake, 44% (n = 62) reported no changes, 30% (n = 42) reported decreased intake and 26% (n = 36) reported increased intake.

For changes to HED sweet, savoury snack and savoury meal food intake, 25% (n = 34), 29% (n = 39) and 21% (n = 28) reported increased intake, respectively. In contrast, 48% (n = 65), 55% (n = 75) and 56% (n = 76) reported no changes to HED sweet foods, savoury snacks or savoury meal foods, respectively. The remaining participants reported decreased intake of HED sweet, savoury snacks and savoury meal foods [27% n = 37; 16% (n = 22) and; 24% (n = 32), respectively]. This pattern of percentages of participants reporting no changes, increased and decreased intake for overall intake, overall snack intake, meal intake and HED food groups is similar to the percentage distribution reported in Buckland et al., (2021).

1.3.2 Associations between perceived stress and changes to food intake

Bivariate correlations (n = 124; conservative alpha level of $p < .01$ applied) showed that greater levels of perceived stress were significantly associated with increased overall sweet (r = .24, *p* = .007) and overall savoury snack intake (r = .27, *p* = .002), but not with overall changes to food intake (r = .17, *p* = .06), overall changes to snack intake (r = .21, *p* = .02) or changes to HED sweet (r = .16, *p* = .08), HED savoury snacks (r = .16, *p* = .08) and HED savoury meal foods (r = .14, *p* = .14).

1.3.3 Eating behaviour traits as correlates and predictors of increased HED sweet and savoury foods

Bivariate correlations (n = 125; alpha set at $p < .01$) showed that lower craving control was significantly associated with increased HED sweet (r = -.41, *p* <.001), increased HED savoury snack (r = -.36, *p* <.001) and increased HED savoury meal intake (r = -.39, *p* <.001). Cognitive restraint and disinhibition were not significantly associated with changes to any HED food groups (largest r = -0.18, *p* = .04). Greater emotional eating was significantly associated with increased HED sweet food intake (r = .32, *p* <.001), but was not significantly related to HED savoury snack or meal intake (largest r = .18, *p* = .04).

The stepwise linear regression models showed that of the eating behaviour traits (restraint, disinhibition, emotional eating and craving control), only craving control was a significant predictor of changes to HED sweet and savoury food intake. Lower craving control predicted greater increases in HED sweet and savoury food intake. Habitual food intake was not a significant predictor in any of the models. The models explained 13-17% of the variance in reported changes to HED sweet and savoury foods (see Table 2).

1.3.4 Acceptance coping as a moderator of the relationship between craving control and increased HED food intake

The three moderation models are shown in Table 3. All three models showed that craving control had a significant effect on changes to HED food intake. Acceptance coping had no direct effect on changes to HED food intake, and all interactions between craving control and acceptance coping were non-significant. As such, there was no evidence that acceptance coping moderated the relationship between craving control and changes to HED food intake.

1.4 Discussion

Similar to previous research (e.g. Buckland et al., 2021; Herle et al., 2021), this study showed individual variability in dietary changes in response to the COVID-19 lockdown. In terms of changes to HED food intake, this study replicated the previous result of Buckland et al., (2021) that lower craving control was the main eating behaviour trait that predicted increased HED sweet and savoury food intake during the COVID-19 lockdown, and extended this finding to adults living in Victoria, Australia. Of the eating behaviour traits assessed (trait disinhibition, cognitive restraint and emotional eating), craving control was the only significant predictor of increased HED food intake. The current study was unable to replicate the previous finding of Buckland et al. that adopting an acceptance coping response can moderate the relationship between craving control and increased HED food intake.

Replicating the result that low craving control increases susceptibility to increased HED food intake during COVID-19 has important theoretical and applied implications. Lower craving control has previously been linked to increased selection of HED sweet foods, increased energy intake, higher BMI, and increased fat mass (Dalton et al., 2015). In contrast, higher craving control (Smithson & Hill, 2017) and *improvements* in craving control (Dalton et al., 2017) have been associated with improved weight loss outcomes. Given the considerable COVID-19 health risks associated with an increased BMI and obesity (Popkin et al., 2020), and the link between COVID-19 lockdowns and weight gain (Marchitelli et al., 2020; Pellegrini et al., 2020), it is important to identify strategies that support controlled eating and healthy weight management. The replicated findings here strongly indicate that craving control should be targeted in the current and future lockdowns to promote controlled food intake and prevent the risk of weight gain. Under non-lockdown conditions, interventions involving cognitive training, food cue-exposure, guided imagery and mindfulness or acceptance-based strategies are effective for improving cravings and promoting controlled eating (Alberts, Mulkens, Smeets, & Thewissen, 2010; Boswell & Kober, 2016; Schumacher, Kemps, & Tiggemann, 2018; Sun & Kober, 2020; Wolz, Nannt, & Svaldi, 2020). This research strongly supports the need for future high-quality trials that evaluate the effectiveness of socially-distanced craving control interventions under lockdown conditions in individuals susceptible to increased energy intake.

Although the present study did not replicate Buckland et al.'s (2021) finding that acceptance coping moderates the relationship between craving control and increased HED intake (possibly due to a low sample size), other studies have shown that acceptance-based strategies improve management of cravings and food intake (Alberts et al., 2010). As such, acceptance-based strategies remain a potential avenue to investigate in future lockdown-specific interventions to promote controlled food intake in susceptible individuals. Such future work would benefit from investigating appropriate points at which to intervene. It is currently unclear whether craving control plays a role at the point of purchase, or also at the point at which food is selected and consumed. Food-purchasing patterns changed under the COVID-19 lockdowns (Chenarides, Grebitus, Lusk, & Printezis, 2021; Kinsella, 2020; Public health England, 2020b), and thus it is possible that craving control may have influenced food purchases. For instance, individuals scoring low in craving control may have purchased more HED foods, which resulted in increased subsequent intake of HED foods. If craving control influences food purchasing then it would be important for interventions to target individuals at the point that purchasing decisions are made, as well as targeting the point at which food is consumed.

In addition to craving control, Buckland et al., (2021) found that low cognitive restraint also significantly predicted increased HED sweet and savoury meal intake during the COVID-19 lockdown (albeit to a lower degree compared to craving control). The current study did not replicate this finding as cognitive restraint was not a significant predictor of increased HED food intake. It is unclear why the current findings differed from Buckland et al., (2021), but these conflicting findings add to other mixed results in the restraint literature (Bryant et al., 2019). Mixed findings may reflect different types of restrained eating, such as flexible and rigid eating styles influencing study results (Bryant et al., 2019). Another possible reason is that the sample size of the current study was not sufficient to detect the small effect of cognitive restraint on HED food intake. As such, further investigation into the role of cognitive restraint is needed.

As an extension of previous research, the present study also assessed trait disinhibition as a predictor of increased HED food intake. Contrary to expectations, trait disinhibition was not significantly associated with increased HED food intake. Previous research has linked trait disinhibition with a greater liking and drive for palatable HED foods, increased loss of control over eating, increased food intake, increased BMI, increased body weight and less successful weight management (Bryant et al., 2008; Bryant et al., 2019). There are several reasons why trait disinhibition did not predict increased HED food intake here. First, it is possible that spending increased amounts of time at home due to stay-at-home orders, meant that the lockdown conditions did not increase substantial disinhibiting factors to participants' environment, and as such trait disinhibition did not have the opportunity to play out and influence dietary intake to a greater extent under lockdown conditions compared to non-lockdown conditions. Second, the interaction between trait disinhibition and levels of restraint may determine food intake more than each trait alone (Haynes, Lee, & Yeomans, 2003; Yeomans & Coughlan, 2009). In this study, it is possible that high disinhibition was regulated by high levels of restraint which minimised the impact of disinhibition on increased food intake. Further research with larger samples is needed to test the interactive effects of restraint and disinhibition on food intake under lockdown conditions. Finally, it is possible that high disinhibited eaters did not notice increases in food intake that may have occurred. Underreporting is common with self-reported food intake, especially in individuals with overweight and obesity (Dahle et al., 2021; Govindaraju et al., 2021; Heitmann & Lissner, 1995). In this study, high disinhibited eaters may have misreported changes in HED food intake, meaning that increases in intake could not be observed in this group with the self-report methods used. It would be useful to assess whether other more objective measures detect changes in HED food intake in high disinhibited eaters.

The present study also extended that of Buckland et al., (2021) by assessing perceived stress during COVID-19 in association with changes to HED food intake. Greater perceived stress was significantly associated with reported increases in overall sweet and savoury snack intake, but not with specific HED food groups (sweet or savoury snacks and meals) or changes to overall food intake or overall snack intake. Stress has been linked to increased preferences for, and intake of both HED sweet and savoury foods (Oliver & Wardle, 1999; Wardle, Steptoe, Oliver, & Lipsey, 2000). While the findings on changes to overall sweet and savoury snack intake align with previous research, it is unclear why stress was not linked with specific HED food groups (HED sweet snacks, savoury snacks and savoury meals foods). One possibility is that dietary responses to stress can vary between individuals with some individuals increasing intake and others reducing intake in response to stress (Torres & Nowson, 2007), and there may be large variability in the types of snacks affected by stress that the current study was unable to assess. It is also possible that stress levels fluctuated throughout the lockdown, and as such changes to specific food items forming the HED food groups varied throughout the lockdown. Indeed, another study identified a sub-group of individuals who reported increased food intake at the start of the lockdown but this decreased as the lockdown progressed (Herle et al., 2021). This changing dietary pattern may reflect participants adjusting and learning to appraise the COVID-19 situation as less stressful. As such, specific dietary responses to stress may have largely varied between participants, and/or perceived stress may have fluctuated throughout the COVID-19 lockdown, both of which may have diluted the links between perceived stress and HED sweet and savoury food intake. Another possible explanation concerns the specific food items measured. The present study focused on HED foods, and thus it is possible that intake increased for other non-HED sweet and savoury items not measured. This could also explain why stress was associated with overall sweet and savoury snack intake, but not with the specific HED food groups.

While the current study extended previous research in several important ways, as with all studies, there are limitations that need to be considered. First, the sample size was smaller than the conservative targeted sample size. Nevertheless, it still fell within a powered range based on the strongest effect size reported in Buckland et al., 2021. Of note too, the effect sizes reported in the present study were larger compared to Buckland et al., (current study: R^2 ranged between 0.13 and 0.17 and in Buckland et al.,: R^2 ranged between 0.06 and 0.12). Therefore, for the stepwise regressions, sample size was unlikely to be an issue, but caution is needed when interpreting the results from the moderator analysis. Another issue, typical of much COVID-19 research is that no baseline (pre-COVID-19) data was collected. Responses to the eating behaviour trait questionnaires were collected during the COVID-19 lockdown and in the absence of pre-COVID-19 measures, reverse causality cannot be discounted as an explanation for the findings. It might also have been challenging for participants to accurately report changes to their HED food intake when there is evidence that for some individuals this fluctuated throughout the lockdown (Herle et al., 2021). Another issue, which is common within psychological research (Rad, Martingano, & Ginges, 2018), is that the data collected was restricted to a predominant white, educated, and relatively wealthy sample with a healthy weight. This restricted sample limits the ability to generalise the findings to other groups including those most at risk of obesity and COVID-19, such as people from lower socioeconomic status and some non-White ethnicities (Public Health England, 2020a; World Health Organisation, 2014). It would be beneficial for future studies to adopt recruitment strategies that seek to recruit powered representation of these groups.

In conclusion, similar to previous research this study demonstrated individual variability in dietary changes in response to the COVID-19 lockdown. Within an Australian sample, this study replicated a previous finding that craving control is an important eating behaviour trait that predicts increased HED food intake during lockdown conditions. The previous finding that an acceptance coping response moderated this relationship (Buckland et al., 2021) could not be replicated here. As an extension to previous work, trait disinhibition was unexpectedly not related to increased HED food intake. Furthermore, perceived stress was only significantly associated with increased HED savoury snack intake, and not HED sweet snack intake. Based on the replicated findings here, further trials should consider interventions targeting craving control to promote controlled food intake and weight management in individuals at-risk of weight gain during the current COVID-19 and future potential lockdowns.

1.5 Acknowledgements

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1.6 Author Contributions

Both authors contributed to the study design. NB performed the analysis and wrote the first draft of the paper. All authors have approved the final article.

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1.8 Data availability

The data analysed are available and accessible from Open Science Framework.

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Table 1. Participant characteristics

Variable (total n)	n (%) or M ± SD (95% CI)
Age (n = 142)[a]	38.5 ± 12.9 (36.3, 40.6)
Ethnicity (n = 144)	
White	83 (58%)
European	24 (17%)
Asian	11 (8%)
Mixed or multiple ethnic groups	7 (5%)
Indian	5 (3%)
African or Caribbean	2 (1%)
Other	6 (4%)
Prefer not the say	6 (4%)
Weight status (n = 124)	
Underweight	0 (0%)
Healthy weight	70 (57%)
Overweight	48 (39%)
Obese	6 (4.8%)
Subjective social status (n = 123)[b]	7.0 ± 1.6 (6.7, 7.3)
Household income (n = 124)	
< $20 000	5 (4%)
$20 001 - $36 000	6 (5%)
$36 001 - $55 000	6 (5%)
$55 001 - $73 000	17 (14%)
$73 001 - $91 000	14 (11%)
$91 001 - $110 000	10 (8%)
Above $110 000	53 (43%)
Prefer not to say	13 (10%)
Education (n = 144)	
No formal qualifications	3 (2%)
Secondary school	4 (3%)
Apprenticeship	2 (1%)
TAFE	4 (3%)
Bachelor's degree or equivalent	66 (46%)
Doctoral degree or equivalent	63 (44%)
Other, including foreign qualifications	2 (1%)
Home schooling (n = 124)	
Not home schooling	96 (77%)
1 child	14 (11%)
2-3 children	14 (11%)
Psychometrics	
Perceived stress scale (n = 124)	19.0 ± 6.7 (17.8, 20.2)
Cognitive restraint (TFEQ) (n = 126)	14.3 ± 3.4 (13.7, 14.9)
Uncontrolled eating (TFEQ) (n = 126)	19.4 ± 5.1 (18.5, 20.3)
Emotional eating (TFEQ) (n = 126)	7.1 ± 2.4 (6.7, 7.5)
Craving control (COEQ) (n = 125)	56.0 ± 24.9 (51.6, 60.4)

Note.
[a]Missing data participant >80 years old, n = 1 and 'prefer not to say,' n = 1.
[b]Possible scores range from '1 = highest perceived relative deprivation' to '10 = lowest perceived relative deprivation' (Adler & Stewart, 2007); prefer not to say n = 1.
COEQ = Control of Eating Questionnaire (Dalton et al., 2015).
TFEQ = Three Factor Eating Questionnaire (Karlsson et al., 2000).

Table 2. Stepwise linear regressions for eating behaviour traits regressed on to changes for high energy density (HED) sweet snacks, HED savoury snacks and HED savoury meals (n = 125).

Outcome variable	B	SE B	β
HED sweet snacks			
Constant	12.76	3.21	
Craving control	-0.26	0.05	-.41***
HED Savoury snacks			
Constant	11.32	2.70	
Craving control	-0.19	0.04	-.36***
HED Savoury meal foods			
Constant	10.60	2.84	
Craving control	-0.22	0.05	-.39***

Note.

Three separate models were conducted, one for HED sweet snacks, one for HED savoury snacks and one for HED savoury meal foods.

Habitual intake (stepwise method) was entered as a covariate in step 1 (non-significant predictor all models), followed by all eating behaviour traits in step 2 (cognitive restraint, disinhibited eating, emotional eating and craving control; stepwise method).

Predictor variables not shown in Table 2 were excluded from the model.

For HED sweet snacks: R^2 = .17, p <.001. For HED savoury snacks: R^2 = .13, p <.001. For HED savoury meal foods, R^2 = .15.

B = unstandardized coefficient; B SE = unstandardized coefficient standard error; β = standardised coefficient.

***p<.001.

Table 3. Moderated regression analyses: interaction of craving control and acceptance coping on changes (Δ) to high energy density (HED) sweet and savoury food intake (n = 124).

Effects	B	SE	t	*p*	R^2	F	df1	df2	*p*
Δ HED sweet snack foods					0.18	6.74	4	119	.0001
Craving control	-0.27	0.05	-5.05	<.0001					
Acceptance	0.17	1.06	0.16	.8757					
Craving control x acceptance	0.04	0.04	1.00	.3199					
Habitual sweet snack intake	-1.89	1.73	-1.09	.2758					
Δ HED savoury snack foods					0.17	6.29	4	119	.0001
Craving control	-0.21	0.05	-4.52	<.0001					
Acceptance	0.35	0.92	0.38	0.7065					
Craving control x acceptance	0.03	0.04	0.83	0.4065					
Habitual savoury snack intake	-2.79	1.18	-2.36	0.0201					
Δ HED savoury meal foods					0.18	6.41	4	119	.0001
Craving control	-0.21	0.05	-4.39	<.0001					
Acceptance	-1.40	0.94	-1.48	0.1412					
Craving control x acceptance	0.03	0.04	0.94	0.3487					
Habitual savoury meal food intake	-0.96	1.80	-0.53	0.5939					

Note.
B = unstandardized coefficient; SE = unstandardized coefficient standard error.
Three separate models were conducted using PROCESS for SPSS (Model 1, Hayes, 2017), one for HED sweet snacks, one for HED savoury snacks and one for HED savoury meal foods.
The sample size differs to the analyses reported in Table 2 because one participant withdrew from the survey before completing questions assessing acceptance coping.

Supplementary Materials. Table 1.

Food items used to compute average scores for high energy density (HED) sweet snacks, savoury snacks and HED savoury meal foods.

Foods
HED sweet snacks
Chocolate
Biscuits
Cakes e.g. fruit, sponge, ready or home made
Other sweet baked foods e.g., pastries, scones, doughnuts, etc.
Lollies e.g. jellies, hard boiled, toffees, mints
Ice cream
HED savoury snacks
Crisps or other packet savoury snacks, e.g. Cheezels
Peanuts or other nuts
Crackers, e.g. Plain crackers, Barbecue Shapes
Cheese
HED savoury meal foods
Pizza
White pasta
Chips or wedges
White bread and rolls
Savoury pies e.g. meat pie, pasties, steak & kidney pie, sausage rolls