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Article - Version of Record

Suggested Citation:

Forbes, P. A. G., Raio, C. M., & Kalenscher, T. (2026). Precommitment promotes healthier food choices under stress. *Psychoneuroendocrinology*, 186, Article 107754.
<https://doi.org/10.1016/j.psyneuen.2026.107754>

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Precommitment promotes healthier food choices under stress

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ARTICLE INFO

Keywords:

Acute stress
Precommitment
Food choices
Decision making

ABSTRACT

Stress can result in unhealthy food choices with detrimental consequences for our health. Precommitment is a behavioural strategy whereby individuals restrict their future choice set and can promote healthier food choices – we may forgo buying cake when grocery shopping so we are not tempted to eat it at home. Yet, it is not known whether precommitment can buffer the effects of stress on food choices by providing opportunities to avoid unhealthy food altogether, enabling healthier food choices under stress. To investigate this, we developed a novel ‘precommit-to-eat’ paradigm which involved two stages. This enabled us to first assess precommitment decisions (precommitment stage) and, subsequently, participants’ propensity to select healthier items to eat in a food choice stage (choice stage). Participants ($n = 29$) who all reported generally trying to eat healthily completed this two-stage paradigm twice – once under acute stress and once in a non-stressful control condition. The propensity to choose unhealthy but tastier food to eat increased with subjective stress, but this effect was counteracted by stress-related increases in precommitment. Thus, our findings show the effectiveness of precommitment under stress. This has important implications for interventions aimed at promoting healthier food choices, especially in stressful environments, that could particularly benefit individuals with lower dietary restraint.

1. Introduction

Precommitment is a behavioural strategy that can be used to combat the tension between our immediate wants (e.g. chocolate cake) and longer-term goals (e.g. weight loss). Precommitment involves preemptively restricting our future choice set – we forgo buying unhealthy food at the supermarket, so we are less tempted to eat it at home. By removing items from a choice set which do not align with long term goals, or by adding extra cost to these items, precommitment can enhance the likelihood of achieving more favourable outcomes. Precommitment has been implemented successfully to help people save more for their retirement (Thaler and Benartzi, 2004), buy healthier groceries (Schwartz et al., 2014), engage more with rehabilitation programmes (Studer et al., 2021) and receive larger but more effortful rewards (Studer et al., 2019). An open question, however, is whether precommitment facilitates advantageous decision-making in the face of stress. As stress can have a detrimental effect on healthy food choice (Hill et al., 2022). Thus, we investigated whether precommitment leads to healthier food choices under stress.

The human stress response leads to a myriad of physiological and psychological changes. It is characterised by the rapid activation of the

sympathetic nervous system resulting in the release of noradrenaline and adrenaline, and a slower system which, via the hypothalamic-pituitary-adrenal axis, results in the release of glucocorticoids, such as cortisol (Hermans et al., 2014). Brain regions that contribute to different facets of decision making, such as the prefrontal cortex, amygdala, and striatum (Pruessner et al., 2004, 2008), are particularly vulnerable to stress (Starcke and Brand, 2012). This suggests that prospective control strategies such as precommitment may be especially useful to circumvent the need to control food choice under stress.

Acute and chronic stress lead to increased consumption of unhealthy food and reduced consumption of healthy food (for a meta-analysis, see Hill et al., 2022). Stress induction leads to increases in the consumption of sweet foods and overall energy intake in the absence of hunger (Lemmens et al., 2011; Rutters et al., 2009). Herhaus and Petrowski (2021) found that participants with obesity who showed stronger cortisol responses ate more food following psychosocial stress. Papier et al. (2015) found that greater self-reported stress was linked to unhealthy food consumption in a large sample of Australian undergraduates and similar results have been demonstrated in Chinese students (Liu et al., 2007). Tomiyama et al. (2011) found that highly stressed women reported greater emotional eating. Finally, Maier et al.

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<https://doi.org/10.1016/j.psyneuen.2026.107754>

Received 5 April 2025; Received in revised form 9 January 2026; Accepted 12 January 2026

Available online 13 January 2026

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(2015) found that participants under acute stress were more influenced by the tastiness of food items when making food choices – that is, the immediately rewarding attribute of the food – rather than the healthiness of the food. Acute stress was also associated with reduced connectivity between the ventromedial and dorsolateral prefrontal cortex – these regions have been linked to self-control success. Given the detrimental effect of stress on healthy food choices, we aimed to investigate whether precommitment can result in healthier food choices under stress. Such findings would have important implications for interventions aimed at promoting healthier food choices, which are especially pertinent given that one in three people globally are overweight or obese (Chooi et al., 2019).

Given that stress increases unhealthier food choice, which is thought to reflect impulsivity in the context of dietary choice, precommitment has emerged as a promising strategy to prevent such decisions. In fact, previous studies suggest that acute stress could lead to greater precommitment (Raio and Glimcher, 2021) potentially via its effects on impulsivity (Soutschek and Tobler, 2020). Specifically, Raio and Glimcher (2021) showed that hungry dieters were willing to pay around 15 % of a \$10 endowment to avoid having a highly tempting food item placed in front of them during a waiting period. Participants under acute stress were willing to pay more than double this amount to avoid the temptation. This shows the willingness to remove tempting unhealthy food increases under acute stress, and supports the view that when impulsiveness is high, as can be the case under stress (Maier et al., 2015; Shields et al., 2016), precommitment is implemented more readily (Soutschek and Tobler, 2020). Further, Soutschek and Tobler (2020) showed that when participants' impulse control was compromised after high cognitive demand, their tendency to precommit increased. This suggests that precommitment is most effective when impulsiveness is high, rather than being dependent on impulse control.

It is worth noting, however, that not all studies find links between stress and all forms of impulsivity. For example, we conducted a meta-analysis of 11 studies investigating monetary delay discounting – where participants must choose between a sooner-smaller or larger-later financial (i.e., secondary/non-food) reward (Forbes et al., 2024). In this context, we did not observe any consistent effects of acute stress on

delay discounting. Monetary delay discounting captures only one of several types of impulsivity, and these may differ from the mechanisms underlying impulsive choices concerning primary rewards, such as food (Evenden, 1999; Kalenscher et al., 2006; Kalenscher and Pennartz, 2008). Thus, given the relatively well-established links between stress and unhealthier food choices (Hill et al., 2022) as well as stress and impulsivity in the context of food choices (Maier et al., 2015), we aimed to establish how stress-induced increases in impulsivity could impact precommitment. Thus, we investigated precommitment under stress and whether this could mitigate the detrimental effects of stress on food choices.

To this end, we developed a novel experimental procedure, the precommit-to-eat paradigm (Fig. 1), which involved two stages. Students who reported generally trying to eat healthily first completed a precommitment stage in which they viewed pairs of food items. In each pair, one item was always rated as healthier but less tasty than the other item. The pairs were created based on each participant's personal ratings of the items (completed before the experimental sessions). On half of the trials in the precommitment stage, participants were given the opportunity to remove the unhealthier but tastier item (restriction trials) - this allowed us to measure the rate of precommitment. On the other half of the trials (viewing trials), participants simply viewed the pairs of food items. The choice stage followed the precommitment stage. Participants were presented with the same pairs of food items and had to choose which food item they would like to eat at the end of the experiment. Thus, in the choice stage, we could measure participants' propensity to choose the healthier food item in each pair. If participants removed an item during the precommitment stage, this item was unavailable to them during the subsequent choice stage. Thus, for such a trial, they had to choose the healthier item in this pair due to their previous precommitment. To ensure that participants' choices reflected their genuine preferences, one choice from the choice stage was selected for each participant and they ate the chosen food item at the end of experiment.

Participants completed this procedure twice at least six days apart – once under acute stress (Smeets et al., 2012) induced before both the precommitment stage and, again, before the choice stage, and then once in a non-stressful control condition (Fig. 2). Such an experimental design

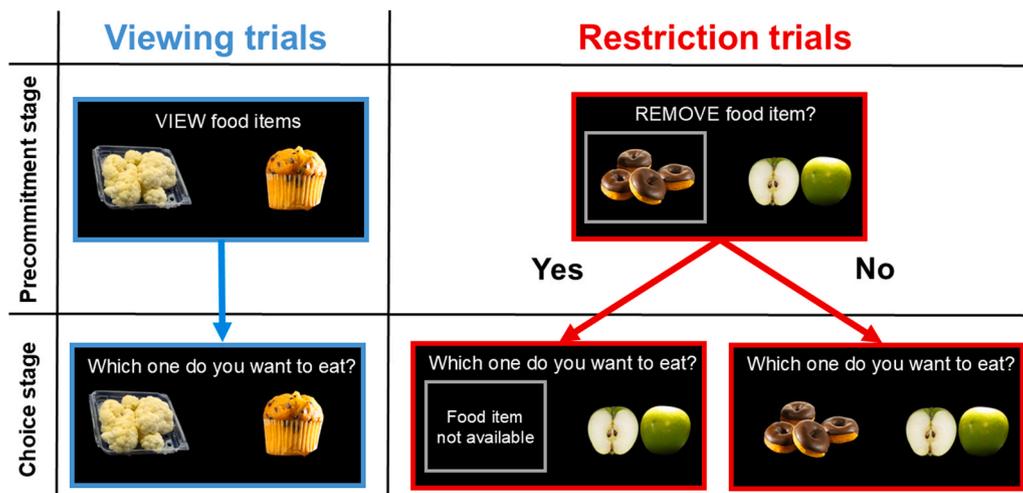


Fig. 1. Precommit-to-eat paradigm. Participants completed two stages in which they were presented with participant-specific pairs of food items where one item had been rated as healthier but less tasty than the other item by the participant. On half the trials in precommitment stage, participants viewed the food items and waited for the next trial (viewing trials). All food items which appeared in viewing trials in precommitment stage were available to eat in choice stage. On the other half of trials in precommitment stage (restriction trials), participants were given the opportunity to remove the unhealthier but tastier food item in each pair. If participants decided to remove this item ('Yes'), then it was not available to eat in the subsequent choice stage. If participants did not remove the unhealthier item during the restriction trials in the precommitment stage ('No'), then it was available to eat in the subsequent choice stage. The key comparison was the difference in the tendency to choose to eat the healthier item in the choice stage on viewing trials, this acted as a 'baseline' measure of participants' tendency to choose the healthier items as participants had not had the chance to restrict their future choice set, compared to restriction trials, where participants had been given the opportunity to remove the unhealthier food items in precommitment stage. More healthier choices in choice stage on restriction trials compared to viewing trials indicated the relative benefit of precommitment.

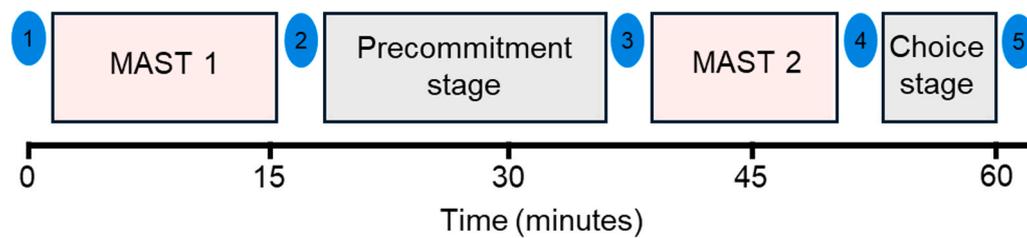


Fig. 2. The experimental timeline. Participants completed stress induction (MAST; Smeets et al., 2012) before the precommitment stage and before the choice stage (or the non-stressful control task on the control day). Saliva samples and stress ratings were collected at five timepoints throughout the experiment shown by the blue ovals.

allowed us to examine how much participants' choices in the choice stage benefitted from precommitment and whether the beneficial effect of precommitment differed across the stress and control conditions. We collected participants' self-reported stress ratings and salivary cortisol samples to capture variation in participants' stress responses. This allowed us to determine how both acute stress and individual differences in stress reactivity predicted both initial precommitment in the precommitment stage and the subsequent selection of healthier versus unhealthy food items in the choice stage. To ensure our potential stress effects were not driven by changes in hunger or thirst, we asked participants to indicate how hungry and thirsty they were at two timepoints during each session.

We expected that in the choice stage, stress would result in fewer healthier food choices on viewing trials (where participants had had no opportunity to restrict their future choice set), as has been shown before (Maier et al., 2015). This acted as our 'baseline' measure of food choices under stress. Our key prediction was that the opportunity to precommit would mitigate this stress-related tendency to make unhealthy food choices. To assess the benefit of precommitment under stress, we compared the number of healthier food choices in those trials where participants could precommit (restriction trials, i.e., where they could voluntarily restrict their choice set) to the number of healthier choices in trials where they could not precommit (viewing trials, which served as a 'baseline' measure for participants' propensity to make healthier choices). The greater the selection of healthier food items on restriction trials compared to viewing trials in the choice stage, the greater the benefit of precommitment. Conversely, if the number of selected healthier food items on restriction trials and viewing trials were similar in the choice stage, then this would indicate that precommitment - the opportunity to previously remove unhealthy items in precommitment stage - provided no additional benefit in promoting healthier choices. For example, if a participant decides not to precommit at all during the precommitment stage, then all unhealthy food items would be available to them across restriction trials and viewing trials in the choice stage. In contrast, the greater number of unhealthy items a participant removes during the precommitment stage, the fewer unhealthy items would be available to them on restriction trials compared to viewing trials in the choice stage. If a participant decides to precommit on a given restriction trial during the precommitment stage, this removes the active selection at the choice stage as the participant defaults to selecting the healthier item on this restriction trial due to earlier precommitment. However, restriction trials do not guarantee healthier choices in the choice stage, as if the participant decides not to precommit on a given restriction trial in the precommitment stage then both the healthier and unhealthy items would be available to them on this trial (Fig. 1).

If stress encourages precommitment (Raio and Glimcher, 2021), then stress should result in the removal of more unhealthy items in precommitment stage. In turn, removing these unhealthy items through precommitment should protect participants from the detrimental effects of stress on the selection of healthier food items on restriction trials in the choice stage.

2. Material and methods

2.1. Participants

We recruited psychology undergraduates who took part in the study for course credits. We conducted a power calculation based on detecting medium effect sizes in a within-subject design (Cohen's d : 0.5–0.6) and this showed that we required between 24 and 34 participants to achieve 80 % power. In total 35 participants came to the lab twice and took part in both the stress and control condition. Participants were excluded if they were pregnant, had an acute or chronic physical, psychological, or neurological disorder, regularly used medication (i.e. weekly or daily use of medications including aspirin, paracetamol, beta-blockers, steroids and cortisol-containing medications and creams), or had heavy alcohol or nicotine use (>5 cigarettes per day) or never consumed food containing milk due to the presence of this in the choice set. Participants were asked not to engage in strenuous physical activity, alcohol, nicotine or medication use 24 h before the session, and two hours before the session not to eat or consume anything other than water.

Four participants were excluded as they had previously been diagnosed with a psychiatric or neurological disorder, one participant was excluded as they had a previous diagnosis of an eating disorder, and one participant answered 'no' to the question 'Do you generally try to eat healthily?'. This left 29 participants (25 women; 4 men) in the final analysis who all reported generally trying to eat healthily, thus their choices in the task represented genuine self-control challenges for the participants (Maier et al., 2015). The sample had a mean age of 22.14 years ($SD=4.12$; range=18–37) and mean BMI of 22.36 ($SD=2.39$; range=18.43–29.07) which was calculated based on self-reported height and weight.

The two sessions were 16.41 days apart on average ($SD=7.80$; range: 6–40 days). Testing always took place between 13:00 and 18:30 to account for diurnal fluctuations in cortisol. We counterbalanced the order of the stress condition and the control condition: 10 participants took part in the stress condition on day 1 and 19 participants took part in the control condition on day 1. A binomial test indicated that the proportion of participants who completed the control condition first compared to the stress condition was not significantly different from a 50/50 split ($p = .136$), nevertheless we controlled for potential day effects (i.e. day 1 vs. day 2 independent of condition effects) in the analyses.

All participants provided written informed consent, and the study was approved by the local ethics committee.

2.2. Creation of food pairs

Participants completed an online questionnaire before coming to the lab in which they rated 285 food items (partly containing the images from Maier et al., 2015) on how healthy, tasty and tempting they found them on a 5-point Likert scale with a higher rating indicating a healthier, tastier or more tempting food item (e.g. 1 = very unhealthy; 5 = very healthy). In addition, participants indicated the frequency with which they ate different types of food, such as meat, fish and milk products, and completed several questionnaires: Perceived Stress Scale (PSS, Cohen

et al., 1983; Klein et al., 2016), Self-Regulation of Eating Behaviour Questionnaire (SREBQ; Klieemann et al., 2016), Barratt Impulsiveness Scale (BIS-15 Spinella, 2007), and Metacognitive Prospective Memory Inventory (short version; Rummel et al., 2019).

From each participant's individual ratings, we created 96 pairs of food items where participants had rated one item as healthier but less tasty (e.g. cauliflower) than the other item (e.g. muffin; Fig. 1). If participants never ate meat ($n = 9$) or fish ($n = 13$), then items containing fish and/or meat were removed from the stimuli set before creating the pairs. To create the maximum number of unique pairs based on each participant's ratings, we used the NetworkX library in Python (<http://networkx.org>).

2.3. Precommit-to-eat paradigm

In the precommit-to-eat paradigm (Fig. 1), we used the 96 pairs of food items which had been created individually for each participant. Each pair contained one food item which had been rated as healthier but less tasty than the other item.

Participants were instructed that they would take part in two stages related to the choice of food items: the precommitment stage and choice stage. Participants were told that they would see pairs of food items in the choice stage and they should choose the food item in each pair they would like to eat immediately at the end of the study. Participants were told that one of their choices would be randomly selected and then they would eat this food item at the end of the study.

Participants were informed that in the precommitment stage, which preceded the choice stage, they would have the opportunity, on some of the trials (48 restriction trials), to remove one of the food items. If an item was removed in the precommitment stage, it would not be available for selection in the choice stage. Thus, it could then not be consumed at the end of the study. On other trials in the precommitment stage (48 viewing trials), participants were told they simply had to view the food items and wait for the trial to continue.

Participants were told that the purpose of the study was to gain insights into how people make food choices and to better understand under what circumstances people are more likely to eat certain food.

2.3.1. Precommitment stage: "remove food item?"

Viewing trials: On the viewing trials, participants simply looked at the pair of food items for 8 s before proceeding to the next trial. No key presses were required. Above the food items was the instruction "VIEW food items" (original German: "Lebensmittel ANSCHAUEN").

Restriction trials: On each restriction trial, participants saw a pair of food items where the tastier, less healthy item was highlighted with a grey box. Above the food items was the question "REMOVE food item?" ("Lebensmittel ENTFERNEN?"). If participants wanted to remove the food item, they were instructed to press *j* (= 'ja' / yes) on the keyboard. If they did not want to remove the food item participants were told to press *n* (= 'nein' / no). If participants decided to remove the food item, then the grey box surrounding the tastier, less healthy item turned red and the text "removed" ("entfernt") appeared on the screen. Conversely, if participants decided to not remove the tastier, less healthy item, then the grey box surrounding the tastier, less healthy item turned green and the text "keep" ("behalten") appeared.

Removing unhealthier items: The key dependent measure during the precommitment stage was how often participants decided to remove the unhealthier item on restriction trials (0 = item not removed; no precommitment; 1 = item removed; precommitment).

2.3.2. Choice stage: "which one do you want to eat?"

Viewing trials: On the viewing trials, participants saw exactly the same pairs of food items as they had seen in the precommitment stage in the viewing trials. Above the pair of food items was the question "Which one do you want to eat? (original German: "Welches willst du essen?") and participants could choose using the left and right arrow keys.

Restriction trials: On the restriction trials, participants saw the same pairs of food items they saw in the precommitment stage in the restriction trials. However, if the unhealthier food item had been removed during the precommitment stage then this was not available to participants; in its place was a text box with the text "Food item not available" ("Lebensmittel nicht verfügbar"). In this case, the participants could only select the available healthier food item using the left or right arrow key, depending on which side the healthier item was. If participants had not removed a food item from a given pair, then a restriction trial was the same as a viewing trial in that both food items were available and could be selected using the left and right arrow keys.

Choosing healthier items: The key dependent measure in the choice stage was how often participants decided to eat the healthier item (0 = healthier item not chosen; 1 = healthier item chosen). This was assessed under two conditions: (1) *viewing trials*, where both the healthier and unhealthier items were present because participants had not had the opportunity to remove the unhealthier item during the precommitment stage, and (2) *restriction trials*, where only the healthier item remained if participants had previously removed the unhealthier item and both remained if they did not previously precommit. Viewing trials, thus, measured participants' 'baseline' food choices without prior precommitment, whereas restriction trials measured participants' food choices with the opportunity of prior precommitment. By comparing how often participants selected healthier food items on the restriction trials versus viewing trials in the choice stage, we could measure the relative benefit of precommitment. The greater the selection of healthier food items on restriction trials compared to viewing trials, the greater the benefit of precommitment.

Both stages were self-paced but if participants did not respond within 8 s, "Please decide" ("Bitte entscheiden") appeared on the screen prompting them to decide. Participants responded within 8 s on 98.42 % of trials in the precommitment stage and on 99.32 % of trials in the choice stage.

In both stages, the viewing trials and restriction trials were presented in a pseudorandom order - we ensured that there were never more than four consecutive viewing trials or four consecutive restriction trials.

As participants completed the precommit-to-eat paradigm twice—once under stress and once under control conditions—we switched the restriction trial pairs and viewing trials pairs across the two sessions. The pairs which had been viewing trial pairs in the first session became restriction pairs in the second session, and vice-versa. Thus, participants were not making the same precommitment decisions across both sessions. At the end of both sessions one of the participant's choices was selected and participants ate this food item following the final saliva sample.

2.4. Stress induction

Participants completed the Maastricht Acute Stress Test (MAST), which is a well-established stress induction procedure resulting in activation of the autonomic nervous system and a reliable cortisol response (Smeets et al., 2012). The MAST involves alternating between a physical challenge – keeping one's hand in very cold water (4°C) – and a psychological challenge – completing mental arithmetic stages under pressure with social evaluative feedback following errors. To increase feelings of social evaluation participants believed that they are being video recorded and to increase feelings of uncontrollability the test involves unpredictable switches between the physical and psychological challenge. In our study, participants completed two runs of the MAST on the stress day—immersing their left hand in one run and their right hand in the other. On the control day participants completed two runs of a non-stressful version of the MAST: placing their hand in warm water (36°C) and a simple counting task without social evaluation. The first run was performed before the precommitment stage and the second run was before the choice stage ensuring that participants were stressed before both stages on the stress day (Fig. 2).

To obtain measures of participants' stress reactivity during the task, we collected participants' momentary stress ("At the moment I feel stress") on a 7-point Likert scale (1 =not at all; 7 =very) at 5 time points across the experiment (Fig. 3) and collected participants' salivary cortisol using oral swabs (Sarstedt Salivette, Nuembrecht, Germany). Participants also reported their momentary hunger and thirst at two timepoints during each session on a 7-point Likert scale (1 =not at all; 7 =very): once before the start of the precommitment stage and once before the start of the choice stage.

3. Results

Data and code are available on the Open Science Framework (<https://osf.io/7mx3y/>).

3.1. Increased stress and cortisol following stress induction

To create a summary measure of the stress ratings and salivary cortisol, we calculated the area under the curve with respect to ground (AUCg; Pruessner et al., 2003) in each condition across the five sampled time points (Fig. 3). One participant was missing the final cortisol sample on the control day and the first stress rating on the control day. To enable AUCg to be calculated for this participant on the control day, missing data were interpolated from adjacent data points. We conducted paired-samples *t*-tests to examine differences between the control and stress conditions. Stress ratings were higher in the stress condition compared to the control condition with a large effect size ($t[28]=-5.98$, $p < .001$, $d=-1.11$) with the same pattern for salivary cortisol ($t[28]=-5.42$, $p < .001$, $d=-0.846$). Pairwise comparisons (Bonferroni corrected for multiple comparisons) showed significant differences in

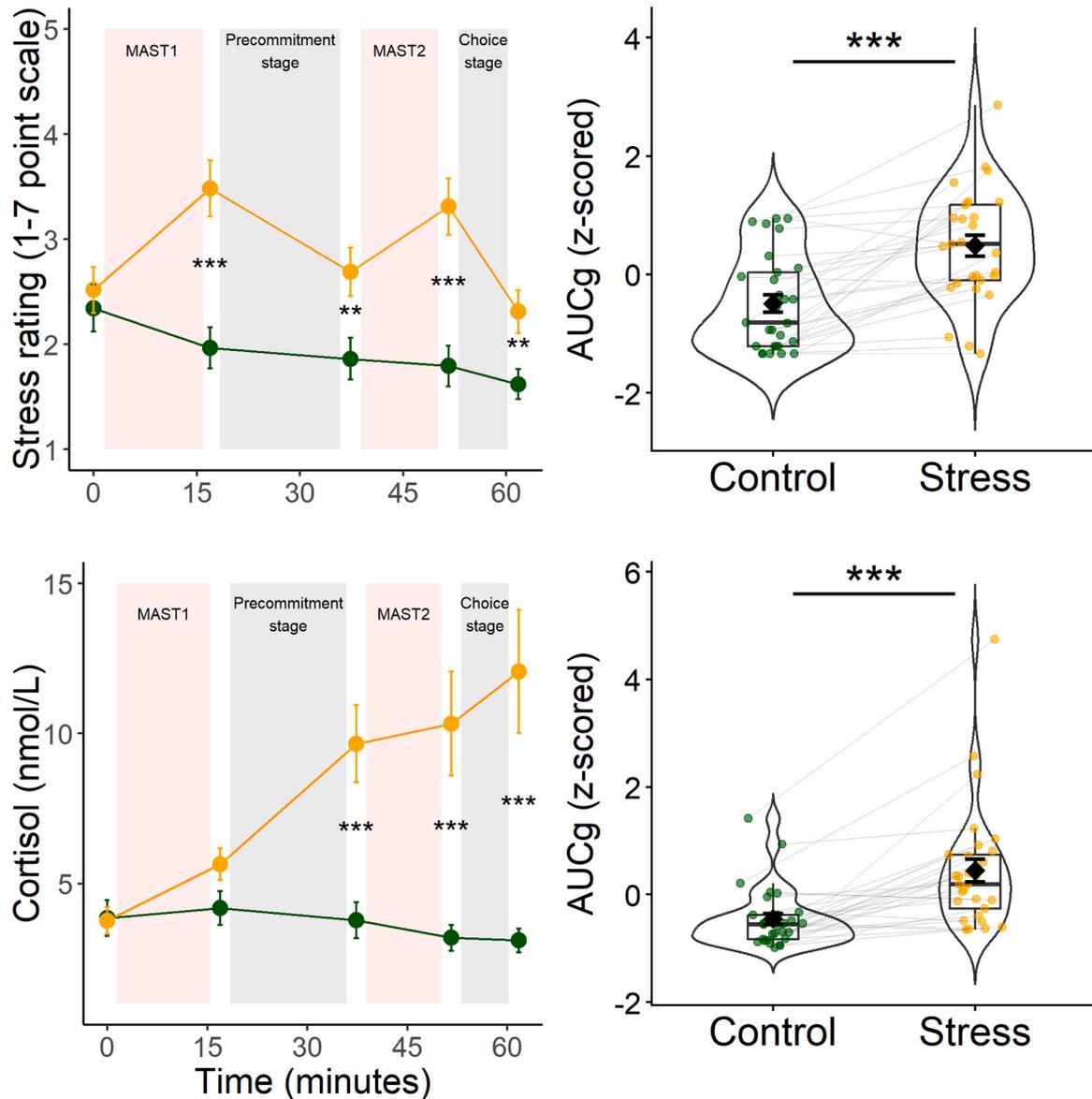


Fig. 3. Stress ratings (top panels) and salivary cortisol (bottom panels). The left panels show the mean (+/- SE) of the stress ratings (top left panel) and salivary cortisol (bottom left panel) across five timepoints in each session. The yellow line represents the stress condition and the green line represents the control condition. The MAST (or the non-stressful control task; pink boxes) was performed before the precommitment stage and again before the choice stage (both stages showed with a grey box). The right panels show the area under the curve with respect to ground (AUCg, Pruessner et al., 2003) calculated for each participant in the control condition (green dots) and the stress condition (yellow dots) for stress rating (top right panel) and cortisol (bottom right panel). Violin plots and boxplots show the distributions; the means (+/- SE) are also shown in black. Each participant's values across the two sessions are connected by a grey line. * $p < .05$, ** $p < .01$, *** $p < .001$.

stress ratings at every time point, except for the first rating. For cortisol, there were significant differences at the third, fourth and fifth timepoints (Fig. 3).

3.2. Hunger and thirst ratings

Participants reported their momentary hunger and thirst at two timepoints during each session on a 7-point Likert scale (1 =not at all; 7 =very): once before the start of precommitment stage and once before the start of choice stage.

To compare hunger ratings across the control and stress conditions, we performed a series of paired samples *t*-tests. There were no differences in hunger before the start of the precommitment stage in the control condition (mean[SD] = 4.59 [1.40]) compared to the stress condition (4.62 [1.50]; $p = .905$), however, there was a trend effect showing that participants were marginally hungrier before the start of the choice stage in the control condition (5.21[1.42]) compared to the stress condition (4.66[1.45]; $t[28]=1.92$, $p = .065$, $d=0.384$). When we compared the change in hunger from rating 1 to rating 2, we found a significant difference between the two sessions ($t[28]=3.00$, $p = .006$, $d=0.675$) with an increase in hunger in the control condition (0.621 [0.561]; $t[28]=5.95$; $p < .001$) but no change in hunger in the stress condition (0.034[1.05]; $p = .861$).

Next to compare thirst ratings across the control and stress conditions, we again performed paired samples *t*-tests. There were no significant differences in thirst before the start of the precommitment stage in the control condition (4.03 [1.35]) compared with the stress condition (4.14 [1.53]; $p = .703$). Similarly, there were no significant differences in thirst before the start of the choice stage in the control condition (4.66 [1.26]) and the stress condition (4.45 [1.45]; $p = .406$). When we compared the change in thirst from rating 1 to rating 2, we did not find a significant difference between the two sessions ($p = .222$) with a significant increase in thirst in the control condition (0.621 [1.15]; $t[28]=2.91$, $p = .007$) and a trend effect in the stress condition (0.310 [0.850]; $t[28]=1.97$, $p = .059$). Hunger and thirst ratings, or changes therein, did not correlate with either precommitment (removing unhealthier food items) or the selection of healthier food items during either session (Table S1). There was also no correlation between hunger and thirst ratings and stress reactivity (stress ratings or cortisol AUC; see Table S2).

3.3. Analyses approach

In the choice stage, we compared the probability of choosing the healthier food item (0 =unhealthier item chosen; 1 =healthier item chosen) on restriction trials—where participants had had the chance to remove the unhealthier item in the precommitment stage—to viewing trials—where they had not had the opportunity to remove the unhealthier item in the precommitment stage. Note that choices were analysed across all viewing trials and all restriction trials. So, importantly, this included restriction trials where the unhealthier item *had* previously been removed *and* restriction trials where the unhealthier item had *not* been removed. In the former case, participants defaulted to choosing the healthier item; in the latter case, participants could actively choose either the healthier item or unhealthier item, as in the viewing trials.

By comparing the likelihood of choosing the healthier food items on viewing trials compared to all restriction trials in choice stage, we could quantify the extent to which choices benefitted from precommitment in the previous stage. The viewing trials in the choice stage served as a ‘baseline’ measure of healthy choices where prior precommitment was not available. Conversely, on restriction trials in the choice stage participants defaulted to choosing the healthier item if they had removed the unhealthier item in the precommitment stage. Hence, the greater the selection of healthier items on restriction trials compared to viewing trials in the choice stage, the greater the benefit of prior precommitment. Crucially, we compared the benefit of precommitment (i.e., restriction versus viewing trials) under acute stress compared to the control

condition.

To this end, we conducted a mixed-effects logistic regression with choice in the choice stage as the dependent variable (0 =unhealthier item chosen; 1 =healthier item chosen) and included the interaction term between trial type (restriction vs. viewing) and condition (control vs. stress) as fixed effects. Additionally, we included the factor day (1 vs. 2) as a fixed effect to control for potential order effects. For random effects, we included random intercepts for participants and random slopes for the interaction between trial type and condition. This ensured the random effects structure was ‘maximal’ (Barr et al., 2013). The R package *emmeans* (Lenth, 2022) was used to calculate the estimated marginal means, which for interpretability were the reported as probabilities rather than on a logit scale (unless stated otherwise). The R package *interactions* was used to estimate the simple slopes of any significant interactions (Long and Long, 2021).

3.4. Healthier choices on restriction versus viewing trials

The benefit of precommitment was similar in both the stress and control conditions as shown by the greater probability of making a healthy choice on restriction trials compared to viewing trials in the choice stage. In the stress condition, the probability of making a healthier choice during the restriction trials was 0.287 (SE = 0.026) versus 0.198 (SE = 0.021) on viewing trials (44.9 % increase). In the control condition, the probability of making a healthier choice during the restriction trials was 0.318 (SE = 0.030) compared to 0.224 (SE = 0.024) in the viewing trials (42.0 % increase). There was no interaction between trial type and condition ($\beta=-0.008$, SE=0.180, $p = .964$) suggesting that the effect of trial type (restriction vs. viewing) on healthier choices was not significantly different in the stress condition compared to the control condition. To test for main effects (rather than the interaction), we simplified the model to include the main effects of trial type (restriction vs. viewing), condition (control vs. stress), and day (1 vs. 2). As above, we kept the random effects structure ‘maximal’ by including random intercepts for participants and random slopes for the main effect of trial type and condition. This model revealed a main effect of trial type ($\beta=-0.482$, SE=0.117, $p < .001$) with the probability of making a healthier choice higher on restriction trials ($M=0.303$, SE=0.025) compared to viewing trials ($M=0.212$, SE=0.020) in the choice stage (42.92 % increase). The main effects of condition ($p = 0.144$) and day ($p = 0.146$) were not significant.

3.5. Precommitment mitigates stress effects on unhealthier food choices

Given the individual differences in participants’ subjective stress (Fig. 3), we aimed to test how participants’ stress ratings (AUCg) across both experimental sessions impacted healthier choices in the choice stage on restriction trials compared to viewing trials. In the model, we included the interaction term between trial type (restriction vs. viewing) and stress ratings (AUCg; z-scored) as fixed effects and the factor day (day 1 vs. day 2) to control for potential order effects. For random effects, we included random intercepts for participants and random slopes for trial type and day.

We found a significant interaction between participants’ stress ratings and trial type ($\beta = -0.185$, SE = 0.086, $p = .031$). Simple slopes analysis (on a logit scale) revealed a significant negative effect of stress ratings on healthier choices on viewing trials ($\beta = -0.231$, SE = 0.074, $p = .002$) where participants had not had the chance to previously remove the unhealthier food items. However, there was no effect of stress ratings on healthier choices on restriction trials ($\beta = -0.047$, SE = 0.073, $p = .525$) - where participants had had the chance to remove the unhealthier food items in the precommitment stage (Fig. 3). This suggests that precommitment prevented the decline in healthier choices at increasing levels of stress. Note, when we ran the same analysis for cortisol reactivity, there was no interaction between salivary cortisol (AUCg) and trial type in the choice stage ($\beta = 0.091$, SE = 0.083,

p = .273).

3.6. Increased stress associated with more precommitment

To explore the significant interaction between stress ratings and trial type further, we again used mixed-effects logistic regression to investigate the effect of participants' stress ratings on the probability of precommitment in the precommitment stage (0 =unhealthier item not removed; 1 =unhealthier item removed). Whilst there was no overall effect of stress ratings on precommitment when collapsed across the stress and control conditions ($\beta = 0.145$, $SE = 0.099$, $p = .143$), differences emerged when we looked at each condition separately. In the stress condition, we found a significant positive effect of participants' stress ratings on precommitment ($\beta = 0.514$, $SE = 0.243$, $p = .035$), such that the more stressed participants felt, the more unhealthier food items they removed. In the control condition, we did not find a significant effect of participants' stress ratings on precommitment ($\beta = 0.054$, $SE = 0.317$, $p = .864$). Note, when we directly compared precommitment in the stress condition to the control condition (whilst controlling for day effects, i.e. day 1 vs. 2), there was no significant difference ($\beta = 0.245$, $SE = 0.175$, $p = .160$) in probability of precommitment in the control condition ($M = -0.125$, $SE = 0.029$) compared to the stress condition ($M = 0.154$, $SE = 0.030$).

For completeness, we report the raw data in Table 1. This shows the mean number of choices for each trial type in the precommitment stage and choice stage. These results mirror the findings from the mixed effects models with more healthier choices on restriction trials compared to viewing trials in the choice stage across the stress and control condition. We also report the number of healthier choices on the restriction trials in the choice stage where participants did not previously remove the unhealthier food item (unrestricted restriction trials). Here, paired samples t-tests showed that participants made more healthier choices in the control condition compared to the stress condition. Thus, stress resulted in unhealthier food choices, if participants did not restrict their future choice set despite having opportunities to do so on restriction trials in the precommitment stage.

In Table 2, we report the correlations between participants' stress reactivity (AUCg for stress ratings and salivary cortisol) and the number of choices for each trial type in the precommitment stage and choice stage in the control and stress condition. Again, these results mirrored the findings from the mixed effects models with a significant positive correlation between stress ratings and precommitment in the stress condition (i.e. the number of unhealthier items removed in the precommitment stage).

In summary, participants were more likely to select healthier food choices on restriction trials compared to viewing trials in the choice stage. This benefit of precommitment was comparable in both stress (44.9 %) and control conditions (42.0 %). Higher stress ratings were

Table 1

Means (+/- SD) for the choice behaviour in the precommitment stage and choice stage. The p values show the results of a paired samples t-test. The pattern of differences between conditions remains consistent when controlling for the effects of day (i.e. whether the stress or control condition was on the first day of testing).

	Control	Stress	p value
Precommitment stage: unhealthier items removed	9.62 (7.73)	9.17 (8.16)	0.448
Choice stage: healthier items chosen on VIEWING trials	11.83 (6.27)	10.14 (5.41)	0.121
Choice stage: healthier items chosen across all RESTRICTION trials	16.21 (7.39)	14.21 (6.86)	0.130
Choice stage: healthier items chosen on unrestricted RESTRICTION trials (where unhealthier item not previously removed)	6.59 (5.24)	5.03 (4.12)	0.026*

Table 2

Spearman's Rho correlations between the choice behaviour in the precommitment stage and choice stage and cortisol and stress ratings (AUC) in the control condition and stress condition.

	Control		Stress	
	Ratings	Cortisol	Ratings	Cortisol
Precommitment stage: unhealthier items removed	0.076	-0.015	0.374*	-0.226
Choice stage: healthier items chosen on VIEWING trials	-0.265	0.176	-0.285	0.106
Choice stage: healthier items chosen across all RESTRICTION trials	0.008	0.065	0.099	-0.037
Choice stage: healthier items chosen on unrestricted RESTRICTION trials	-0.104	0.238	-0.314	0.174

* p < 0.05

associated with a decrease in healthier choices on viewing trials but not on restriction trials (Fig. 3). This suggests that the more stressed participants felt, the more prone they were to select unhealthier food items in the viewing trials. Notably, the opportunity to precommit (remove the unhealthier item) prevented this decline in healthier choices at higher levels of stress. Analyses of precommitment choices in the precommitment stage confirmed this – in the stress condition, higher stress ratings were associated with a significant increase in precommitment (removing unhealthier items) but there was no effect of stress ratings in the control condition.

To determine whether precommitment or food choices were related to the questionnaire measures we conducted a correlation analysis shown in Table S1. In short, greater perceived stress (PSS-10) and impulsivity (BIS-15) were related to fewer healthier choices in the choice stage, whilst participants scoring higher on self-regulation of eating (SREBQ) and prospective memory abilities made more healthier

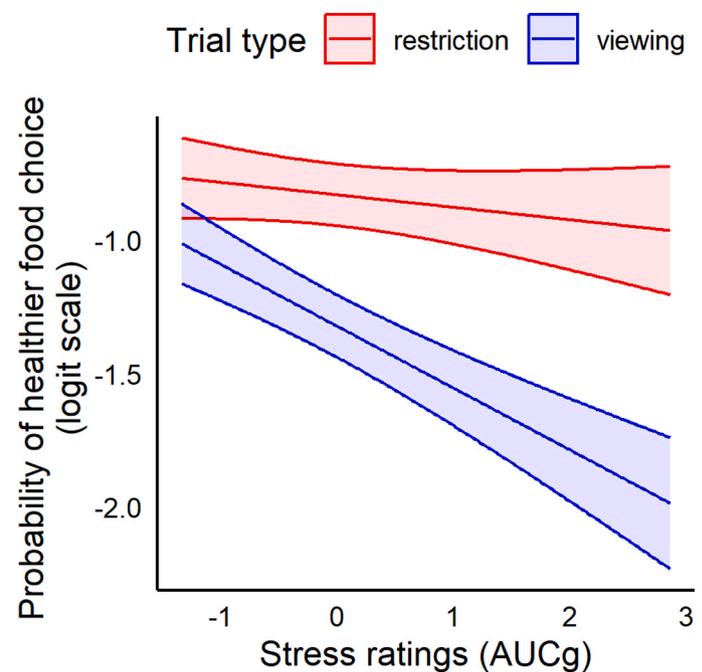


Fig. 4. The effect of stress ratings on the probability of healthier choices in the choice stage. On viewing trials (blue line), increasing stress reduced the probability of a healthier choice. There was no effect of increasing stress on the probability of a healthier choice on restriction trials where participants had had the chance to remove unhealthier items in the precommitment stage. The estimated slopes (+/- SE) were derived from the mixed effects logistic regression model using the R package *emmeans* (Lenth, 2022).

choices in the choice stage.

4. Discussion

We investigated the effect of acute stress in a novel ‘precommit-to-eat’ paradigm. Participants made choices between pairs of food items where they had previously rated one item as healthier but less tasty than the other item. The paradigm involved two stages which first tested the effect of acute stress on the removal of the unhealthier food item in each pair in a precommitment stage and, subsequently, the selection of the healthier food items to eat in a food choice stage. Participants who reported generally trying to eat healthily came to the lab twice—once in a stress condition and once in a non-stressful control condition—and showed a strong psychological and physiological response to the stressor. Choices were incentivised rather than hypothetical - one choice was selected for each participant, and they then ate their chosen food item at the end of each session.

Overall, we found that precommitment was an effective strategy to boost healthier food choices. Compared to viewing trials where precommitment had not been available, restriction trials in the choice stage resulted in an over 40 % increase in the selection of healthier food items. That is, the opportunity to voluntarily remove the unhealthier food items boosted the selection of healthier items.

In terms of stress effects, participants were more likely to make unhealthier food choices the more stressed they were (measured in terms of stress ratings collected throughout the experiment). This effect, however, was counteracted by the opportunity to precommit. Specifically, those participants with higher stress ratings made fewer healthier choices on viewing trials in the choice stage – on those trials where they had not had the chance to remove unhealthier food items in the precommitment stage. However, on restriction trials in the choice stage, where participants had had the opportunity to remove unhealthier food items in the precommitment stage, there was no effect of increased stress ratings on healthier choices (Fig. 3). This finding was driven by higher stress ratings in response to the stressor leading to more precommitment in the precommitment stage. Thus, higher stress ratings led to the removal of a greater number of unhealthier items in the precommitment stage, which protected participants against the stress-related increases in the selection of unhealthier items in the choice stage. Our findings show that precommitment could help to maintain healthier food choices even in the face of increased stress.

4.1. Precommitment promotes healthier food choices under stress

Our findings align with previous studies showing that increased stress resulted in unhealthier food choices (Herhaus and Petrowski, 2021; Lemmens et al., 2011; Rutters et al., 2009). In a recent meta-analysis of 54 studies, Hill et al. (2022) found stress was related to increased consumption of unhealthy foods and decreased consumption of healthy foods. In our study, both participants’ stress ratings during the experimental sessions (Fig. 3) and their perception of stress in everyday life (PSS scores; Table S1) were related to unhealthier food choices. Crucially, however, our findings show that restricting a future choice set through precommitment could counter the effects of stress on the selection of unhealthier food. We found that greater stress reactivity—as measured by participants’ stress ratings during the stress condition—resulted in more precommitment. This is consistent with a previous study investigating precommitment behaviour under acute stress. Raio and Glimcher (2021) found that participants under acute stress, compared to a control condition, were willing to pay more to avoid a tempting food item. Both findings suggest that individuals could anticipate greater difficulties with resisting tempting food when stressed and thus take pre-emptive action when given opportunities to do so. In this regard, stress could act as a state-dependent cue which makes people aware of their vulnerability to unhealthy eating and thereby promotes precommitment. This fits with previous work showing that a

metacognitive awareness of one’s tendency to succumb to temptation is key for precommitment (Soutschek and Tobler, 2020). Stress could heightened one’s awareness of this vulnerability. More generally, our findings support previous research showing that precommitment is most effective when impulsiveness is high (Soutschek and Tobler, 2020; Wertenbroch, 1998), as is often the case under stress (Maier et al., 2015; Shields et al., 2016).

These findings have clear implications for promoting healthier food choices, especially in potentially stressful environments, such as the workplace. For example, Stites et al. (2015) found that overweight or obese hospital employees who pre-ordered their lunches ate fewer calories and less fat compared to baseline. Similarly, providing highly structured meal plans and grocery lists to overweight women trying to lose weight was shown to improve outcomes in a behavioural weight control program (Wing et al., 1996).

Our findings suggest that similar precommitment interventions are likely to be resistant to the effects of acute stress or could even be enhanced by it.

There are obvious differences in the timescales of precommitment in the lab compared to everyday contexts, where there could be hours or possibly days between shopping and eating. These temporal differences could be important for precommitment. Milkman et al. (2010) showed that when the delay between online orders and delivery was greater, the number of “should” items increased (e.g. vegetables) and “want” items decreased (e.g. ice cream). Thus, future studies, potentially using ecological momentary assessments (Stijovic et al., 2025), will need to test the effects of stress, and other aversive states, on precommitment and food choices in real world settings.

We did not find any differences in hunger at the start of the experiment in the stress condition or the control condition. Hunger ratings did, however, increase in the control condition but not in the stress condition. This aligns with previous findings showing reductions in hunger, appetite and a desire to eat following acute stress (Geliebter et al., 2012; van Strien et al., 2014). Furthermore, van Strien et al. (2014) found that the failure of a stressor to reduce feelings of hunger predicted stress-induced emotional eating. Crucially, our analyses showed that there was no relationship between hunger ratings (or changes therein) and either precommitment in the precommitment stage or food choices in the choice stage (Table S1). This suggests that feelings of stress rather than hunger drove our effects, and that potential stress-related increased in metacognitive awareness are likely to be independent of hunger cues.

4.2. Implications and future directions

An aim for future work will be to understand the mechanisms of precommitment under stress. Precommitment has distinct neural mechanisms which are different from those involved in impulse inhibition, such as dorsolateral prefrontal cortex (Crockett et al., 2013; Maier et al., 2015). Specifically, the frontopolar cortex has been strongly implicated in precommitment (Crockett et al., 2013; Soutschek et al., 2017) and more broadly in metacognitive abilities, such as counterfactual reasoning (for an overview, see Kapetaniou and Soutschek, 2025). Current theories suggest that prefrontal regions involved in such executive functions and goal-directed, flexible behaviour are compromised under stress. There is a shift towards a ‘salience network’, promoting vigilance (Hermans et al., 2014) and habitual responding (Schwabe and Wolf, 2009) (but see Smeets et al., 2023). For example, van Ruitenbeek et al. (2021) found reduced activation in the frontal pole related to goal-directed behaviour under acute stress. If precommitment is dependent on prefrontal regions which are compromised under stress, why did we find greater precommitment with increasing stress? One possibility is that the frontal regions responsible for precommitment (e.g. frontopolar cortex) are less vulnerable to stress compared to regions responsible for impulse inhibition. Uy and Galván (2017) showed that whilst adolescent boys showed a reduction in frontal pole activation when making risky decisions under stress, there was no such reduction

in men, women, or adolescent girls. Additionally, one study found increased activity in the frontal pole under stress: Nakamura et al. (2020) used magnetoencephalography to show a greater reduction in alpha band power (reflective of increased cortical activity) in the frontal pole in a stress condition, compared to a control condition, when viewing food images. Future neuroimaging studies will need to establish the precise mechanisms, including the role of the frontopolar cortex, in precommitment decisions under stress.

All participants in our sample reported that they tried to eat healthily in their everyday lives. The mean score on a measure of self-regulation of eating (SREBQ; Kliemann et al., 2016) in our sample (mean=3.39, SD=0.66) aligned with the German norms for those with a BMI below 25 (mean=3.43, SE=0.74) (Schmalbach et al., 2021). Yet, the detrimental effects of stress on eating behaviour have been shown to be strongest in those with lower levels of dietary restraint (Hill et al., 2022), such as individuals who engage in binge eating (Goldfield et al., 2008; Schulz and Laessle, 2012). Thus, a challenge for future work will be to establish whether precommitment is resistant to the effects of acute stress in individuals who have lower levels of dietary restraint compared to the present sample. There is some evidence to suggest that precommitment strategies, such as 'deposit contracts', could be effective for reducing weight in obesity - here individuals deposit a sum of money with a third party and the money is only returned if they reach a certain weight (Cawley, 2016).

Whilst individuals with obesity or lower levels of dietary restraint are likely to profit from precommitment, especially when stressed, previous work suggests that precommitment is often not implemented when it would be most beneficial (Laibson, 2015). Soutschek and Tobler (2020) showed that a metacognitive awareness of one's vulnerability to succumb to temptation is important for implementing precommitment. Thus, making individuals aware of their vulnerability to tempting food, especially under stress, is likely to be a prerequisite for the success of precommitment strategies in individuals with lower levels of dietary restraint.

Finally, in the precommitment stage the unhealthier item was highlighted with a grey box. Future studies will need to rule out purely attention-driven explanations for the current findings as it is possible that stress enhances responses to salient task-relevant cues (van Marle et al., 2009; Wirz and Schwabe, 2020). This feature of the design aimed to replicate everyday food choices where unhealthier items are explicitly highlighted with health warnings or colour-coded nutritional information (Cecchini and Warin, 2016; Song et al., 2021). An open question for future studies will be to determine how stress affects the removal of unhealthier food items when these are not explicitly highlighted.

5. Conclusion

Stress has been consistently linked to unhealthier food choices – our findings suggest that giving stressed individuals the opportunity to restrict their future choice set can mitigate these detrimental effects. Thus, precommitment promotes healthier food choices under stress. Future work will need to unravel the mechanisms underlying enhanced precommitment under stress, in particular the role of impulsivity and metacognitive awareness of one's ability to resist temptation (Soutschek and Tobler, 2020). Whether our results are applicable to real world settings and to populations with lower levels of dietary restraint will also need to be tested. This work will have important implications for developing interventions which promote healthier food choices in people's everyday lives, particularly in stressful environments.

CRedit authorship contribution statement

Tobias Kalenscher: Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Funding acquisition, Conceptualization. **Paul A.G. Forbes:** Writing – review & editing, Writing – original draft, Visualization, Project administration,

Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Candace M. Raio:** Writing – review & editing, Supervision, Conceptualization.

Funding

Paul Forbes is supported by a Marie Skłodowska-Curie Postdoctoral Fellowship from the European Commission (Grant number: 101107160).

Declaration of Competing Interest

None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.psyneuen.2026.107754.

References

- Barr, D.J., Levy, R., Scheepers, C., Tily, H.J., 2013. Random effects structure for confirmatory hypothesis testing: Keep it maximal. *J. Mem. Lang.* 68 (3), 255–278.
- Cawley, J., 2016. Does Anything Work to Reduce Obesity? (Yes, Modestly). *J. Health Polit. Policy Law* 41 (3), 463–472. <https://doi.org/10.1215/03616878-3524020>.
- Cecchini, M., Warin, L., 2016. Impact of food labelling systems on food choices and eating behaviours: A systematic review and meta-analysis of randomized studies. *Obes. Rev. Off. J. Int. Assoc. Study Obes.* 17 (3), 201–210. <https://doi.org/10.1111/obr.12364>.
- Choi, Y.C., Ding, C., Magkos, F., 2019. The epidemiology of obesity. *Metabolism* 92, 6–10. <https://doi.org/10.1016/j.metabol.2018.09.005>.
- Cohen, S., Kamarck, T., Mermelstein, R., 1983. A Global Measure of Perceived Stress. *J. Health Soc. Behav.* 24 (4), 385–396. <https://doi.org/10.2307/2136404>.
- Crockett, M.J., Braams, B.R., Clark, L., Tobler, P.N., Robbins, T.W., Kalenscher, T., 2013. Restricting Temptations: Neural Mechanisms of Precommitment. *Neuron* 79 (2), 391–401. <https://doi.org/10.1016/j.neuron.2013.05.028>.
- Evenden, J.L., 1999. Varieties of impulsivity. *Psychopharmacology* 146 (4), 348–361. <https://doi.org/10.1007/PL00005481>.
- Forbes, P.A., Nitschke, J.P., Hochmeister, N., Kalenscher, T., Lamm, C., 2024. No effects of acute stress on monetary delay discounting: A systematic literature review and meta-analysis. *Neurobiology of Stress* 31, 100653. <https://doi.org/10.1016/j.ynstr.2024.100653>.
- Geliebter, A., Gibson, C.D., Hernandez, D.B., Atalayer, D., Kwon, A., Lee, M.I., Mehta, N., Phair, D., Gluck, M.E., 2012. Plasma Cortisol Levels in Response to a Cold Pressor Test Did Not Predict Appetite or Ad Libitum Test Meal Intake in Obese Women. *Appetite* 59 (3), 956–959. <https://doi.org/10.1016/j.appet.2012.08.025>.
- Goldfield, G.S., Adamo, K.B., Rutherford, J., Legg, C., 2008. Stress and the relative reinforcing value of food in female binge eaters. *Physiol. Behav.* 93 (3), 579–587. <https://doi.org/10.1016/j.physbeh.2007.10.022>.
- Herhaus, B., Petrowski, K., 2021. The effect of restrained eating on acute stress-induced food intake in people with obesity. *Appetite* 159, 105045. <https://doi.org/10.1016/j.appet.2020.105045>.
- Hermans, E.J., Henckens, M.J.A.G., Joëls, M., Fernández, G., 2014. Dynamic adaptation of large-scale brain networks in response to acute stressors. *Trends Neurosci.* 37 (6), 304–314. <https://doi.org/10.1016/j.tins.2014.03.006>.
- Hill, D., Conner, Mark, Clancy, Faye, Moss, Rachael, Wilding, Sarah, Bristow, Matt, O'Connor, D.B., 2022. Stress and eating behaviours in healthy adults: A systematic review and meta-analysis. *Health Psychol. Rev.* 16 (2), 280–304. <https://doi.org/10.1080/17437199.2021.1923406>.
- Kalenscher, T., Pennartz, C.M.A., 2008. Is a bird in the hand worth two in the future? The neuroeconomics of intertemporal decision-making. *Prog. Neurobiol.* 84 (3), 284–315. <https://doi.org/10.1016/j.pneurobio.2007.11.004>.
- Kalenscher, T., Ohmann, T., Windmann, S., Freund, N., Güntürkün, O., 2006. Single forebrain neurons represent interval timing and reward amount during response scheduling. *Eur. J. Neurosci.* 24 (10), 2923–2931. <https://doi.org/10.1111/j.1460-9568.2006.05167.x>.
- Kapetanidou, G.E., Soutschek, A., 2025. Beyond impulse control – toward a comprehensive neural account of future-oriented decision making. *Neurosci. Biobehav. Rev.* 172, 106115. <https://doi.org/10.1016/j.neubiorev.2025.106115>.
- Klein, E.M., Brähler, E., Dreier, M., Reinecke, L., Müller, K.W., Schmutzer, G., Wölfling, K., Beutel, M.E., 2016. The German version of the Perceived Stress Scale—psychometric characteristics in a representative German community sample. *BMC Psychiatry* 16, 1–10.
- Kliemann, N., Beeken, R.J., Wardle, J., Johnson, F., 2016. Development and validation of the Self-Regulation of Eating Behaviour Questionnaire for adults. *Int. J. Behav. Nutr. Phys. Act.* 13 (1), 87. <https://doi.org/10.1186/s12966-016-0414-6>.
- Laibson, D., 2015. Why don't present-biased agents make commitments? *Am. Econ. Rev.* 105 (5), 267–272. <https://doi.org/10.1257/aer.p20151084>.
- Lemmens, S.G., Rutters, F., Born, J.M., Westerterp-Plantenga, M.S., 2011. Stress augments food 'wanting' and energy intake in visceral overweight subjects in the

- absence of hunger. *Physiol. Behav.* 103 (2), 157–163. <https://doi.org/10.1016/j.physbeh.2011.01.009>.
- Lenth, R., 2022. Emmeans: Estimated marginal means, aka least-squares means. R. Package Version 1 (4), 7, 2020.
- Liu, C., Xie, B., Chou, C.-P., Koprowski, C., Zhou, D., Palmer, P., Sun, P., Guo, Q., Duan, L., Sun, X., Anderson Johnson, C., 2007. Perceived stress, depression and food consumption frequency in the college students of China seven cities. *Physiol. Behav.* 92 (4), 748–754. <https://doi.org/10.1016/j.physbeh.2007.05.068>.
- Long, J.A., Long, M., 2021. Package 'interactions'. *Comprehensive. Use Friendly Toolkit Probing Interact.* (<https://cran.r-project.org/Web/Packages/Interactions/Interactions.Pdf> (Assessed July 29, 2021)) (Available Online at).
- Maier, S.U., Makwana, A.B., Hare, T.A., 2015. Acute Stress Impairs Self-Control in Goal-Directed Choice by Altering Multiple Functional Connections within the Brain's Decision Circuits. *Neuron* 87 (3), 621–631. <https://doi.org/10.1016/j.neuron.2015.07.005>.
- van Marle, H.J.F., Hermans, E.J., Qin, S., Fernández, G., 2009. From specificity to sensitivity: How acute stress affects amygdala processing of biologically salient stimuli. *Biol. Psychiatry* 66 (7), 649–655. <https://doi.org/10.1016/j.biopsych.2009.05.014>.
- Milkman, K.L., Rogers, T., Bazerman, M.H., 2010. I'll have the ice cream soon and the vegetables later: A study of online grocery purchases and order lead time. *Mark. Lett.* 21 (1), 17–35. <https://doi.org/10.1007/s11002-009-9087-0>.
- Nakamura, C., Ishii, A., Matsuo, T., Ishida, R., Yamaguchi, T., Takada, K., Uji, M., Yoshikawa, T., 2020. Neural effects of acute stress on appetite: A magnetoencephalography study. *PLOS ONE* 15 (1), e0228039. <https://doi.org/10.1371/journal.pone.0228039>.
- Papier, K., Ahmed, F., Lee, P., Wiseman, J., 2015. Stress and dietary behaviour among first-year university students in Australia: Sex differences. *Nutrition* 31 (2), 324–330. <https://doi.org/10.1016/j.nut.2014.08.004>.
- Pruessner, J.C., Kirschbaum, C., Meinlschmid, G., Hellhammer, D.H., 2003. Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology* 28 (7), 916–931. [https://doi.org/10.1016/S0306-4530\(02\)00108-7](https://doi.org/10.1016/S0306-4530(02)00108-7).
- Pruessner, J.C., Champagne, F., Meaney, M.J., Dagher, A., 2004. Dopamine release in response to a psychological stress in humans and its relationship to early life maternal care: A positron emission tomography study using [¹¹C]raclopride. *Journal Neuroscience Official Journal Society Neuroscience* 24 (11), 2825–2831. <https://doi.org/10.1523/JNEUROSCI.3422-03.2004>.
- Pruessner, J.C., Dedovic, K., Khalili-Mahani, N., Engert, V., Pruessner, M., Buss, C., Renwick, R., Dagher, A., Meaney, M.J., Lupien, S., 2008. Deactivation of the Limbic System During Acute Psychosocial Stress: Evidence from Positron Emission Tomography and Functional Magnetic Resonance Imaging Studies. *Biol. Psychiatry* 63 (2), 234–240. <https://doi.org/10.1016/j.biopsych.2007.04.041>.
- Raio, C.M., Glimcher, P.W., 2021. Quantifying the subjective cost of self-control in humans. *Proc. Natl. Acad. Sci.* 118 (35), e2018726118. <https://doi.org/10.1073/pnas.2018726118>.
- van Ruitenbeek, P., Quaedflieg, C.W., Hernaes, D., Hartogsveld, B., Smeets, T., 2021. Dopaminergic and noradrenergic modulation of stress-induced alterations in brain activation associated with goal-directed behaviour. *J. Psychopharmacol.*, 026988112111044679 <https://doi.org/10.1177/026988112111044679>.
- Rummel, J., Danner, D., Kuhlmann, B.G., 2019. The short version of the Metacognitive Prospective Memory Inventory (MPMI-s): Factor structure, reliability, validity, and reference data. *Meas. Instrum. Soc. Sci.* 1, 1–8.
- Rutters, F., Nieuwenhuizen, A.G., Lemmens, S.G.T., Born, J.M., Westerterp-Plantenga, M. S., 2009. Acute Stress-related Changes in Eating in the Absence of Hunger. *Obesity* 17 (1), 72–77. <https://doi.org/10.1038/oby.2008.493>.
- Schmalbach, I., Schmalbach, B., Zenger, M., Petrowski, K., Beutel, M., Hilbert, A., Brähler, E., 2021. Psychometric Properties of the German Version of the Self-Regulation of Eating Behavior Questionnaire. *Front. Psychol.* 12. <https://doi.org/10.3389/fpsyg.2021.649867>.
- Schulz, S., Laessle, R.G., 2012. Stress-induced laboratory eating behavior in obese women with binge eating disorder. *Appetite* 58 (2), 457–461. <https://doi.org/10.1016/j.appet.2011.12.007>.
- Schwabe, L., Wolf, O.T., 2009. Stress Prompts Habit Behavior in Humans. *J. Neurosci.* 29 (22), 7191–7198. <https://doi.org/10.1523/JNEUROSCI.0979-09.2009>.
- Schwartz, J., Mochon, D., Wyper, L., Maroba, J., Patel, D., Ariely, D., 2014. Healthier by Precommitment. *Psychol. Sci.* 25 (2), 538–546. <https://doi.org/10.1177/0956797613510950>.
- Shields, G.S., Sazma, M.A., Yonelinas, A.P., 2016. The effects of acute stress on core executive functions: A meta-analysis and comparison with cortisol. *Neurosci. Biobehav. Rev.* 68, 651–668. <https://doi.org/10.1016/j.neubiorev.2016.06.038>.
- Smeets, T., Cornelisse, S., Quaedflieg, C.W.E.M., Meyer, T., Jellic, M., Merckelbach, H., 2012. Introducing the Maastricht Acute Stress Test (MAST): A quick and non-invasive approach to elicit robust autonomic and glucocorticoid stress responses. *Psychoneuroendocrinology* 37 (12), 1998–2008. <https://doi.org/10.1016/j.psyneuen.2012.04.012>.
- Smeets, T., Ashton, S.M., Roelands, S.J.A.A., Quaedflieg, C.W.E.M., 2023. Does stress consistently favor habits over goal-directed behaviors? Data from two preregistered exact replication studies. *Neurobiol. Stress* 23, 100528. <https://doi.org/10.1016/j.ynstr.2023.100528>.
- Song, J., Brown, M.K., Tan, M., MacGregor, G.A., Webster, J., Campbell, N.R.C., Trieu, K., Mhurchu, C.N., Cobb, L.K., He, F.J., 2021. Impact of color-coded and warning nutrition labelling schemes: A systematic review and network meta-analysis. *PLOS Med.* 18 (10), e1003765. <https://doi.org/10.1371/journal.pmed.1003765>.
- Soutschek, A., Tobler, P.N., 2020. Know your weaknesses: Sophisticated impulsiveness motivates voluntary self-restrictions. *J. Exp. Psychol. Learn. Mem. Cogn.* 46 (9), 1611–1623. <https://doi.org/10.1037/xlm0000833>.
- Soutschek, A., Ugazio, G., Crockett, M.J., Ruff, C.C., Kalenscher, T., Tobler, P.N., 2017. Binding oneself to the mast: Stimulating frontopolar cortex enhances precommitment. *Soc. Cogn. Affect. Neurosci.* 12 (4), 635–642. <https://doi.org/10.1093/scan/nsw176>.
- Spinella, M., 2007. Normative data and a short form of the Barratt Impulsiveness Scale. *Int. J. Neurosci.* 117 (3), 359–368. <https://doi.org/10.1080/00207450600588881>.
- Starcke, K., Brand, M., 2012. Decision making under stress: A selective review. *Neurosci. Biobehav. Rev.* 36 (4), 1228–1248. <https://doi.org/10.1016/j.neubiorev.2012.02.003>.
- Stijovic, A., Forbes, P., Pronizius, E., Feneberg, A., Piperno, G., Nater, U.M., Lamm, C., Silani, G., 2025. Affective and Social Predictors of Food Consumption During the COVID-19 Lockdown. *S0006 Biol. Psychiatry* 3223 (25). <https://doi.org/10.1016/j.biopsych.2025.02.007>.
- Stites, S.D., Singletary, S.B., Menasha, A., Coobllall, C., Hantula, D., Axelrod, S., Figueredo, V.M., Phipps, E.J., 2015. Pre-ordering lunch at work. Results of the what to eat for lunch study. *Appetite* 84, 88–97. <https://doi.org/10.1016/j.appet.2014.10.005>.
- van Strien, T., Ouwens, M.A., Engel, C., de Weerth, C., 2014. Hunger, inhibitory control and distress-induced emotional eating. *Appetite* 79, 124–133. <https://doi.org/10.1016/j.appet.2014.04.020>.
- Studer, B., Koch, C., Knecht, S., Kalenscher, T., 2019. Conquering the inner couch potato: precommitment is an effective strategy to enhance motivation for effortful actions. *Philosophical Transactions of the Royal Society B* 374 (1766), 20180131. <https://doi.org/10.1098/rstb.2018.0131>.
- Studer, B., Timm, A., Sahakian, B.J., Kalenscher, T., Knecht, S., 2021. A decision-neuroscientific intervention to improve cognitive recovery after stroke. *awab128 Brain*. <https://doi.org/10.1093/brain/awab128>.
- Thaler, R.H., Benartzi, S., 2004. Save more tomorrow™: Using behavioral economics to increase employee saving. *J. Political Econ.* 112 (S1), S164–S187.
- Tomiyama, A.J., Dallman, M.F., Epel, E.S., 2011. Comfort food is comforting to those most stressed: Evidence of the chronic stress response network in high stress women. *Psychoneuroendocrinology* 36 (10), 1513–1519. <https://doi.org/10.1016/j.psyneuen.2011.04.005>.
- Uy, J.P., Galván, A., 2017. Acute stress increases risky decisions and dampens prefrontal activation among adolescent boys. *NeuroImage* 146, 679–689. <https://doi.org/10.1016/j.neuroimage.2016.08.067>.
- Werthenbroch, K., 1998. Consumption Self-Control by Rationing Purchase Quantities of Virtue and Vice. *Mark. Sci.* 17 (4), 317–337. <https://doi.org/10.1287/mksc.17.4.317>.
- Wing, R.R., Jeffery, R.W., Burton, L.R., Thorson, C., Nissinoff, K.S., Baxter, J.E., 1996. Food provision vs structured meal plans in the behavioral treatment of obesity. *International Journal of Obesity and Related Metabolic Disorders. J. Int. Assoc. Study Obes.* 20 (1), 56–62.
- Wirz, L., Schwabe, L., 2020. Prioritized attentional processing: Acute stress, memory and stimulus emotionality facilitate attentional disengagement. *Neuropsychologia* 138, 107334. <https://doi.org/10.1016/j.neuropsychologia.2020.107334>.