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ABSTRACT

Stress and Food Preferences: A Lab Experiment with Low-SES Mothers*

We investigate whether short-term everyday stressors leads to unhealthier dietary choices among low socioeconomic status mothers. We propose a novel stress protocol that aims to mimic everyday stressors experienced by this population, involving time and financial pressure. We evaluate the impact of stress on immediate and planned food choices, comparing a group exposed to our stress protocol relative to a control group. Immediate consumption is measured with in-laboratory consumption of low calorie and high calorie snacks; planned consumption is measured with an incentivized food shopping task. The stressfulness of the stress protocol is evaluated using subjective assessments, as well as physiological measurements (heart rate and salivary cortisol levels). We find no evidence of an effect of stress on the nutritional content of immediate or planned food consumption, thus no support for the hypothesis that everyday stressors are a likely explanation for unhealthy food choices.

JEL Classification: I12, D91
Keywords: diet, acute stress, everyday stressors, lab experiment

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1 Introduction

Stress is pervasive. According to a survey in the UK by the Mental Health Foundation in 2018 almost three quarters of the population at some point over the previous year were so stressed that they felt either overwhelmed or unable to cope[1]. Americans report similar levels of stress. Levels that are higher than believed to be healthy (American Psychological Association, 2015). Stress has detrimental effects on our health and longevity (Schneiderman et al., 2005) and is associated with significant health care and other costs to society. The UK's Health and Safety Executive estimate the cost to society of new cases of work-related stress to be in the region of £5.2 billion per year (Health and Safety Executive, 2016).

Previous studies in psychology have documented that individuals of low socioeconomic status experience more stress and negative affective states (Adler et al., 1994). The famous epidemiological studies on UK public servants (Marmot et al., 1978, and Marmot et al., 1991) for example were among the first to show that individuals at the lower end of the hierarchy are more affected by high blood pressure and heart conditions, indicators usually associated with greater exposure to stress.

In this paper, we investigate the impact of everyday acute stressors on diet in a low socioeconomic status (SES) population[2]. There is evidence that lower SES groups tend to have a poorer diet and an unhealthier lifestyle in general (Pampel et al., 2010), which in turn could contribute to the socio-economic gradient in health and obesity in particular (McLaren, 2007; Cutler and Lleras-Muney, 2010). A number of explanations have been proposed to explain why the poor have unhealthier lifestyles, such as income, relative prices of healthier and unhealthier foods, maternal employment, and technological change (see Cawley, 2011, for a review), or more recently behavioural anomalies, such as present bias (Loewenstein et al. 2012). Here we propose to investigate the role of stress and, specifically, the effects of temporary everyday stressors on eating decisions.

Several mechanisms could explain why short-term stress leads to unhealthier dietary choices. First, the recent literature in behavioural economics suggests a causal link between stress and decision-making. Experimental evidence shows an impact of acute stressors in the lab on a variety of economic behaviours and decisions (Delaney et al., 2014; Buckert et al.,

[1] Mental Health Foundation (2018).
[2] An acute stressor is a short-term demand or pressure placed on the body. It can be of a physiological or psychological nature. In the following we use acute and short-term interchangeably when describing stressors and stress.

2017a; Buckert et al., 2017b; Buser et al., 2017; Zhong et al., 2018; Goette et al., 2015). A stressor is an event that requires immediate attention and therefore shifts the necessary resources (cognitive and/or physical) to dealing with the stressor. Stress can therefore be a drain on resources such as mental energy, which in a bounded rationality context are necessary to make sound decisions (Allen and Armstrong, 2006). Stress has also been found to temporarily alter time preferences and risk attitudes (Delaney et al., 2014; Kandasamy et al., 2014) thereby affecting the ability to make utility maximizing decisions. Experimental evidence shows that cognitive overload weakens self-control and leads to unhealthier food choices (Shiv and Fedorikhin, 1999). Impaired decision making abilities may lead to more habitual behaviour, such as buying and consuming well known foods, and more impulsive choices. In a low-SES population both habitual and impulsive food choices are likely less healthy than choices made after thorough consideration.

Second, the literature in biology suggests that short-term stress may affect the desire to eat as well as what foods to eat. Hormonal responses to a stressor have been frequently cited to cause cravings for energy-dense “comfort foods” and hence a temporary change in food preferences (e.g. Adam and Epel, 2007). Both short-term and chronic stress stimulate the release of cortisol (in humans) or of other glucocorticoids (in animals) which has been shown to affect food intake of rats (Zakrzewska et al., 1999; Dallman et al., 2004) and humans (Tataranni et al., 1996; George et al., 2010) when administered exogenously.

We conduct a laboratory experiment to study how low SES individuals respond to a short-term stressful experience. We focus on low SES mothers as they play a crucial role in families’ dietary choices, often being in charge of the family’s food shopping and meal preparation (Harnack et al., 1998). Maternal food choices hence have considerable spillover effects on the diet of their children (Klohe-Lehman et al., 2007). Furthermore, women report greater stress than men across a whole range of stressful events (The Physiological Society, 2017) and parents report greater stress than individuals without children (American Psychological Association, 2015).

We propose a novel protocol for a stressful experience that aims at mimicking everyday stressors experienced by low-socioeconomic mothers. The stress protocol consists of time and budget allocations tasks, under time and financial pressure. The protocol also involves social incentives and distractions (mimicking the environment mothers face when taking decisions for the family). Participants were assigned either to the stress protocol or to a control task, which involved reading short texts and answering simple questions without financial incentives, distractions or time pressure.

We are interested in the effects of short-term stress on immediate food choices, but also on planned food choices, as they may involve different decision processes. In the spirit of Kahneman (2011), immediate consumption may for example be more vulnerable to impulses or temptation, while planned consumption may involve deeper cognitive processes. It has been documented that planned food choices tend to be healthier than immediate food choices (Sadoff et al., 2019). We expect that the relative importance of the two possible channels (biological or cognitive), linking stress to food choices, differs between immediate and planned consumption choices. As shopping choices require planning of future consumption and often involve larger choice sets, impaired decision making (second channel) would be expected to affect these choices more than the less complex immediate consumption choices. We furthermore randomly vary the complexity of the experimental food shopping choice, allowing us to examine the relevance of the second channel for planned consumption choices.

Immediate food consumption is measured by the in-laboratory consumption of high-calorie (muffins) and low-calorie (apple slices) snacks made available to the participants directly on their computer desk. Planned food consumption is measured by incentivized choices in a "virtual supermarket", a computer-based tool with similar features to online supermarket platforms. Participants were asked to use a fixed budget to purchase grocery items among a variety of high-calorie and low-calorie foods and drinks. The prices were matching market prices at a real on-line supermarket. We have detailed information on the nutritional content of all the foods and drinks included in the choice set and will evaluate the impact of the stressful task on the nutritional content of the baskets chosen.

The second experimental variation we introduce is in the planned food choice environment, which was either "simple" or "complex". Both the stress and the control groups were split into two further experimental conditions corresponding to the different choice environments. In the simple choice environment, items were displayed in 10 different categories (e.g. fruit, vegetable, eggs & dairy etc.). In the complex choice environment, items were displayed in a long list, grouped by category but without labelling of categories.

This experimental assignment of choice complexity allows us to test the relevance of the first channel outlined above. If stress affects dietary choices by impairing individuals' decision-making, a more complex choice environment is expected to lead to less healthy food shopping choices under stress.

The evidence shows that participants in the stress group perceived the task as significantly more stressful than the control group; this is supported by a significant rise in their heart rate during the task. However, we find no statistically significant effects of this stressor on participants' immediate food consumption ("snack choice") or planned food consumption ("shopping choice"). Our results suggest that day-to-day short-term stress per se does not affect dietary choices, immediate or planned. When controlling for the performance in the stress task though, we find a higher intake of high-calorie snacks among those performing poorly, suggesting a combined role of stress and failure in eating behaviour.

Our contribution is threefold. First, this is the first study focusing on the dietary impact of short-term stress among low socio-economic mothers, which we believe have a key influence on dietary choices at home. Second, we propose a novel protocol for inducing short-term stress, which aims at mimicking the type of stressors this group may frequently experience in everyday life. There are a number of previous laboratory experiments examining the impact of stress on food choices[3], but they all have used artificial and often unrealistic stressors (such as solving arithmetical tasks, preparing a speech for an audience etc.). The cortisol and perceived stress responses to these stressors are marked, but they do not resemble everyday-like stressors often faced by our population of interest. Third, we study the impact on both immediate and planned food consumption. The focus of previous laboratory experiments was exclusively on immediate consumption.

This paper is structured as follows. Section 2 presents the experimental design. Section 3 describes the data collected during the experiment. Section 4 outlines the hypotheses tested. In section 5, we present our empirical analysis and our results. Section 6 concludes.

[3] Table 1 reports an overview of the previous experimental literature on stress and eating.

2 Experimental Design

We conducted a lab experiment with 196 participants.[4]. The sessions took place between 15 October and 19 October 2018 in the experimental laboratory of the University of Essex (EssexLab). Sessions lasted approximately two hours and started at 10:30 am, 2:00 pm and 5:00 pm.

The experimental design was pre-tested in June 2018 using a sample of 50 low-SES mothers in Florence, Italy[5].

2.1 Sample and Recruitment

We recruited low-SES mothers living in the area of Colchester. The specific eligibility criteria for participation in the study were:

1) Aged between 18 and 45
2) Fluent in English
3) Being a mother whose youngest child is aged between 2 and 12 years old
4) Net annual household income below £35 000
5) Does not hold a university degree and is not currently enrolled at university
6) Has not been pregnant in the past 6 months
7) Has no allergies or intolerances to foods used for the snack consumption choice
8) Does not have medical conditions which can affect diet[6]

Participants were recruited using multiple channels. A marketing agency sent personalized letters to women in the Colchester area who match our age restriction and live in low SES neighbourhoods. The study was furthermore promoted to the participants of a previous experiment.[7]

Those interested in participation were invited to complete an online screening questionnaire or to contact the experiment team by telephone. Eligible mothers were then

[4] The lab experiment was conducted with ethical approval by the European University Institute and the University of Edinburgh. The experiment and the hypotheses tested in this study and in Belot et al. (2019) were pre-registered in the AEA RCT registry under the following trial ID: AEARCTR-0003410. Details can be found under https://www.socialscienceregistry.org/trials/3410/history/35937.

[5] The pre-test was conducted with ethical approval by the European University Institute and the University of Edinburgh and was pre-registered in the AEA RCT registry under the following trial ID: AEARCTR-0003089. Details can be found under https://www.socialscienceregistry.org/trials/3089/history/30976. Initially this pre-test was planned as the main experiment, but recruitment of participants proved too difficult to reach the necessary sample size.

[6] Specifically, we asked participants whether they have diabetes, an eating disorder or a metabolic disorder.

[7] Examples of the recruitment materials used to advertise the study can be found in Appendix A.

invited to one of the experimental sessions; they received an information leaflet and a consent form by post.

31 of the 227 participants who signed up did not fulfil all eligibility criteria when answering the questions about eligibility on the day of the experiment and are hence excluded from the analysis, a sample of 196 low-SES mothers remains for our analysis, see Table 2 for details.

2.2 Randomisation

We conducted 15 experimental sessions with 13 to 18 participants per session. The 15 sessions were spread over a period of five days.

The experiment follows a 2x2 experimental design resulting in four experimental conditions:

1) Stress Task & Simple Shopping Task
2) Stress Task & Complex Shopping Task
3) Control Task & Simple Shopping Task
4) Control Task & Complex Shopping Task

These experimental conditions were pre-assigned at the session level aiming to ensure balance in terms of day of the week and time of day.

When signing up for participation in the experiment, participants were asked to indicate their preferred session slots, but were not informed of the treatments associated with each time slot. If participants indicated availability for multiple slots, they were assigned to one of the slots solely based on scheduling concerns. Participants could only attend one session.

2.3 Procedure

A timeline of the experimental sessions is shown in Table 3. Upon arrival at our lab facilities, participants' body weight and body height without shoes and heavy clothing was measured by trained lab assistants. Throughout the experimental session, participants were asked to wear an armband monitoring their heart rate using an optical sensor. At the beginning of the experimental session, participants were asked to provide a first saliva sample (9 min before the start of the stress / control task).

Following this, participants were asked to complete a 10-minute task. The nature of the task depended on the session's randomly assigned experimental condition:

- In conditions 1) and 2) (stress conditions), participants were asked to complete an incentivised task aimed at inducing mild stress.
- In conditions 3) and 4) (control conditions), participants were asked to complete a task of similar nature but with no stress inducing features.

Detailed descriptions of these tasks can be found below.

Following the first task, participants were asked to complete a food shopping task. They were given a fixed budget of £30 to purchase grocery items in a “virtual supermarket”, a computer-based tool similar to online supermarkets. The complexity of the food shopping environment depended on the experimental condition assigned to the session:

- In conditions 1) and 3) (simple shopping task), products were listed separately in 10 different food categories.
- In conditions 2) and 4), (complex shopping task), products were shown in a long list.

Details of these food shopping tasks are outlined below.

After the food shopping task, participants were asked to provide a second saliva sample (29 mins after the start of the stress / control task) and then given a five-minute break. After the break, participants were asked to complete a questionnaire on demographics, family characteristics and behaviours, which might affect cortisol levels. During the break and the time given to complete the first questionnaire, participants were given permission to consume the snacks provided on their desks: high-calorie blueberry mini-muffins and low-calorie apple slices (not labelled with their calorie content or in any other way). After 20 minutes, the bowls of snacks were collected.[8]

Participants were then asked to complete a second questionnaire. The questionnaire featured questions about food consumption and food preferences of the participant and their youngest child as well as the participant’s food consumption during pregnancy. The questionnaire furthermore included questions about the stressfulness of the stress/control task, chronic stress, participants’ coping behaviours when dealing with stress and about potentially stressful events during the last 3 months as well as during the pregnancy. The data collected in this questionnaire is used in Belot et al. (2019) to examine the link between chronic maternal stress during pregnancy and children’s food preferences.

[8] Six blueberry mini-muffins (mean weight: 136.3g) and approx. 160g of apple slices (mean weight: 158.6g) were provided for each participant. The total costs of the snacks provided were £0.75 for the muffins and £1.00 for the apples.

At the end of the experimental session, a final saliva sample was collected (85 mins after the start of the stress / control task). Before receiving their payment, participants were told that the snacks provided differed in calorie content (at the request of the ethics committee).

2.4 Stress Protocol

The goal of this study is to examine the effects of exogenously induced short-term stress on dietary choices. According to biologists, stress in the human context is based on three components: stress is triggered by a physical or psychological stimulus or stressor "that perturbs or threatens to perturb homeostasis" (Sapolsky, 2004). Perception or anticipation of this threat to homeostasis causes psychological stress. Common features of psychological stress are a lack of predictability, control, outlets for frustration and of social support (Sapolsky, 2004). Following the perception of the threat "the body reestablishes homeostasis by marshalling neural and endocrine adaptations" (Sapolsky, 2004). Key players in this physiological stress response are the autonomic nervous system (ANS) which triggers a rise in heart rate and blood pressure and the hypothalamic-pituitary-adrenal (HPA) axis which increases its release of the hormone cortisol. Depending on its duration, stress is classified as acute or chronic. Our study focuses on mild acute, in other words short-term, stress and its impact on dietary choices.

One concern with previous studies that have investigated the effects of acute stress on dietary choices is their use of artificial stressors (for example, the Trier Social Stress Test by Kirschbaum et al., 1993, or arithmetic exercises), which make it difficult to extrapolate to real life situations low SES individuals may face. We propose a novel protocol aimed at mimicking the kind of stressors mothers are frequently exposed to in real life. We ask mothers to solve a series of time and money budgeting tasks, choosing the cheapest or the most time efficient option amongst all, as often required in real life. The task incorporates several features that have been shown to induce stress: financial incentives and losses, time pressure, social pressure and distractions. A detailed description of the task follows below.

Participants were asked to complete a 10-minute block of short incentivised decision tasks. While the tasks were completed individually, incentives were based on the joint performance of social groups, to elicit stress through social pressure. Social pressure and social-evaluative threat, inherent in tasks where participants are exposed to team incentives (Babcock et al., 2015), increase the level of stress in subjects (Kirschbaum et al., 1993; Dickerson and Kemeny 2004). Each group consisted of two randomly matched participants in the same session. Group matching was anonymous, for ethical motives. Incorrect answers and incomplete tasks were penalized, since uncertain financial pay-offs such as in economic competitions have been shown to induce stress (Buckert et al., 2017b; Buser et al., 2017; Zhong et al., 2018). Participants had a tight overall time limit as well as time penalties and time limits per task, indicated by the use of a prominent countdown timer, to induce stress through time pressure (Kocher et al., 2013; Buckert et al., 2017a). Short incentivised pop-up knowledge questions unrelated to the main task appeared on screen throughout the course of the task block at pre-specified times unknown to participants. Buckert et al. (2017a) show that distractions induced via pop-up Stroop-tasks raises physiological stress levels of subjects.

As mentioned above, this protocol was designed to mimic stressors often experienced by low-socioeconomic mothers: making decisions with consequences for others (e.g. for the family) subject to financial and time constraints as well as distractions (e.g. by children requiring attention). Child- and household related stressors, financial concerns as well as time pressure are among the most frequently encountered and most severe daily hassles facing mothers with young children (Chamberlain and Zika, 1990; Olson and Banyard, 1993).

After an initial instruction period, participants were asked to complete a block of 15 short decision tasks on the lab computers.[9] They were given 10 minutes to complete as many tasks as they could. This overall time constraint was expected to be binding for most of the participants[10] and hence to induce time pressure.

Participants also faced individual time limits of 120 seconds for each of the 15 tasks. A countdown timer at the top of the screen indicated how much time they had left for the current task. The timer turned red after 70 seconds to indicate that time was running out and that an initial pay-off deduction (after 75 seconds – details below) was imminent. If participants had not submitted an answer after 120 seconds, their current answer was submitted automatically and the next task appeared.

The decision tasks comprised budget tasks and time management tasks. For the budget tasks, participants were asked to choose the cheapest way to purchase a given basket of household expenditure items from a list of options. For example, participants were asked to purchase five t-shirts choosing from a list of t-shirts, which included single items as well as value packs consisting of multiple items. For the time management task, participants were given a list of diary items and were asked to schedule these in a timetable provided. The items

[9] Sample screenshots of the stress tasks are shown in Figures B.2 – B.5 of Appendix B.
[10] 64.5% of participants in the stress group did not complete all 15 tasks.

to be scheduled were of different lengths and a variety of constraints needed to be considered when scheduling them: some items needed to be scheduled at a specific time or within some given time window. These types of decision tasks were chosen to reflect prominent aspects of decisions faced by low-SES mothers: limited financial and time resources.

To induce additional stress through distractions, 10 simple knowledge questions appeared as pop-ups on screen throughout the block of tasks. The pop-ups were programmed to appear at predetermined times within the 10 minutes[11], no matter what task was currently shown and how much time had elapsed on this task. When a pop-up was open, participants could not see or continue their work on the current task until they submitted an answer; however, the countdown timer for the current task was visible and continued to run down. The knowledge questions in the pop-ups were chosen such that a majority of participants would know the answer (e.g. "What is the capital of the UK?").[12] Stress was not to be induced by the difficulty of the questions, but by the interruption of the current task and the added time pressure.

Participants in the stress treatment were randomly assigned to "social groups" of two. While participants needed to complete the tasks individually, they were incentivised jointly. Each group was initially allocated £30, the maximum joint incentive they could earn in the stress task block. The performance of each group member in the decision tasks and the pop-up knowledge questions determined how much of the initial £30 was "lost" by the group. This joint incentive structure was chosen to induce social stress as participants feel that their choices have consequences for others. We chose to frame the incentives in terms of "losses" rather than "gains" to avoid inducing positive emotions.

Each participant could lose a maximum of £15 to the group, £13.50 from the decision tasks and £1.50 from the pop-up knowledge questions. In each of the 15 decision tasks, a participant could lose up to £0.90 to the group. There was no loss if the correct answer was submitted within 75 seconds of starting a decision task. If a correct answer was given more than 75 seconds after starting a task, £0.30 was lost. If a wrong answer was given or a task was not attempted or completed, £0.90 was lost.[13] Each of the 10 pop-up knowledge questions was

[11] Pop-ups were programmed to appear 20, 70, 130, 180, 230, 280, 360, 440, 490 and 540 seconds after the beginning of the 10 minute block of tasks.

[12] 93.5% of participants in the stress group answered at least 8 out of 10 pop-up knowledge questions correctly. 92.6% of all pop-up knowledge questions were answered correctly.

[13] The mean and median number of correctly solved decision tasks was 7 out of 15 (46.7%). Of these correct answers, 5.5% were submitted after the initial 75 seconds had elapsed.

worth £0.15. If a participant gave a correct answer, there was no deduction. If a participant gave a wrong answer, £0.15 was lost to the group.

This incentive structure ensured that participants' performance in every single task and pop-up question would affect the group's pay-off. This reduced the risk of participants giving up due to difficulties in solving some of the tasks. Participants were made aware of the joint incentive structure and that they are part of a group with another participant in the same session. However, the group assignments were not announced to the participants.

2.5 Control task

Instead of undergoing the stress protocol, participants in the control group were asked to complete a task which was comparable in length and of a similar nature, but which was not aimed at inducing stress. Specifically, they were asked to answer 14 simple knowledge questions after reading seven short texts about a variety of topics.[14] The correct answers to each question could be found in the corresponding text. The questions were similar to those asked via pop-ups during the stress task. Each text and the corresponding two questions were on a single page, allowing the participants to easily move back and forth between questions and texts. Participants were given 10 minutes for this task, there were no consequences from not completing all questions. The task was not incentivised and no "social groups" were formed.

2.6 Food Shopping Task

In both experimental conditions, participants were asked to complete a food shopping task. They were given 10 minutes to allocate a fixed budget of £30 to food and drink items offered in a "virtual supermarket", a computer-based tool similar to online supermarkets.[15] This "virtual supermarket" tool used to record participants' choices was adapted from a tool by Spiteri et al. (2019). A variety of low-calorie and high-calorie food and drink items was available to choose from with prices matching market prices at a local supermarket. Participants were encouraged to make their shopping choices as they would during a weekly shop at their local supermarket.

The supermarket choice was incentivised: 1 out of 15 participants was randomly chosen to receive their chosen basket delivered to their home approximately two weeks after the experimental session. This incentive scheme was chosen to motivate participants to make

[14] A sample screenshot of a control task is shown in Figure B.6 of Appendix B.
[15] Sample screenshots of the food shopping task are shown in Figures B.7-B.9 of Appendix B.

choices representative of normal shopping behaviour and the 2-week delay in delivery was chosen to ensure that current stocks (of fresh produce in particular) would not affect their choices. Participants were informed that, if they were selected and had not spent the entire £30 budget, they would be paid the difference in cash up to £2 maximum. This was to discourage non-representative shopping choices aimed at spending exactly £30, and to ensure that participants did not feel any pressure to spend the exact amount, which could induce stress for all participants. Under this incentive scheme, it was optimal for participants to aim to spend between £28 and £30.[16]

To examine whether choice complexity leads to less healthy decisions under stress, sessions were pre-assigned to one of two supermarket choice environments (independently of the assignment to the stress or control group): a simple or a complex choice environment. In both choice environments, 156 grocery items from the following 10 different product categories were on offer: fruit, vegetables, eggs & dairy, meat & fish, bakery, pasta & rice, pantry, snacks, ready meals, drinks. In the simple choice environment, items were displayed on 10 different pages – one for each product category. In the complex choice environment, items were displayed on a single page, grouped by category but without labelling of categories. The order in which items were displayed within each category was randomized at the participant level to avoid order effects. Furthermore, the display order of categories and the first category shown when opening the supermarket tool was randomized.

2.6 Monetary Compensation

Participants in the stress group (conditions 1 and 2) received a compensation between £60 and £75 depending on their group's performance in the stress task, the mean compensation received was £67.86. Participants in the control group (conditions 3 and 4) received a compensation of £60. Of the 227 participants, 16 additionally received the food basket they selected during the food shopping task, worth up to £30.

2.7 Power calculations

We use the final sample size of 196 eligible participants and the mean, standard deviation and intraclass correlation coefficient (ICC) observed in the control group for our primary outcome variables to ex-post calculate the minimum detectable effects (MDE) of our experiment, taking the potentially clustered error structure at the session level into account. Our calculations show

[16] 97.5% of participants spent between £28 and £30 in the food shopping task.

that comparisons between stress and control group have 80% power to detect effects of 0.43-0.54 standard deviations in the snack choice (25-49% of the control group mean) and effects of 0.43-0.45 standard deviations in the food shopping choice (10-19% of the control group mean). The sample used in our experiment, which is larger than the samples of most studies reviewed in Table 1: Overview of the literature on stress and dietTable 1, is therefore sufficient to detect sizable effects on snacking similar to those reported in Epel et al. (2001) and Habhab et al. (2009).

2.8 External Validity

We have chosen stressors that aim to closely mimic stressors experienced by our target population in their everyday lives, and the design of the food shopping task was chosen for its familiarity. There are however potential limitations to the external validity of the study, which we discuss here briefly.

First, there is a possible concern surrounding the Hawthorne effect. The study was advertised to participants as a study on common household decisions, avoiding any mention of "stress" or "food choices" in the description of the study. Nonetheless, participants may have realised that the experiment is about food choices, particularly with respect to the planned food choices, in contrast to a field experiment where participants are unaware that they are part of a study. It could be the case that lab participants make healthier choices than they normally would. While this is a concern, we study choices that are incentivised to reduce this possibility. Our experiment furthermore involves a control group which would be subject to the same Hawthorne effect.

Second, our sample is not a random sample of the general population. We restrict our sample to low-SES mothers as we are interested in this particular population due to the higher risk of obesity and the likely spillover effects of food choices to other family members. As is the case with any experiment, participants self-selected into our study sample which is therefore not a random sample from the population of interest. To assess whether certain subsets of the population were more likely to self-select into our sample, we compare the demographic characteristics of our sample to those of individuals matching the same demographic eligibility criteria 1)-6) in the nationally representative Understanding Society survey (Institute for Social and Economic Research, 2018).[17] We find little differences in the age of the mothers, the age of their youngest child, the number of children and the mothers'

[17] Results of the comparison are shown in Table C.1 of Appendix C.

highest qualification. We observe moderate differences in marital status, household income, received benefits and employment status. Specifically, participants in our sample are less likely to be single, have a somewhat lower household income, receive lower monthly benefit payments and are more likely to work part-time. Overall, we do not find large differences in the demographic characteristics of our experimental sample and a nationally representative sample from our population of interest.

Third, our planned shopping task only had 156 grocery items whereas an online supermarket would have many more products, potentially leading to different choices. Zizzo et al. (2016) found that participant's choices in a similar incentivised experimental food shopping task were negatively related to the current product stock at home, indicating that participants were making realistic choices aimed at refilling the grocery stock at home. To further assess the validity of our food shopping task, we compare the spending shares by participants on the 10 grocery categories in our experiment with grocery expenditure shares of a nationally representative sample in the food-diary based UK Living Costs and Food Survey 2016/17 (Department for Environment, Food and Rural Affairs, 2018), showing similar expenditure patterns in both.[18] While we observe somewhat more purchases of fruit, vegetables, pasta and rice and less purchases of snacks and ready meals in our experiment, these differences are not large and likely driven by our experimental task covering a larger product range in the former than in the latter categories (compared to a real-life supermarket). In total, the 10 grocery categories used in our task correspond to 79% of non-alcohol grocery spending for consumption at home.

3 Data

We have collected measures relating to the experience of the experimental treatments and the dietary decisions made by participants in the lab, as well as a range of control variables. In the following, we describe the measures used to answer our research questions.

[18] Results of the comparison are shown in Table C.2 of Appendix C.

3.1 Food Choice

a) Immediate food consumption

Immediate food consumption is measured by the snack choice faced by participants. For a duration of 20 minutes, participants were permitted to consume the snacks provided on their desks: high-calorie blueberry mini-muffins and low-calorie apple slices. Snacks were weighed before and after the experiment, the consumption quantities of each snack type (in grams) are the primary outcomes relating to the snack choice. Secondary outcomes are the total calories (in kcal), saturated fat (in grams) and sugar content (in grams) of the consumed snacks; these measures are deterministic functions of the two primary outcome variables.

b) Planned food consumption

Planned food consumption is measured by the food shopping choice made using the "virtual supermarket" tool (Spiteri et al., 2019). We construct measures of the nutritional content of the baskets based on the nutritional information of each of the products chosen. Primary outcomes are the energy (in kcal), the saturated fat (in grams) and the sugar content (in grams) of the chosen basket. The total weight of fruit and vegetables (in grams) chosen by the participant is considered as a secondary outcome.

3.2 Measures of stress

a) Self-reported measure:

Participants were asked in the final questionnaire to indicate their perception of the stress or control task. Specifically, they were asked whether they perceived the task as relaxing, easy, stressful, difficult, enjoyable and tiring. Each perception is rated on a 5-point Likert scale from 1 ("not at all") to 5 ("very much"). Of particular interest is the perceived stressfulness of the tasks, which is the primary measure of short-term stress in our analysis.

b) Physiological measures:

As secondary measures, we collected two physiological measures of the response to stress: heart rate and salivary cortisol. The heart rate captures the response of the autonomic nervous system (ANS) to stress. Cortisol on the other hand captures the response of the hypothalamic–pituitary–adrenal (HPA) axis. We furthermore collected measures of salivary testosterone. Testosterone and cortisol levels are positively correlated (Mehta and Josephs, 2010), but have been suggested to capture different responses to stress. While a more pronounced increase in cortisol indicates a passive coping style, a stronger increase in testosterone is indication of an active coping style (Salvador and Costa, 2009).

Heart Rate

Participants were asked to wear an armband with an optical heart rate sensor (Polar OH1) during the course of the lab experiment. Heart rate data was recorded in one-second intervals and stored on the internal memory of the sensor.[19]

The resulting heart rate profiles were matched with the precise start times of the experiment and the stress or control tasks. To capture the heart rate responses to the stress or control tasks, we defined a baseline period of 5 minutes, beginning with the start of the experiment, and a task period of 10 minutes, beginning with the start of the stress or control task. Comparison of the means during the baseline and the task period provides a measure of the heart rate response to the tasks.[20]

Salivary Cortisol and Testosterone

Participants were asked to provide three saliva samples during the course of the experimental session. The baseline sample was collected at the beginning of the experiment, 9 minutes prior to the start of the stress or control task. The second sample was collected 29 minutes after the start of the stress / control task and the final sample was collected 85 minutes after the start of the stress / control task. Cortisol reactivity to a stressor is found to peak between 10 and 40 minutes following the start of the stress protocol (Newman et al., 2007). Cortisol levels should revert to regular levels by the time the final sample is collected.

The samples were collected using synthetic swabs (Sarstedt Salivette® Cortisol), which were chewed by participants for 60 seconds and then placed in storage tubes. Samples were frozen immediately after collection. After completion of the experiment, the samples were shipped under dry ice to Daacro Saliva Lab in Trier (Germany) for analysis. Samples were analysed in duplicate for salivary cortisol and testosterone concentrations.[21]

Comparing salivary cortisol concentrations of the baseline and the second saliva samples provides a measure of the cortisol response to the tasks. Cortisol responses can be problematic

[19] Due to technical problems with the sensors, heart rate data is not available for 29 participants.
[20] We report results for the absolute changes in heart rate between baseline and the task period. The reported results are robust to using the relative changes in heart rate instead.
[21] Absolute changes in salivary cortisol and testosterone levels are used in our analysis. The reported results are robust to using relative changes instead.

to induce and measure, so a failure to capture a cortisol response to the stressor should not be seen as a failure to induce stress.

3.3 Stress task performance

Participants in the stress group were asked to complete a 10-minute block of incentivised tasks. Each participant could lose between £0 and £15 to their randomly assigned group. Rescaling this measure to run from 0% (no correct answers given) to 100% (all tasks and pop-ups solved correctly) allows us to capture participants' performance in the stress task.

4 Hypotheses

The primary hypothesis we test in our study is the following:

1) Short-term stress leads to increased selection of foods high in calories, sugar and saturated fats, both in the context of immediate consumption ("snack choice") and planned consumption ("food shopping choice").

We propose two channels, which might be responsible for such stress-induced changes in dietary choices: (1) impaired decision making and (2) food cravings. The first channel is one of cognitive depletion. Coping with stress requires mental energy and time. Depletion of these resources will affect decision making, as they are necessary to make sound decisions in a bounded rationality context (Allen and Armstrong, 2006). Weakened self-control due to cognitive overload (Shiv and Fedorikhin, 1999) as well as stress-induced temporary changes in time preferences and risk attitudes (Delaney et al., 2014; Kandasamy et al., 2014) further affect the ability to make decisions that optimize long-term utility. Impaired decision making abilities may lead to more habitual and impulsive food choices, which in a low-SES population are likely less healthy than choices made after thorough consideration.

The second channel is a biological one. The stress-induced release of cortisol in the hypothalamic-pituitary-adrenal (HPA) axis has been argued to cause cravings for energy-dense "comfort foods" (e.g. Adam and Epel, 2007), i.e. a temporary and endogenous change of individuals' food preferences. Exogenous administration of cortisol and other glucocorticoids have been shown to affect food intake in rats (Zakrzewska et al., 1999; Dallman et al., 2004) and humans (Tataranni et al., 1996; George et al., 2010).

Comparison between the effects on immediate and planned consumption can provide insights into the importance of these two potential mechanisms linking short-term stress and dietary choices. Since stress-induced food cravings (the second channel) are expected to affect immediate consumption more than planned consumption, a larger effect of short-term stress on immediate consumption would point to a stronger relevance of temporary food cravings as a mechanism. If on the other hand a larger effect on planned consumption was observed, this would point to impaired decision making due to cognitive overload (the first channel) as an important mechanism. Shopping choices require planning of future consumption and often involve larger choice sets, impaired decision making is therefore expected to affect these choices more.

In addition to the primary hypothesis described above, we furthermore test the following two secondary hypotheses:

2) The impact of short-term stress on planned consumption ("food shopping choice") will be stronger among participants assigned to the complex choice environment.
3) The impact of short-term stress on both types of food consumption choices will be stronger among participants who cope less well with stress.

Hypothesis 2 derives from the potential mechanism of impaired decision making due to cognitive overload (first channel). Decisions in a complex choice environment require additional cognitive resources. We therefore expect cognitive depletion to harm decision making more in a complex than in a simple choice environment.

Hypothesis 3 holds if coping well with stress limits the cortisol response and the resulting food cravings (second channel) or if coping well limits the stress-related cognitive depletion (first channel).

5 Empirical Analysis

5.1 Empirical Strategy

We analyse the impact of the randomly assigned short-term stressor on the dietary choices taken by the participants in the lab, by estimating linear models for the outcomes described in the previous section. Initially, we estimate bivariate models of the following form:

$$Y_i = \beta_0 + \beta_1 T_i + \varepsilon_i$$

where Y_i denotes an outcome measure of the dietary choices and T_i is a dummy variable for the randomly assigned experimental treatment, taking value 1 for participants in a stress session and value 0 for participants in a control session. β_1 is the coefficient of interest and ε_i is an idiosyncratic error term.

To analyse the relevance of choice complexity, we further estimate the following models for the outcomes relating to the food shopping choice:

$$Y_i = \gamma_0 + \gamma_1 T_i + \gamma_2 C_i + \gamma_3 T_i C_i + \varepsilon_i$$

where C_i is a dummy variable for the randomly assigned choice environment, taking value 1 for participants in a complex choice session and value 0 for participants in a simple choice session. γ_1 captures the impact of short-term stress on the outcome variable, γ_2 the impact of choice complexity and γ_3 the additional impact of choice complexity when stressed.

To capture any potentially confounding factors we furthermore augment the above models by including a vector of control variables X_i:

$$Y_i = \beta_0 + \beta_1 T_i + X_i'\delta + \varepsilon_i$$

$$Y_i = \gamma_0 + \gamma_1 T_i + \gamma_2 C_i + \gamma_3 T_i C_i + X_i'\delta + \varepsilon_i$$

The set of control variables X_i includes dummy variables for the time of the experimental session, for the consumption of any food in the last hour, any drink in the last hour, any cocoa product in the last 6 hours and any big meal in the last 6 hours.[22] These control variables were chosen as they differed significantly between the stress and the control group.[23]

We estimate all models using the ordinary least squares (OLS) estimator.[24] To account for potential error correlation among individuals in the same experimental session, we estimate standard errors robust to clustering at the session level. Due to the relatively small number of clusters, the wild cluster bootstrap approach proposed by Cameron et al. (2008) is used to estimate the clustered standard errors.

5.2 Pre-test of the Experimental Design

The experimental design was pre-tested in June 2018 using a sample of 50 low-SES mothers in Florence, Italy. Results from this pre-test using an eligible sample of 41 participants showed the novel stress protocol to be effective.[25] The stress task was perceived as significantly more

[22] We control for these variables since they may correlate with salivary cortisol levels and with food consumption choices.
[23] For more details on these balance checks, see Table 5.
[24] The reported results are robust to estimation with a session random effects estimator.
[25] Results of the pre-test can be found in Appendix D.

stressful than the control task. The mean heart rate of participants in the stress group increased significantly by 7.0 bpm (8.5%) between baseline and the stress task, a difference-in-difference comparison relative to the control group showed a statistically significant increase by 10.0 bpm. A difference-in-difference comparison showed the stress protocol to induce a statistically significant and sizable increase in salivary cortisol levels. Comparison of salivary cortisol levels before and after completion of the stress/control task showed an increase by 1.1 nmol/L (24.0%) in the stress group and a decrease by 1.1 nmol/L (22.2%) in the control group.

No significant impacts of short-term stress on food choices were observed in the pre-test. The consumed quantities in the snack choice and the nutritional content of baskets chosen in the food shopping choice were not found to differ significantly between stress and control group.[26]

5.3 Descriptive Statistics

Demographic characteristics of our sample can be found in Table 4. The only statistically significant difference between the stress and the control group is the age of the youngest child.[27] The average age of mothers is approximately 36 years and on average they have two children. 28% of mothers raise their youngest child by themselves. 61% of mothers are married or in a cohabiting relationship. 43% of participants completed GCSEs as their highest qualification, for 38% A levels are the highest qualification. 10% of mothers work full-time, 59% are in part-time employment and 24% are not employed.

Descriptive statistics of the dietary measures used in our analysis are displayed in Table 6. On average, participants ate 41g (171 kcal) of the blueberry mini-muffins and 74g (41 kcal) of the apple slices offered during the snack choice. The average shopping basket selected during the food-shopping choice contained approximately 17000 kcal, 460g of fat, 200g of saturated fat and 750g of sugar. We observe a small positive, but statistically insignificant, correlation between participants' immediate food intake and the nutrient content of their selected food-shopping basket. This underlines the importance of separately examining both types of food choices.

[26] In a bivariate regression, saturated fat content of the chosen food shopping baskets in the stress group was found to be lower at a 10% level of statistical significance. When controlling for factors unbalanced between treatment and control group, this difference was no longer found to be statistically significant.

[27] All results reported below are robust to the inclusion of child age as a control variable.

5.4 Effectiveness of Stress Protocol

Our study crucially relies on the effectiveness of our novel stress protocol in inducing short-term stress. We check this effectiveness by examining the participants' perceptions of the stress and control tasks as well as the response of heart rate and salivary cortisol to the tasks.

Table 7 shows participants' mean perceptions of the stress and control tasks. Perceived stressfulness of the task, the primary measure of short-term stress in our analysis, is significantly higher for the stress task. With a mean perceived stressfulness of 2.7 on the 5-point Likert scale from 1 ("not at all") to 5 ("very much"), the stress task was perceived as mildly stressful. This is a considerable difference to the mean perceived stressfulness of 1.5 for the control task. The stress task was furthermore perceived as significantly less relaxing, less easy, more difficult, less enjoyable and more tiring.

We now turn to the two secondary measures of short-term stress, capturing the physiological response to the stress and control tasks. The first measure is participants' heart rate, the second is salivary cortisol.

Participants wore a heart rate monitor during the course of the experiment to track the physiological response of the autonomic nervous system to the stress and control tasks. Figure 1 shows the mean heart rate of participants in the stress and control group for minute intervals during the baseline (the first 5 minutes of the experiment), the pre-task phase, the task and the post-task phase. There are no significant differences in the heart rate levels during baseline between the stress and control group. The pre-task period shows slightly higher heart rate levels in the stress than in the control group, this is likely due to anticipation effects as participants were instructed about the tasks during this phase. Significant differences in heart rate appear immediately after the start of the stress and control task. During the first minute of the task, the mean heart rate of participants completing the stress task is 3.8 bpm (4.8%) above the heart rate of those completing the control task. The second minute of the task shows an even larger difference of 6.1 bpm (7.8%). In the remainder of the task stage the difference in mean heart rate reduces somewhat. However, the mean heart rate remains significantly higher in the stress group, with the exception of the last minute of the task when the difference is only marginally significant. The gap in heart rate between the two groups closes within minutes of completing the task, no significant differences are found during the post-task period.

Difference-in-difference comparison of the mean heart rate across the two groups and between the baseline and task stages are shown in Table 8. For the control group, mean heart rate is reduced by 3.7 bpm (4.6%) between baseline and the task stage. This downward trend in heart rate is likely due to an elevated heart-rate from physiological activity (e.g. the walk from the car park to the laboratory) wearing off over time as participants remained seated during this part of the experiment. For the stress group, we observe no significant change in mean heart rate from the baseline to the task stage – the downward trend observed in the control group is cancelled out in the stress group by the increase in heart rate caused by the short-term stressor. The difference-in-difference comparison shows a significantly increased heart rate during the stress task by 3.8 bpm relative to the control group. These differences in heart rate between stress and control task are sizeable considering the physiological requirements of both tasks were the same. In comparison, the related studies shown in Table 1 show no significant difference in heart rate found when using stressors related to mathematical skills or similar to the Trier Social Stress Test. In contrast, Delaney et al. (2014) use a cognitive stressor (IQ tests that increase in difficulty) and a physiological stressor (the cold pressor test where participants were asked to place their feet into ice-cold water). They find no impact of the cognitive stressor, but a 5% and 8% increase in diastolic and systolic blood pressure respectively for the physiological stressor.

Over the course of the experiment, we collected three saliva samples from each participant to track the physiological response of the hypothalamic-pituitary-adrenal (HPA) axis to the stress and control tasks. A baseline sample was collected prior to completion of the stress or control task, a second sample 29 minutes after the start of the task and a final sample at the end of the experimental session. Figure 2 shows the mean salivary cortisol concentrations of participants in the stress and control groups across these three measurements. For both groups, we observe a downward trend in salivary cortisol over the course of the experiment. With the exception of a marginally significant difference in baseline cortisol, we do not observe any differences in salivary cortisol between the stress and control group. Difference-in-difference comparison of mean cortisol concentrations across the two groups are shown in Table 9. A comparison of the cortisol change from the baseline to the second measurement shows a marginally significant difference, with cortisol concentrations decreasing less in the stress group. As this result is entirely driven by differences in the baseline cortisol levels, it cannot be used as indication of a cortisol response to the short-term stressor.

The saliva samples were furthermore analysed for testosterone, an indicator of an active coping style (Salvador and Costa, 2009). The results of this analysis can be found in Table C.3 and Figure C.1 of Appendix C. Similar to salivary cortisol, we observe a downward trend in testosterone over the course of the experiment for both groups, but no significant differences between the stress and the control group.

Our findings show that the stress protocol was perceived as mildly stressful. An increased heart rate during the stress task indicates a physiological response of the autonomic nervous system to this stressor. We do not observe a response of the hypothalamic-pituitary-adrenal (HPA) axis to our stress protocol. However, the lack of a cortisol response should not be seen as indication of a failure to induce stress, as cortisol measurements are very sensitive to the timing of the measurements (relative to the stressor) and to a variety of unobservable factors. Also, the protocol did not intend to trigger high or extreme levels of stress, but rather mimic everyday stressors.

5.5 Impact of Short-term Stress on Food Choices (Hypothesis 1)

In the following, we examine the impact of short-term stress by comparing the food choices made during the experiment by participants assigned to the stress and control group. We consider food choices in the context of immediate and planned consumption.

Immediate food choices

Table 10 shows OLS results for the impact of short-term stress on immediate food consumption as captured by the snack choice during the experiment. Columns 1 and 3 correspond to bivariate models. Columns 2 and 4 correspond to augmented models, which control for the time of the experimental session and for the consumption of foods and drinks prior to the experiment. As shown in column 1, participants in the control group ate 38.2g of the high-calorie mini-muffins. Participants in the stress group consumed an additional 5.4g of the muffins. While this difference is not negligible in size, it is not statistically significant. When controlling for potentially confounding factors that differed between stress and control groups in column 2, we observe a similar difference in muffin intake of 5.1g, which again is not statistically significant.

As reported in column 3, participants in the control condition ate 72.8g of the low-calorie apple slices while those in the stress condition ate an additional 3.1g. This difference in apple intake increases to 5.7g when controlling for session time and for the prior consumption of foods and drinks in column 4. In both specifications, the difference in apple consumption between stress and control group is not precisely estimated. While we observe short-term stress to increase intake of both high- and low-calorie snacks, these increases are not statistically significant. When examining the total energy, saturated fat and sugar intake from both snack types (see Table C.4 of Appendix C), we again find no statistically significant differences between stress and control group.

Planned food choices

We now turn to examining the impact of short-term stress on planned future food consumption, by analysing the nutrient content of the baskets selected during the food shopping choice by participants in the stress and control group. OLS results for the impact of the stress protocol on total energy, saturated fat and sugar content of the selected grocery items can be found in Table 11. Participants in the control group selected baskets with a mean energy content of 17,138 kcal, 202g of saturated fat and 775g of sugar. Results for the bivariate models in columns 1, 3 and 5 show participants in the stress group on average selected baskets containing 327 kcal less energy, 5g less saturated fat and 48g less sugar. When controlling for the timing of the experimental sessions and the intake of food and drink prior to arrival, the differences in energy and saturated fat content are substantially reduced, to 103 kcal and 2g respectively. The difference in sugar content, on the other hand, increases slightly to 53g. The differences in nutrient content of baskets selected by the stress and control groups are not statistically significant in any of the specifications.[28] In further estimations (see Table C.5 of Appendix C), we find no significant difference in the weight of fruit and vegetables purchased by the stress and control groups. These findings do not support the hypothesis that short-term stress leads to less healthy food choices in the context of planned consumption.

Summarizing, these results suggest no significant relationship between mild stress and either immediate or planned food consumption.

5.6. Role of choice complexity (Hypothesis 2)

We now examine whether the complexity of the food shopping choice affects the healthiness of the chosen grocery items, in particular under short-term stress. OLS results for the impact of the stress protocol and the choice complexity – both randomly pre-assigned - on the nutrient content of the chosen food-shopping basket are reported in Table 12. Results in columns 1 and 2 show a lower energy content of baskets selected in the complex choice environment, both among the stress and the control group. As shown in columns 3 and 4, we observe the saturated

[28] A test of joint significance for all three primary outcomes also shows no statistically significant differences between the stress and control group.

fat content of baskets selected in the complex choice environment to be lower in the control, but higher in the stress group. Columns 5 and 6 show the sugar content of baskets chosen in the complex choice environment to be higher in the control, but lower in the stress group. The impact of choice complexity on the above outcomes is not statistically significant.

Thus, the evidence does not suggest stress to have differential effects on dietary choices depending on the complexity of the choices. We hence find no indication of a cognitive depletion channel between short-term stress and planned dietary choices.

5.7 Role of coping style and stress response (Hypothesis 3)

In addition, we examine whether certain coping styles or a strong physiological or psychological response to the experimental stressor affect the susceptibility of participants' dietary choices to the short-term stress protocol. The self-assessed use of avoidance-based, emotion-oriented and task-oriented coping styles are not found to significantly alter the dietary choices made by the stress group (see Tables C.6 and C.7 of Appendix C). Despite some significant coefficient estimates, we find no strong evidence that perceiving the task as stressful makes participants' food choices more susceptible to the stressor (see Tables C.8 and C.9 of Appendix C). The physiological responses to the stressor as captured by the heart rate as well as the salivary cortisol and testosterone responses do not predict stronger susceptibility of participant's choices to the stress protocol (see Tables C.10 – C.13 of Appendix C).[29]

5.8 Role of emotional eating, time preferences and risk attitudes

We do not find evidence that the self-assessed tendency to eat when emotional, as captured by the emotional eating dimension of the Dutch Eating Behaviour Questionnaire (Van Strien et al., 1986), affects the dietary response to stress (see Tables C.14 and C.15 of Appendix C). Self-assessed time preferences, both generally and in the context of health, are not found to alter the susceptibility of participants' dietary choices to the experimental stressor (see Tables C.16 and C.17 of Appendix C). Self-assessed general risk aversion is found to significantly decrease muffin intake in the snack choice, however only in the control group (see Table C.18 of Appendix C). In the food shopping task, general risk aversion is found to decrease energy content of baskets selected by participants in the stress group, this association is statistically

[29] In an additional analysis, we split the stress group in cortisol responders and cortisol non-responders using the 75th percentile of the cortisol response in the stress group as a threshold. No statistically significant differences between cortisol responders and non-responders as well as the control group are found, except for a lower sugar content of the baskets purchased in the food shopping choice.

significant (see Table C.19 of Appendix C). Altogether, the evidence we collected provides no empirical support to the hypothesis that short-term stress leads to unhealthier dietary choices.

5.9 The role of failure (exploratory evidence)

Finally, we present some exploratory evidence on the impact of performance in the stress task on dietary choices (see Table 13 and Table 14)[30]. Table 13 shows OLS results for the impact of short-term stress on immediate food consumption, controlling for the performance in the stress task. The performance in the task ranges from 0% to 100%, where 100% corresponds to solving all 15 tasks and answering the 10 pop-up questions correctly, all without a time penalty. The performance in the task is positively related to participants' education and household income. Consistent with cortisol capturing a passive and testosterone capturing an active coping style (Salvador and Costa, 2009), performance is negatively related to the cortisol and positively related to the testosterone response to the stress task. We, however, observe no significant relation to perceived stressfulness of the task or the heart rate response. The results reported below are robust to controlling for these correlates or predictors of task performance.

We find that a poor performance in the stress task[31] increases muffin intake by 30.8g (80.6% of the control intake) compared to the control group, which corresponds to an additional intake of 127.8 kcal, as shown in column 1. This difference is not only big in magnitude, but also statistically significant. An improved task performance by 1 percentage point significantly reduces the intake of muffins by 0.5 grams. Controlling for potentially confounding factors in column 2 leads to similar results. There is no significant effect on the intake of apple slices.

Table 14 reports the impact of short-term stress on planned future food consumption, controlling for stress task performance. We estimate a performance of 0% in the stress task to decrease the energy content of the selected basket by 2152 kcal (12.6%), the saturated fat content by 35g (17.3%) and the sugar content by 68g (8.8%), however these differences are not statistically significant. Performing well in the task increases energy, saturated fat and sugar content of the selected basket. When controlling for the timing of the experimental sessions and the intake of food and drink prior to arrival, the magnitude of these estimates is similar.

While performance in the task is of course not exogenous and hence these results cannot be interpreted as causal, we find a substantial and statistically significant correlation of a worse

[30] Note that this was not part of the original pre-analysis plan and should therefore be considered as explorative evidence.

[31] A performance of 0% corresponds to no correct answers given in any of the 15 tasks or the 10 pop-ups. The lowest performance in our sample was 13%.

performance in the stress task and an increased consumption of high-calorie snacks. Participants in the lowest performance quartile of the stress group consume 47.2% more of the high-calorie snacks than participants in the control group, and 50.4% more than the top quartile of the stress group. This hints at the role of failure in mediating an impact of short-term stress on the intake of high-calorie foods. This effect seems in line with the literature, where solvable versus unsolvable tasks are often used to study stress-induced changes in dietary choices, possibly hinging on failure and stress combined more than stress per se to find an impact on food consumption (see Table 1 for a review of the stressors used).

6 Conclusion

In this study, we examine the impact of short-term stress on food choices, both in the context of immediate and planned consumption, by evaluating a lab experiment with 196 low-SES mothers. We introduce a novel incentivised stress protocol developed to mimic everyday stressors in low-SES families. At the start of the experiment, participants in the stress group were asked to complete this stress task, while participants in the control group were asked to complete a control task. After, participants were asked to purchase food items in a "virtual supermarket" as part of an incentivised food shopping choice and were offered high- and low-calorie snacks for immediate consumption. We use the nutritional content of the chosen food-shopping basket and the quantity of snacks eaten to determine the impact of short-term stress on planned and immediate food consumption choices. We asked participants about their perceptions of the stress or control task and measured their salivary cortisol as well as their heart rate over the course of the experimental sessions to assess the stressfulness of the stress task.

The novel stress protocol was perceived by participants as significantly more stressful than the control task. This is supported by a significant increase in the heart rate of participants in the stress group when compared to the control group. However, we do not observe a significant difference in the cortisol levels of the stressed and the control groups. Cortisol responses can be problematic to induce and measure, so this should not be seen as a failure to induce stress. The task perceptions and heart rate data are reliable evidence that mild stress was induced among the stress group, but not among the control group. We do not find evidence of a significant impact of short-term stress on immediate or planned food choices. Previous findings in the literature report a positive impact of short-term stress, induced using artificial stressors such as unsolvable mathematical tasks or the Trier Social Stress Test, on food consumption. Contrary to these studies, our stress protocol is more realistic as it mimics common everyday stressors and we focus on the population of low-SES mothers. Our results hence do not support the hypothesis that everyday stressors lead to unhealthier eating choices among low-SES mothers.

The complexity of the choice environment, participants' coping styles as well as the psychological and physiological response to the experimental stressor are not found to affect the susceptibility of dietary choices to short-term stress. If we control for performance in the task though, we find that poor performance leads to a higher intake of calorie dense foods (muffins), indicating that it may not be exposure to stress per se that matters but a combination of stress and failure. Further research is needed to investigate this possibility.

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Tables and Figures

Table 1: Overview of the literature on stress and diet[32]

Paper	Sample	Stressor	Measure of stress	Magnitude of the change in stress	Dietary outcome measure	Timing of dietary choice	Magnitude of the dietary effect
Oliver et al. (2000)	27 male and 41 female students and university staff (mean age 26). Between subjects.	Prepare a 4-minute speech, expecting it to be filmed and assessed vs. listen to a passage of neutral text.	Heart rate, blood pressure and self-reported measure of perceived stressfulness (1 to 7 scale).	Non-significant change in heart rate. Blood pressure increased in the stressed and decreased in the control group. Increased self-reported stressfulness in the stress than the control group (M=4.26, SD=1.4 vs. M=1.62, SD=1.0)	Immediate appetite and food intake during a 15 min meal. Sweet, salty, and bland + low and high fat food.	After stress task, with unspecified delay.	No effects of stress group on weight of food consumed, total energy intake, or energy density of the meal (kcal/g), or preference for certain macronutrients. Increased intake of sweet fatty foods after stress in emotional eaters.
Epel et al. (2001)	59 women, 30 to 45 years (mean age 36). Within subjects, 2 days.	Adapted 45 min version of the Trier Social Stress Test (Kirschbaum et al., 1993) vs. sat quietly, reading and listening to music.	10 salivary cortisol samples and the Profile of Mood States (POMS) negative affect scales.	Cortisol (calculated as area under the curve, AUC, to capture total cortisol exposure) significantly higher on the stress day than the rest day (M=28.6, SE=1.7 vs. M=22.6, SE=1.5).	Immediate food intake over 30 min break. Sweet, salty + low and high fat snacks.	After stress task, immediate.	On the stress day high cortisol reactors consumed significantly more calories than low reactors (M=216.3, SE=29 vs. M=137.3, SE=31.8). On the control day high reactors consumed similar amounts as low reactors (M=176.7, SE=27 vs. M=187, SE=29.9)
Roemmich et al. (2002)	23 boys and 17 girls, 8 to 11 years. Within subjects, 2 days.	15 minutes to prepare and 5 minutes to deliver a speech about them that was videotaped and judged vs reading children's magazines and colouring.	Self-reported measure of perceived stressfulness (100-mm visual analog scale).	Stress group significantly more stressed. Stress more than doubled in the high reactivity group (from 20 to more than 40 mm), no significant increase in the low reactivity group.	Immediate calorie consumption out of 500 calorie portions of the three favourite snack food.	After stress task, with unspecified delay.	When stressed, low-restrained children reduced energy intake by 61 kcal, and high-restrained children increased it by 46 kcal.
Zellner et al. (2006)	34 female undergraduate students (mean age 22). Between subjects.	10 unsolvable five-letter anagrams vs 10 solvable five-letter anagrams with a word-bank of the answers at the bottom of the page.	Self-reported measure of perceived stressfulness (0 to 10 scale).	Stress group significantly more stressed than the control (M= 5.8, SD = 3.0 vs. M= 0.7, SD = 1.1).	Immediate food intake of M&M chocolate candies (about 100g), Lays potato chips (about 50 g), Planter's dry roasted peanut (about 100 g), and red seedless grapes (about 100 g).	Throughout lab session.	No significant differences in consumption of either the peanuts or the potato chips. The no-stress group ate more grapes than the stress group (M= 15.6, SD=22.3 vs. M= 4.0g, SD = 7.2). The stress group ate more M&Ms than the no-stress group (M=6.9 g, SD=10.4 vs. M= 1.2 g, SD = 2.4).
Newman et al. (2007)	50 women (mean age 33.96). Within subjects, 1 day.	15 min Trier Social Stress Test vs reading magazines and listening to a 'Classical Chillout' compact disc.	Salivary cortisol samples at different points in time. Self-reported measure of perceived stressfulness (1 to 7 scale).	Average cortisol increase of 1.36 nmol/l (SD=3.77) (difference between mean baseline cortisol level and maximum after the stressor). Mean self-reported stressfulness of the stress manipulation 4.78, SD=1.43.	Relationship between hassles and snack intake outside the laboratory in high and low cortisol reactors.	Not during lab sessions.	In high reactors, significant positive associations between hassle number and snack intake (b=0.39,t=3.96,p<0.01), and hassle intensity and snack intake (b=0.51,t=6.30,p,0.001).

[32] Parts of the study descriptions and results are taken directly from the respective study.

Zellner et al. (2007)	36 male undergraduate students (mean age 20). Between subjects.	10 unsolvable five-letter anagrams vs 10 solvable five-letter anagrams with a word-bank of the answers at the bottom of the page.	Self-reported measure of perceived stressfulness (0 to 10 scale).	Stress group significantly more stressed than the control (M=5.7, SD=3.1 vs. M=1.9, SD=1.9	Food intake of M&M chocolate candies (about 100g), Lays potato chips (about 50 g), Planter's dry roasted peanut (about 100 g), and red seedless grapes (about 100 g).	Throughout lab session.	No significant difference in the overall grams of food consumed. The control group ate significantly more of the “unhealthy” snacks (chips and M&Ms) than the treatment group.
Habhab et al. (2009)	40 female students, 18 to 41 years (mean age 21.3). Between subjects.	15 min to complete an unsolvable Sudoku puzzle vs 15 min to complete an easily solvable puzzle (role of failure).	Self-reported level of stress and frustration during and after the Sudoku (10-point scales)	Stress group significantly more stressed than the control during Sudoku (M=8.25, SD=2.83 vs. M=4.45, SD =2.74). Stress group significantly more stressed than the control after Sudoku (M=6.15, SD=3.65 vs. M=3.25, SD=1.89).	Immediate food intake of M&M chocolate candies, potato chips, salty pretzels, honey-flavoured graham crackers. Offered as thank-you for participation.	Throughout lab session.	The stress group ate significantly more food than the no-stress group (M=56.30, SD=25.83 vs. M=34.50, SD=24.31), more sweet food (M=41.50, SD=20.45 vs. M=16.40, SD=15.41) and more high-fat food (M=36.80, SD=20.10 vs. M=7.35, SD=9.84). No difference in salty food consumed.
Rutters et al. (2009)	65 men and 65 women, 18 to 45 years. Within subjects.	A mental arithmetic task with sums that subjects could not solve vs. could solve (role of failure).	Heart rate, blood pressure, the POMS and state anxiety (STAI).	No changes were seen between the stress and control condition in heart rate (70.3 ± 13 vs. 72.3 ± 12.3bpm, P < 0.86) and blood pressure. Stress group significantly more anxious after the task, no change in the control group (4.2 ± 5.7 vs. −0.8 ± 0.3).	Immediate snack intake during 30 min break.	After stress task, 20 min (5 min) after start (end) of stress task.	Significant differences were found between the stress and control conditions in energy intake from sweet snack foods (708.1 ± 798.8 vs. 599.4± 734.4kJ, P < 0.03) and total energy intake (965.2 ± 970.6 vs. 793.8 ± 912.5kJ, P < 0.01).
Appelhans et al. (2010)	16 lean and 18 obese women, 25 to 45 years. Within subjects, 2 days.	Adapted 30 min version of the Trier Social Stress Task vs. viewing and evaluating a nature documentary film.	Salivary cortisol samples before, 20 min from onset and after the task. Positive and Negative Affect Schedule (PANAS) on arrival, pre-task and post-task.	Post-task cortisol adjusting for pre-task levels significantly higher on the stress day (4.06 ng/ml vs. 3.56 ng/ml; $F(1,31)=13.33$, $P < 0.001$). Negative affect increased over time on the stress day ($F(1,31) = 11.04$, $p < 0.01$), but decreased on the control day ($F(1,33) = 8.57$, $P < 0.01$).	Immediate food intake of caramel flavoured miniature rice cakes (24 g), low-fat butter popcorn (20 g), miniature chocolate chip cookies (50 g), and potato chips (40 g).	After stress task, very short delay.	No significant difference in the overall grams of food consumed over the 2 days. Higher cortisol reactivity predicted lower snack intake among obese women, but not among lean women.
Born et al. (2010)	9 females (mean age 24). Within subject, 2 days.	An unsolvable mathematical test vs solvable test (role of failure).	5 blood samples, 2 functional MRI (fMRI) scans.	Post-task blood cortisol significantly higher on the stress day (133.73±16.33 vs. 111.92±9.26)	Self-reported satiety and hunger. Immediate food intake in two meals (breakfast after the first scan and a postprandial meal after the second scan).	After stress task, with unspecified delay.	Significantly lower scores for satiety after breakfast in the stress condition. Significantly more energy dense food items selected in the absence of hunger in the stress condition.

Table 2: Sample size

	Stress		Control		Total
	Categorized	Long	Categorized	Long	
Total:	63	58	60	46	227
Not eligible due to:					
- Child's age	0	1	1	0	2
- HH income	0	0	1	1	2
- University degree	0	0	1	0	1
- Food allergy / intolerance	1	2	1	3	7
- Medical condition (diet-related)	2	0	0	0	2
- Depression	2	6	7	2	17
Eligible:	58	49	49	40	196

Table 3: Timeline of the experiment

1) Arrival at the lab:
   - Heart rate monitors fitted
   - Body measurements
   - Mouth rinsed to prepare for saliva sample

2) 1st Saliva Sample

3) Stress / Control Task (10 min)

4) Food Shopping Choice (10 min)

5) 2nd Saliva Sample (29 min after start of stress / control task)

6) Break (5 min)
   - Low and high-calorie snacks available at desks

7) 1st Questionnaire (15 min)
   - Snacks still available at desks

8) Collection of snack bowls
   - Mouth rinsed to prepare for 3rd saliva sample

9) 2nd Questionnaire (30 min)

10) 3rd Saliva Sample (85 min after start of stress / control task)

Table 4: Demographic characteristics

	(1) Stress	(2) Control	(1) vs (2) P-Value
Age - mother	35.70	36.24	0.53
	(5.96)	(5.83)	
Age - youngest child	5.94	7.10	0.01
	(2.79)	(3.09)	
No. of children	1.97	2.18	0.15
	(1.01)	(1.01)	
Single parent	0.28	0.28	0.99
	(0.45)	(0.45)	
Marital status:			
single	0.21	0.26	0.48
married	0.44	0.39	0.52
cohabiting	0.17	0.21	0.42
other	0.18	0.13	0.42
Monthly HH net income:			
<1000 GBP	0.13	0.09	0.37
1000-2000 GBP	0.46	0.49	0.61
>2000 GBP	0.41	0.42	0.95
Monthly benefits:			
none	0.17	0.11	0.26
1-650 GBP	0.56	0.65	0.23
>650 GBP	0.27	0.24	0.66
Highest qualification:			
none	0.08	0.10	0.68
GCSE: <5 A^*-C passes	0.17	0.10	0.18
GCSE: ≥5 A^*-C passes	0.26	0.33	0.33
A levels	0.38	0.37	0.86
professional	0.10	0.10	0.97
Employment status:			
full-time	0.11	0.08	0.43
part-time	0.54	0.64	0.17
self-employed	0.08	0.06	0.45
not employed	0.26	0.22	0.55
N	107	89	196

Table 5: Balance of control variables across groups

	(1) Stress	(2) Control	(1) vs (2) P-Value
Session time:			
10:30	0.43	0.33	0.14
14:00	0.22	0.42	0.00
17:00	0.35	0.26	0.19
Room temperature	22.90	22.89	0.92
	(0.69)	(0.47)	
Diet - mother:			
vegetarian	0.07	0.06	0.79
	(0.25)	(0.23)	
vegan	0.00	0.00	.
	(0.00)	(0.00)	
allergies	0.02	0.02	0.85
	(0.14)	(0.15)	
intolerances	0.03	0.00	0.11
	(0.17)	(0.00)	
other	0.05	0.02	0.36
	(0.21)	(0.15)	
Snack position: apples - right	0.44	0.45	0.88
	(0.50)	(0.50)	
Previous experiment	0.21	0.16	0.39
	(0.41)	(0.37)	
Food - last 1hr	0.18	0.06	0.01
	(0.38)	(0.23)	
Big meal - last 6hrs	0.19	0.09	0.05
	(0.39)	(0.29)	
Cocoa - last 6hrs	0.08	0.03	0.14
	(0.28)	(0.18)	
Drink - last 1hr	0.26	0.13	0.03
	(0.44)	(0.34)	
Alcohol - last 24hrs	0.18	0.15	0.55
	(0.38)	(0.36)	
Caffeine - last 6hrs	0.50	0.51	0.89
	(0.50)	(0.50)	
Medication - last 24hrs	0.36	0.34	0.69
	(0.48)	(0.48)	
Exercise - last 6hrs	0.27	0.21	0.35
	(0.45)	(0.41)	
Smoker	0.30	0.28	0.78
	(0.46)	(0.45)	
Cigarettes per day	8.56	8.12	0.73
	(4.85)	(4.75)	
Any allergies	0.38	0.36	0.73
	(0.49)	(0.48)	
Regular medication	0.27	0.33	0.41
	(0.45)	(0.47)	
Oral contraceptive	0.27	0.22	0.46
	(0.45)	(0.42)	
Menopause	0.01	0.00	0.36
	(0.10)	(0.00)	
Endocrine disorders	0.00	0.00	1.00
	(0.14)	(0.15)	
N	107	89	196

Table 6: Descriptive statistics

	Mean	SD	Min	Max
Snack choice:				
Muffins (g)	41.15	34.80	0.00	142.00
Apples (g)	74.46	48.82	0.00	180.00
Energy (kcal)	211.64	151.95	0.00	667.19
Fat (g)	9.13	7.67	0.00	31.38
Saturated fat (g)	1.15	0.97	0.00	3.98
Carbohydrates (g)	29.73	19.49	0.00	89.31
Sugar (g)	20.68	12.41	0.00	58.51
Protein (g)	1.99	1.53	0.00	6.51
Salt (g)	0.20	0.15	0.00	0.65
Shopping choice:				
Energy (kcal)	16960.10	4046.76	7094.90	27061.19
Fat (g)	463.14	197.50	113.29	1167.79
Saturated fat (g)	199.43	95.32	31.32	555.60
Carbohydrates (g)	2304.84	827.72	106.24	4619.40
Sugar (g)	748.31	245.26	87.00	1675.11
Protein (g)	771.13	169.59	401.07	1199.40
Salt (g)	34.04	9.63	5.23	61.60
Fruit & veg (g)	2838.55	1820.31	0.00	9164.00
N	196			

Table 7: Mean perceptions of stress / control task

	(1) Stressful	(2) Relaxing	(3) Easy	(4) Difficult	(5) Enjoyable	(6) Tiring	N
Stress	2.745	2.642	3.151	2.500	3.377	2.000	106
	(0.064)	(0.096)	(0.107)	(0.078)	(0.044)	(0.089)	
Control	1.517	3.382	4.607	1.258	3.652	1.596	89
	(0.094)	(0.106)	(0.047)	(0.062)	(0.056)	(0.105)	
Difference	1.228	-0.741	-1.456	1.242	-0.274	0.404	
P	0.000	0.000	0.000	0.000	0.002	0.011	
P(Wild)	0.000	0.001	0.000	0.000	0.002	0.024	

Note: Perceptions of the stress / control task were scored from 1 for 'not at all' to 5 for 'very much'. Standard errors of the mean were clustered at the session level and are shown in parentheses. For the difference in mean between treatment and control, p-values based on standard errors clustered at the session level and p-values based on a wild bootstrap clustered at the session level are shown.

Table 8: Heart rate response to stress / control task

	(1) Baseline	(2) Task	(2)-(1) Diff	P	P(Wild)	N
Stress	80.854	80.917	0.062	0.916	0.902	94
	(0.638)	(0.927)				
Control	80.807	77.104	-3.703	0.000	0.015	73
	(1.840)	(1.307)				
Diff-in-Diff			3.766	0.001	0.002	167

Note: Means were calculated based on heart rate data collected every second. Standard errors were clustered at the session level and are shown in parentheses. For the difference between task and baseline, p-values based on standard errors clustered at the session level and p-values based on a wild bootstrap clustered at the session level are shown.

Table 9: Salivary cortisol response to stress / control task

	(1) Baseline	(2) Post-Task	(3) End	(2)-(1) Diff	P	P(Wild)	N
Stress	4.262	3.500	3.095	-0.761	0.001	0.013	107
	(0.322)	(0.240)	(0.282)				
Control	4.892	3.556	3.025	-1.335	0.000	0.009	89
	(0.384)	(0.241)	(0.336)				
Diff-in-Diff				0.574	0.089	0.091	196

Note: Standard errors were clustered at the session level and are shown in parentheses. For the difference between post-task and baseline, p-values based on standard errors clustered at the session level and p-values based on a wild bootstrap clustered at the session level are shown.

Table 10: Impact of acute stress on snack consumption

	Muffins (g)		Apples (g)	
	(1)	(2)	(3)	(4)
Stress	5.396	5.081	3.053	5.736
	(0.433)	(0.394)	(0.627)	(0.406)
	[0.472]	[0.440]	[0.644]	[0.468]
Constant	38.202***	48.178***	72.798***	78.699***
	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:				
Session time	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes
N	196	196	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table 11: Impact of acute stress on food shopping

	Energy (kcal)		Saturated fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	-326.627	-103.019	-5.403	-2.101	-48.356	-52.720
	(0.482)	(0.820)	(0.594)	(0.860)	(0.269)	(0.257)
	[0.538]	[0.836]	[0.589]	[0.871]	[0.279]	[0.308]
Constant	17138.414***	17068.346***	202.380***	199.379***	774.705***	783.333***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:						
Session time	No	Yes	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes	No	Yes
N	196	196	196	196	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table 12: Impact of acute stress and choice complexity on food shopping

	Energy (kcal)		Sat. fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	-222.230	-20.000	-7.775	-4.740	-18.233	-22.833
	(0.755)	(0.974)	(0.524)	(0.736)	(0.754)	(0.701)
	[0.806]	[0.981]	[0.571]	[0.779]	[0.788]	[0.749]
Complex	-340.412	-214.320	-10.009	-11.634	42.809	42.745
	(0.618)	(0.749)	(0.505)	(0.427)	(0.399)	(0.415)
	[0.673]	[0.796]	[0.615]	[0.609]	[0.483]	[0.469]
Stress * Complex	-221.648	-201.619	5.366	5.072	-66.574	-63.893
	(0.792)	(0.802)	(0.794)	(0.814)	(0.431)	(0.515)
	[0.801]	[0.822]	[0.822]	[0.860]	[0.478]	[0.660]
Constant	17291.408***	17126.435***	206.878***	204.421***	755.465***	759.469***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:						
Session time	No	Yes	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes	No	Yes
N	196	196	196	196	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table 13: Impact of acute stress and task performance on snack consumption

	Muffins (g)		Apples (g)	
	(1)	(2)	(3)	(4)
Stress	30.803***	31.214***	4.903	5.510
	(0.003)	(0.001)	(0.648)	(0.661)
	[0.007]	[0.009]	[0.640]	[0.699]
Stress task performance	-0.502**	-0.516***	-0.037	0.004
	(0.000)	(0.000)	(0.874)	(0.985)
	[0.012]	[0.005]	[0.865]	[0.985]
Constant	38.202***	48.098***	72.798***	78.700***
	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:				
Session time	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes
N	196	196	196	196

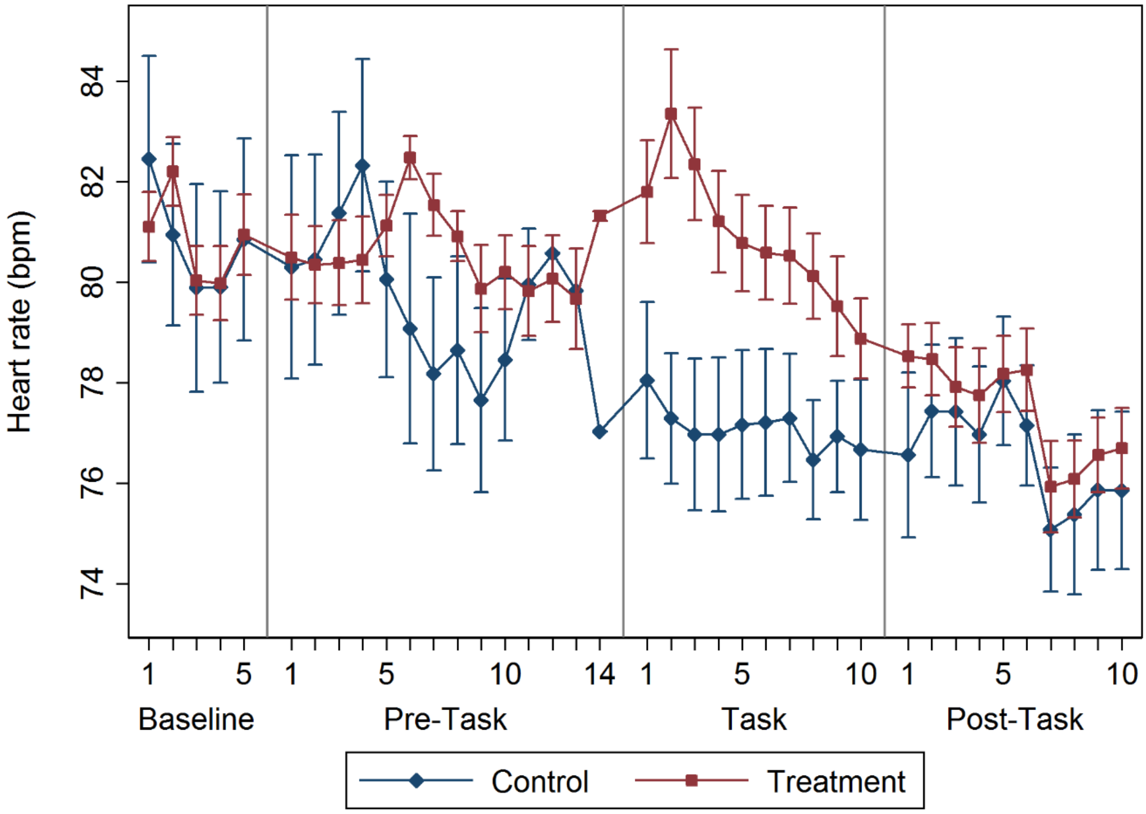
Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table 14: Impact of acute stress and task performance on food shopping

	Energy (kcal)		Saturated fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	-2152.804	-1813.934	-34.934	-32.259	-68.013	-70.393
	(0.142)	(0.216)	(0.237)	(0.315)	(0.332)	(0.344)
	[0.178]	[0.248]	[0.292]	[0.451]	[0.356]	[0.356]
Stress task performance	36.098	33.798	0.584	0.596	0.389	0.349
	(0.179)	(0.225)	(0.243)	(0.271)	(0.745)	(0.776)
	[0.217]	[0.253]	[0.392]	[0.377]	[0.783]	[0.749]
Constant	17138.414***	17073.556***	202.380***	199.471***	774.705***	783.387***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:						
Session time	No	Yes	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes	No	Yes
N	196	196	196	196	196	196

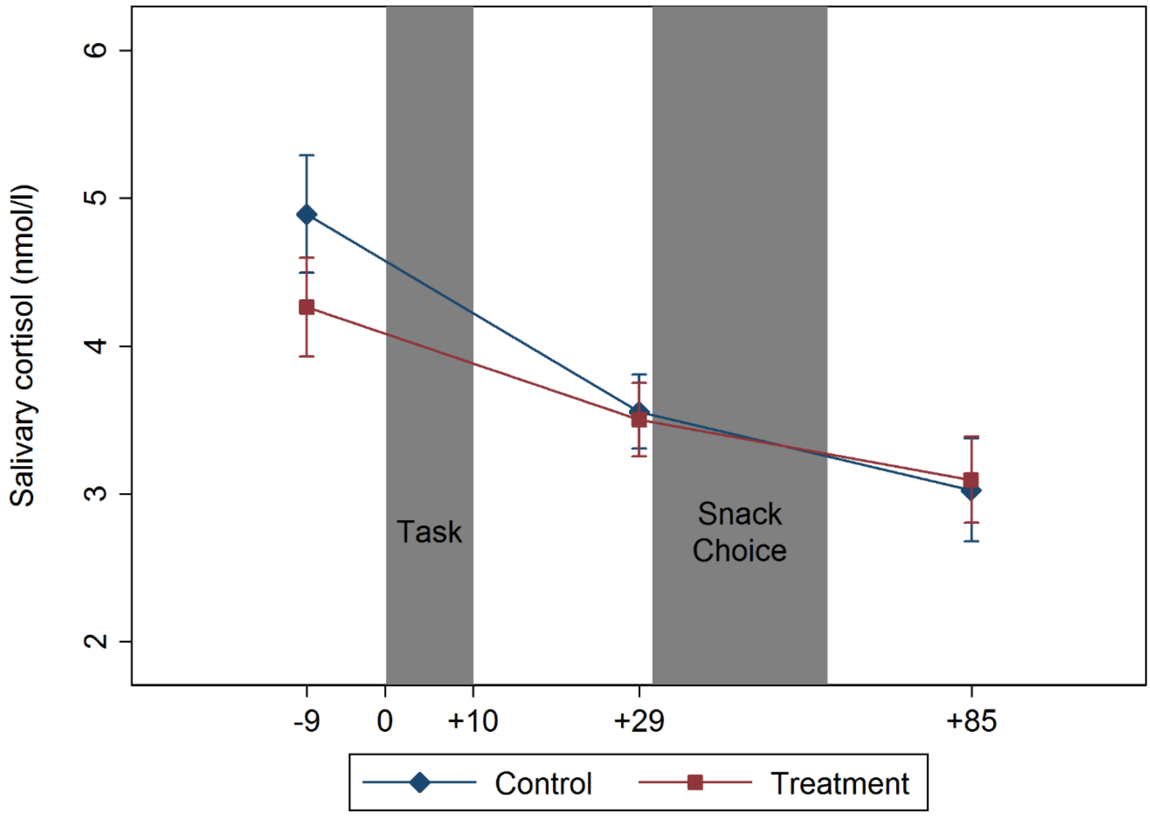
Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Figure 1: Heart rate response to stress / control task



Note: Means were calculated for minute intervals based on heart rate data collected every second. Bands indicate +/- 1 standard error. The length of the pre-task period differed across sessions (between 9 min 45 s and 13 min 39 s), but it did not differ significantly between stress and control session.

Figure 2: Salivary cortisol response to stress / control task



Note: Bands indicate +/- 1 standard error.

ONLINE APPENDIX

Supplementary Material

Stress and Food Preferences: A Lab Experiment with Low-SES Mothers

Michèle Belot[1,2], Jonathan James[3], Martina Vecchi[4] and Nicolai Vitt[2]

[1]European University Institute
[2]University of Edinburgh
[3]University of Bath
4Pennsylvania State University

Appendix A: Recruitment materials

Figure A.1: Leaflet for recruitment

An exciting new research study in Colchester

We are a team of economists from the Universities of Essex, Edinburgh, Bath and the European University Institute and we are interested in understanding how people take a variety of common decisions.

Do you match the following profile?

- You are the mother of at least one child between 2 and 12 years
- You are between 18 and 45 years old
- You live in the Colchester area
- Your annual household after-tax income is below £35 000
- You do not hold a university degree or are currently enrolled at university
- You have not been pregnant in the past 6 months

Take part and you will earn between £60 and £75

We would like to invite you to the ESSEXLab at the University of Essex for a duration of 2 hours, taking place between October 15th and 19th, 2018. Childcare will be provided for free during your visit.

You will receive a compensation of £60 to £75. You will also have the chance to win a free basket of food delivered to your home (worth £30).

Find out more and register now at **www.decisionstudy.co.uk** or call **07981 112 493**.

We look forward to welcoming you as part of our study!

Figure A.2: Letter for recruitment

University of Essex

European University Institute

THE UNIVERSITY *of* EDINBURGH

UNIVERSITY OF BATH

Prof. Michèle Belot
School of Economics
University of Edinburgh
30-31 Buccleuch Place
Edinburgh, EH8 9JT

September 2018

Do you live near Colchester and would be interested in taking part in a paid research study?

We would like to invite you to take part in a **paid research study.** We are a team of economists and we are interested in understanding how people take a variety of common decisions, for example making the choice between different products when shopping.

The study will take place at the ESSEX Lab of the University of Essex in Colchester. If you decide to participate, you will be asked to come to our facilities **for two hours at an arranged date**. You are welcome to bring your child along, childcare facilities will be available for free during the session.

During the session we will ask you to fill out a series of computer-based questionnaires and complete some decision making tasks. All the information we collect will remain anonymous and confidential, and the study has been approved by the Ethics Committee at the University of Edinburgh.

You will receive **a minimum compensation of £60 (up to a maximum of £75)**, payable in cash at the end of the session. You will also have the **chance to win a free basket of food delivered to your home** (worth £30).

The study will be held in the week of **October 15th - 19th, 2018.** You will be able to pick a time and date that best suits you.

The study focuses on mothers of young children. To participate, you need to:

- Have at least one child between 2 and 12 years
- Be between 18 and 45 years old
- Live in the Colchester area
- Have an annual household after-tax income below £35,000
- Have no university degree and not be currently enrolled at university
- Have not been pregnant in the past 6 months.

Everyone matching these criteria is encouraged to participate in the study, no knowledge of social sciences is necessary.

If you are interested in participating in this study, register online at **www.decisionstudy.co.uk.** Alternatively you can call or text us at **07981 112 493** or send an e-mail to **decisionstudy@ed.ac.uk.**

We look forward to welcoming you as part of our study.

Kindly note that in the interest of full disclosure, this letter has been sent by a private marketing intelligence company and is part of a large recruitment effort we are undertaking in the area of Colchester. We do not hold any personal information about you or your household.

Yours Sincerely,

MBelot

Prof. Michèle Belot

www.decisionstudy.co.uk **07981 112 493** **decisionstudy@ed.ac.uk**

To opt-out of receiving any further information, email opt-out@bbsltd.co.uk

Appendix B: Experiment Set-Up and Experimental Tasks

Figure B.1: Picture of participant desk prior to experimental session

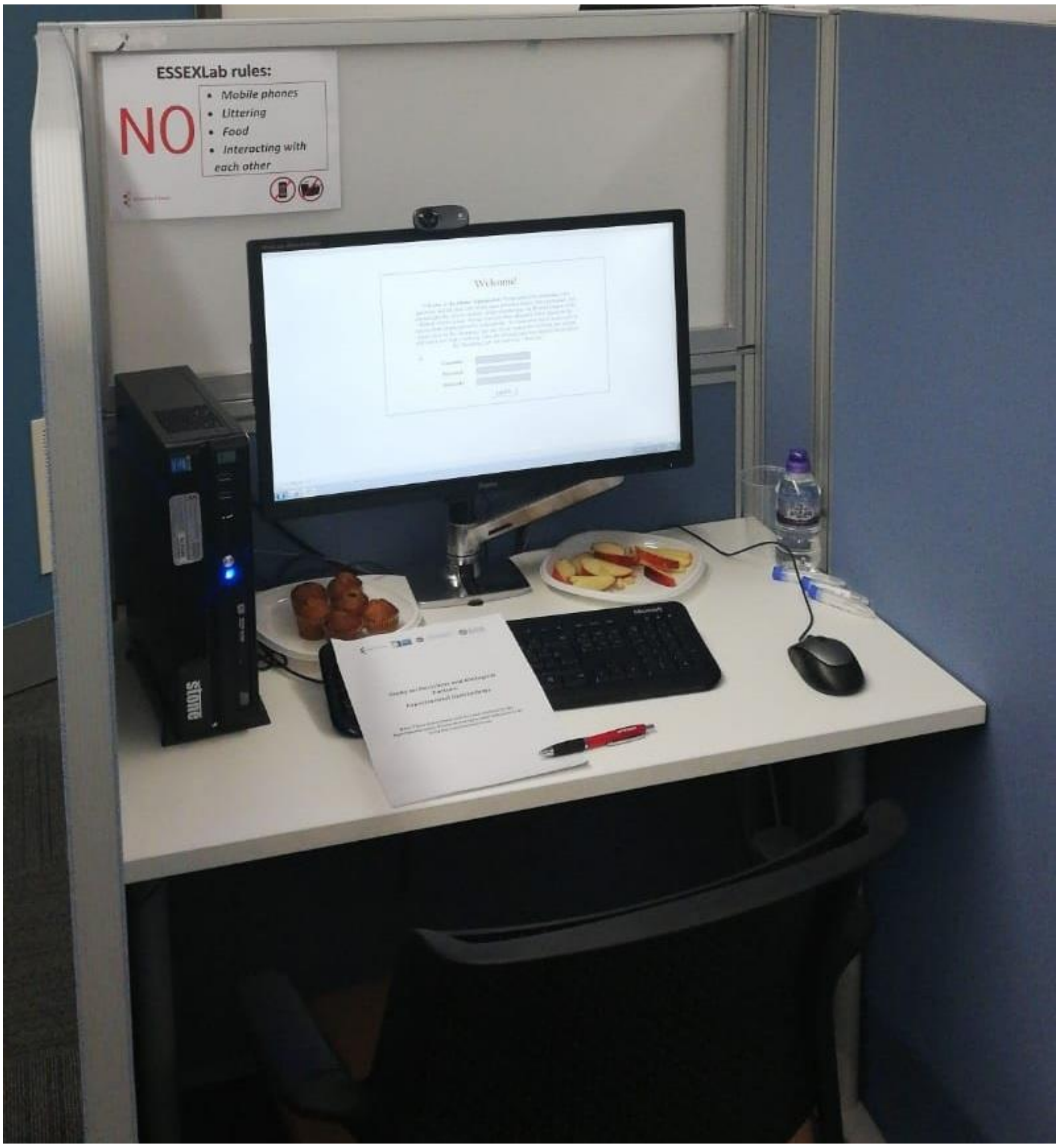


Figure B.2: Screenshot of a budget task

Figure B.3: Screenshot of a budget task after the countdown timer turns red

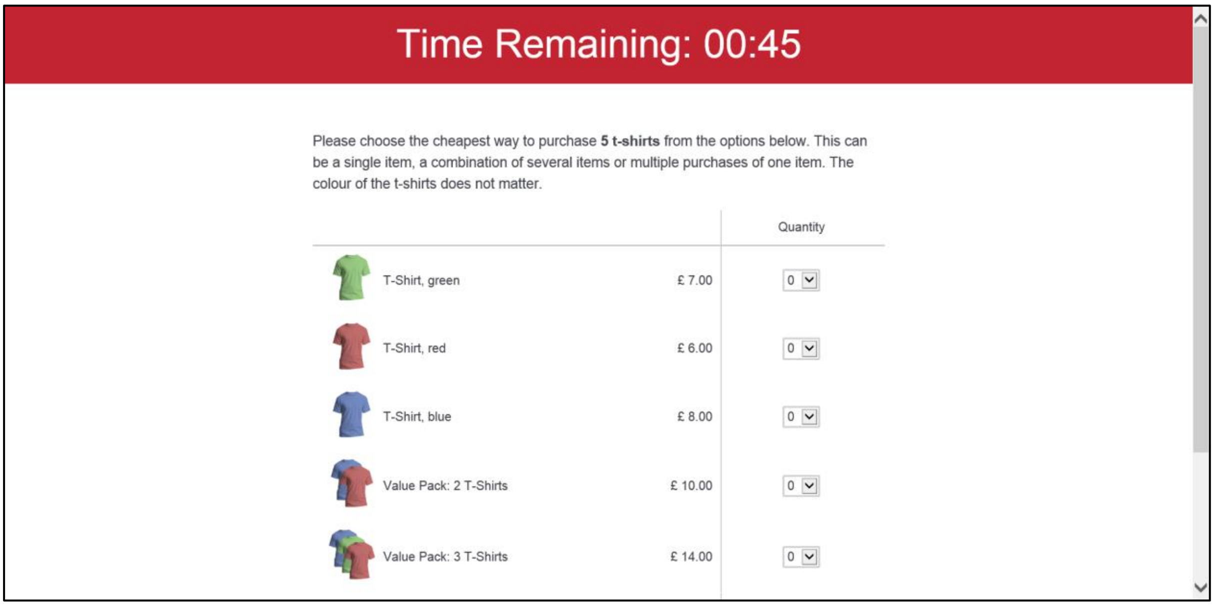


Figure B.4: Screenshot of a time management task

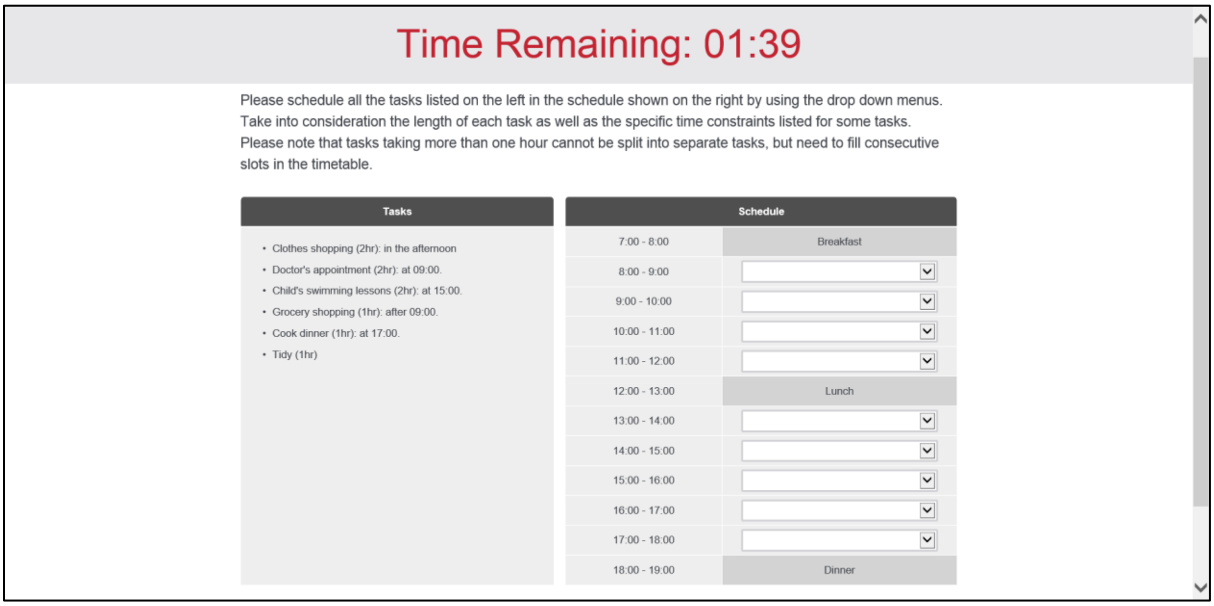


Figure B.5: Screenshot of a pop-up with a knowledge question

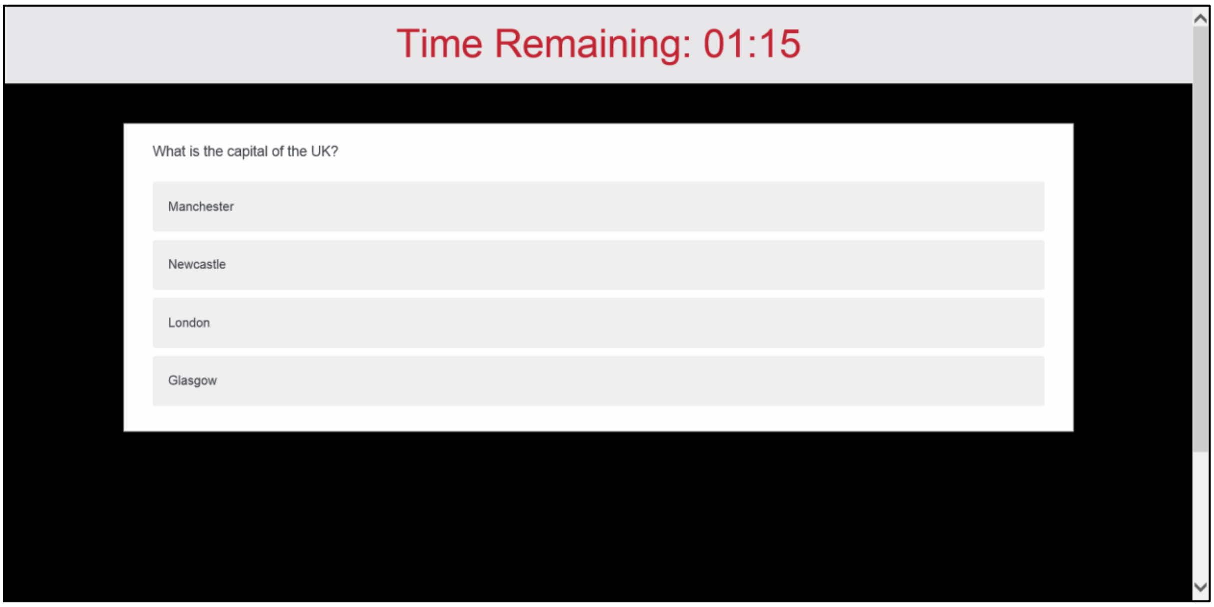


Figure B.6: Screenshot of a control task

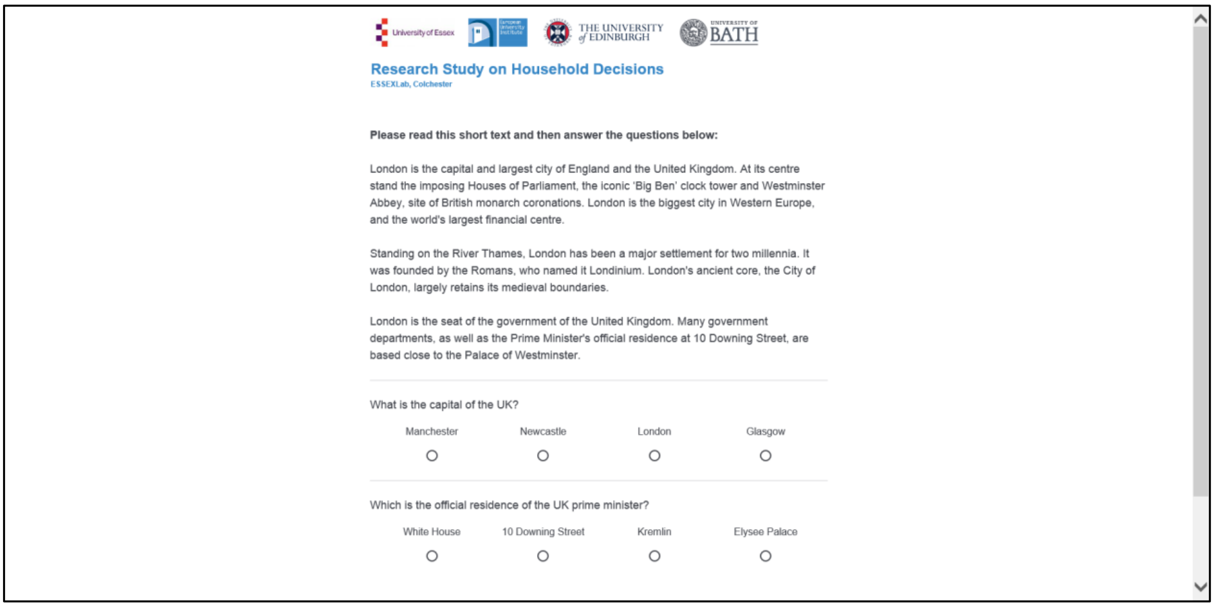
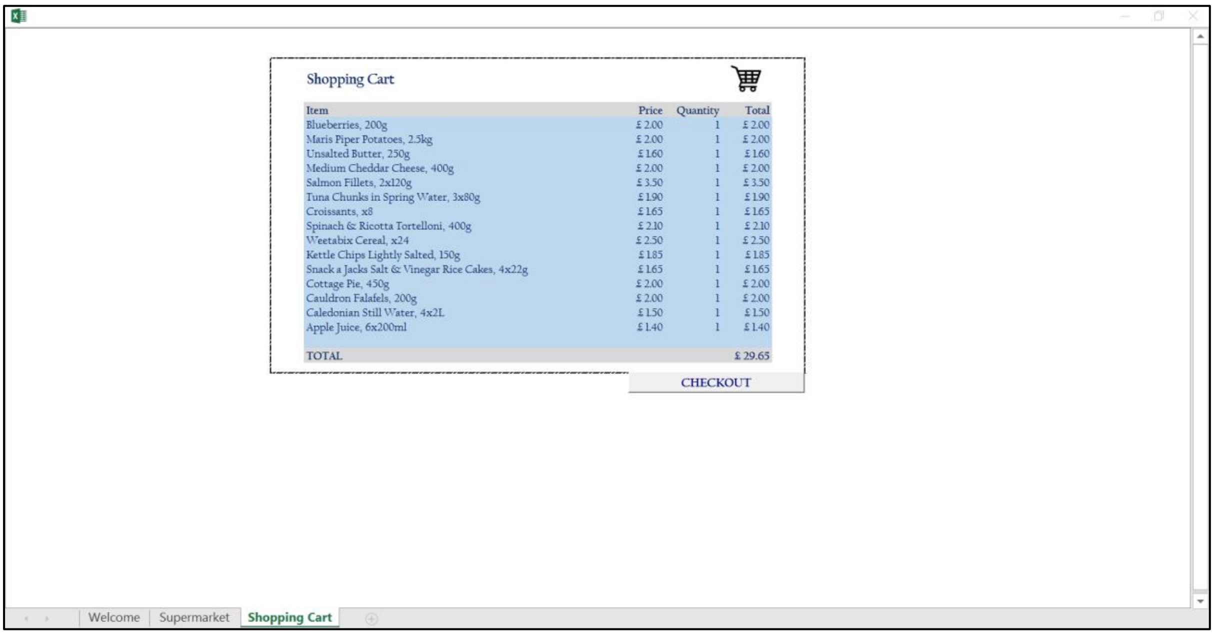


Figure B.7: Screenshot of food shopping task – categorized version[1]

[1] Source of images used in the food shopping task: Sainsbury's Supermarkets Ltd. Used for research purposes under fair dealing (Sections 29 and 30 of the Copyright, Designs and Patents Act 1988).

Figure B.8: Screenshot of food shopping task – long version[2]

Figure B.9: Screenshot of food shopping task - shopping cart



[2] Source of images used in the food shopping task: Sainsbury's Supermarkets Ltd. Used for research purposes under fair dealing (Sections 29 and 30 of the Copyright, Designs and Patents Act 1988).

Appendix C: Additional Results

Table C.1: Comparison of sample demographics

	Experimental Sample		**Understanding Society (2016/17)**	
	Mean	SD	Mean	SD
Age - mother	35.94	(5.89)	34.26	(6.12)
Age - youngest child	6.47	(2.98)	6.13	(2.91)
No. of children	2.07	(1.01)	2.09	(0.96)
Marital status:				
single	0.23		0.37	
married	0.42		0.38	
cohabiting	0.19		0.17	
other	0.16		0.07	
Monthly HH net income:				
<1000 GBP	0.11		0.05	
1000-2000 GBP	0.47		0.38	
>2000 GBP	0.41		0.57	
Monthly benefits:				
none	0.15		0.01	
1-650 GBP	0.60		0.40	
>650 GBP	0.25		0.60	
Highest qualification:				
none	0.09		0.05	
GCSE	0.43		0.48	
A levels / professional	0.48		0.46	
Employment status:				
full-time	0.10		0.17	
part-time	0.59		0.40	
self-employed	0.07		0.05	
not employed	0.24		0.38	

Data source for Understanding Society data: Institute for Social and Economic Research (2018).
Note: The Understanding Society sample was restricted to individuals matching the demographic eligibility criteria 1)-6) of the experiment. Survey weight were used to obtain a representative sample.

Table C.2: Comparison of food shopping expenditures

	Lab experiment task: Food shopping expenditures		**UK LCF Survey 2016/17:** Weekly grocery expenditures p.p.	
	Mean (in £)	Share	Mean (in £)	Share
Categories:				
- fruit	3.79	0.128	1.78	0.086
- veg	3.64	0.123	1.97	0.095
- eggs & dairy	3.90	0.132	2.88	0.139
- meat & fish	7.87	0.266	5.01	0.241
- bakery	1.87	0.063	1.60	0.077
- pasta & rice	1.25	0.042	0.26	0.013
- pantry	2.31	0.078	1.27	0.061
- snacks	1.54	0.052	2.44	0.117
- ready meals	1.36	0.046	2.11	0.102
- drinks	2.04	0.069	1.42	0.069
All 10 categories:	29.57	1.000	20.74	1.000
All grocery expenditures:			26.34	

Data source for UK data in 2016/17: UK Living Costs and Food Survey, 2016/17 (Department for Environment, Food and Rural Affairs, 2018).
Note: To obtain an approximate matching between categories in the lab experiment and the LCF survey, food and drink item groups in the LCF Survey were assigned (if possible) to the categories used in the experiment.

Table C.3: Salivary testosterone response to stress / control task

	(1) Baseline	(2) Post-Task	(3) End	(2)-(1) Diff	P	P(Wild)	N
Stress	85.687	78.578	72.968	-7.109	0.000	0.016	107
	(4.171)	(4.054)	(4.418)				
Control	82.786	72.851	67.361	-10.997	0.000	0.006	88
	(5.203)	(4.906)	(5.339)				
Diff-in-Diff				3.888	0.090	0.283	195

Note: Standard errors were clustered at the session level and are shown in parentheses. For the difference between post-task and baseline, p-values based on standard errors clustered at the session level and p-values based on a wild bootstrap clustered at the session level are shown.

Table C.4: Impact of acute stress on snack consumption - secondary outcomes

	Energy (kcal)		Saturated fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	24.069	24.236	0.151	0.142	1.886	2.128
	(0.439)	(0.376)	(0.433)	(0.394)	(0.456)	(0.359)
	[0.497]	[0.437]	[0.464]	[0.446]	[0.492]	[0.406]
Constant	198.505***	243.143***	1.070***	1.349***	19.651***	23.170***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:						
Session time	No	Yes	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes	No	Yes
N	196	196	196	196	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.5: Impact of acute stress on food shopping - secondary outcome

	Fruit & veg (g)	
	(1)	(2)
Stress	-193.571	-335.937
	(0.527)	(0.276)
	[0.522]	[0.327]
Constant	2944.225***	3117.919***
	(0.000)	(0.000)
Controls for:		
Session time	No	Yes
Time since food/drink	No	Yes
N	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.6: Impact of acute stress and coping style on snack consumption

	Muffins (g)		Apples (g)	
	(1)	(2)	(3)	(4)
Stress	1.964	5.192	44.084	55.531
	(0.961)	(0.899)	(0.304)	(0.197)
	[0.966]	[0.910]	[0.301]	[0.200]
Coping: avoidance	-1.034	0.086	10.160*	11.224*
	(0.686)	(0.971)	(0.041)	(0.019)
	[0.657]	[0.971]	[0.075]	[0.086]
Coping: emotion	2.983	2.581	3.828	3.847
	(0.388)	(0.448)	(0.402)	(0.378)
	[0.409]	[0.465]	[0.445]	[0.394]
Coping: task	-4.961	-5.321	3.512	2.968
	(0.378)	(0.388)	(0.457)	(0.517)
	[0.444]	[0.433]	[0.465]	[0.491]
Stress * Avoidance	1.975	0.831	-10.935	-11.992
	(0.691)	(0.877)	(0.212)	(0.183)
	[0.709]	[0.924]	[0.227]	[0.191]
Stress * Emotion	-3.785	-2.020	-5.885	-5.467
	(0.354)	(0.666)	(0.373)	(0.390)
	[0.352]	[0.671]	[0.381]	[0.396]
Stress * Task	2.203	0.781	2.654	0.725
	(0.727)	(0.909)	(0.693)	(0.924)
	[0.752]	[0.904]	[0.688]	[0.917]
Constant	52.018	61.636*	16.832	22.009
	(0.135)	(0.083)	(0.548)	(0.371)
Controls for:				
Session time	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes
N	196	196	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.7: Impact of acute stress and coping style on food shopping

	Energy (kcal)		Saturated fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	1490.410	1676.567	0.452	23.098	249.014	232.883
	(0.652)	(0.631)	(0.995)	(0.735)	(0.225)	(0.263)
	[0.642]	[0.607]	[0.995]	[0.720]	[0.270]	[0.307]
Coping: avoidance	-101.176	-123.614	4.890	4.042	-18.582	-17.944
	(0.849)	(0.828)	(0.549)	(0.655)	(0.512)	(0.525)
	[0.868]	[0.841]	[0.527]	[0.642]	[0.571]	[0.546]
Coping: emotion	-307.176	-352.800	-14.458	-14.280	9.768	9.415
	(0.590)	(0.544)	(0.088)	(0.076)	(0.651)	(0.657)
	[0.603]	[0.538]	[0.213]	[0.140]	[0.822]	[0.846]
Coping: task	364.684	366.391	5.651	7.662	58.496	57.868
	(0.524)	(0.529)	(0.433)	(0.282)	(0.149)	(0.164)
	[0.533]	[0.555]	[0.448]	[0.291]	[0.224]	[0.223]
Stress * Avoidance	-478.921	-411.252	-10.300	-8.326	2.923	1.634
	(0.462)	(0.551)	(0.279)	(0.401)	(0.925)	(0.959)
	[0.505]	[0.594]	[0.284]	[0.382]	[0.925]	[0.964]
Stress * Emotion	61.582	124.442	13.533	12.592	-11.708	-9.660
	(0.929)	(0.860)	(0.311)	(0.369)	(0.726)	(0.760)
	[0.933]	[0.888]	[0.295]	[0.357]	[0.758]	[0.771]
Stress * Task	-120.450	-216.977	-4.020	-9.630	-67.354	-65.017
	(0.890)	(0.810)	(0.812)	(0.550)	(0.138)	(0.180)
	[0.891]	[0.815]	[0.834]	[0.534]	[0.188]	[0.214]
Constant	16917.933***	17021.025***	209.556***	201.177***	565.223**	574.240***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.011)	(0.008)
Controls for:						
Session time	No	Yes	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes	No	Yes
N	196	196	196	196	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.8: Impact of acute stress and perceived stressfulness on snack consumption

	Muffins (g)		Apples (g)	
	(1)	(2)	(3)	(4)
Stress	-14.025	-12.134	-4.606	1.101
	(0.179)	(0.207)	(0.723)	(0.929)
	[0.202]	[0.221]	[0.710]	[0.921]
Task perception: stressful	-5.188	-4.332	2.012	3.049
	(0.196)	(0.301)	(0.611)	(0.440)
	[0.279]	[0.330]	[0.596]	[0.408]
Stress * Stressful	9.463*	8.208	1.628	-0.140
	(0.034)	(0.066)	(0.750)	(0.977)
	[0.093]	[0.104]	[0.751]	[0.976]
Constant	46.071***	54.221***	69.746***	74.680***
	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:				
Session time	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes
N	195	195	195	195

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.9: Impact of acute stress and perceived stressfulness on food shopping

	Energy (kcal)		Saturated fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	1102.994	1529.846	-24.655	-23.639	75.010	71.793
	(0.422)	(0.257)	(0.218)	(0.352)	(0.372)	(0.373)
	[0.474]	[0.304]	[0.233]	[0.380]	[0.411]	[0.397]
Task perception: stressful	80.999	95.805	0.662	1.178	54.606	55.449
	(0.825)	(0.825)	(0.807)	(0.761)	(0.132)	(0.130)
	[0.868]	[0.879]	[0.801]	[0.764]	[0.073]	[0.110]
Stress * Stressful	-548.764	-609.869	6.157	6.255	-69.615*	-70.220*
	(0.278)	(0.252)	(0.373)	(0.449)	(0.081)	(0.073)
	[0.311]	[0.291]	[0.381]	[0.417]	[0.049]	[0.051]
Constant	17015.549***	16927.178***	201.375***	198.578***	691.876***	703.664***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:						
Session time	No	Yes	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes	No	Yes
N	195	195	195	195	195	195

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.10: Impact of acute stress and heart rate response on snack consumption

	Muffins (g)		Apples (g)	
	(1)	(2)	(3)	(4)
Stress	3.936	4.764	-4.402	-1.175
	(0.586)	(0.430)	(0.622)	(0.896)
	[0.599]	[0.503]	[0.641]	[0.896]
HR response	0.586	0.543	2.235*	1.954*
	(0.237)	(0.127)	(0.062)	(0.077)
	[0.337]	[0.118]	[0.080]	[0.043]
Stress * HR response	-2.108**	-1.952**	-3.293	-2.877
	(0.020)	(0.021)	(0.093)	(0.128)
	[0.035]	[0.014]	[0.126]	[0.162]
Constant	38.351***	45.225***	82.334***	86.993***
	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:				
Session time	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes
N	167	167	167	167

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.11: Impact of acute stress and heart rate response on food shopping

	Energy (kcal)		Saturated fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	-514.505	-221.535	9.456	12.999	-117.593	-123.976
	(0.312)	(0.717)	(0.401)	(0.353)	(0.049)	(0.056)
	[0.327]	[0.737]	[0.411]	[0.336]	[0.128]	[0.155]
HR response	46.689	49.511	-1.840	-2.176	10.941	11.609
	(0.329)	(0.435)	(0.176)	(0.165)	(0.238)	(0.220)
	[0.352]	[0.419]	[0.267]	[0.184]	[0.362]	[0.340]
Stress * HR response	-65.971	-76.362	2.705	3.651	-15.934	-17.892
	(0.520)	(0.527)	(0.170)	(0.089)	(0.172)	(0.127)
	[0.537]	[0.556]	[0.159]	[0.104]	[0.262]	[0.212]
Constant	17356.296***	17268.058***	191.697***	195.132***	833.433***	826.130***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:						
Session time	No	Yes	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes	No	Yes
N	167	167	167	167	167	167

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.12: Impact of acute stress, cortisol and testosterone response on snack consumption

	Muffins (g)		Apples (g)	
	(1)	(2)	(3)	(4)
Stress	8.705	9.477	6.999	10.380
	(0.223)	(0.156)	(0.433)	(0.311)
	[0.242]	[0.208]	[0.467]	[0.371]
Cortisol response	1.467	0.610	-0.284	-1.135
	(0.129)	(0.596)	(0.900)	(0.681)
	[0.346]	[0.601]	[0.887]	[0.607]
Stress * Cortisol response	-0.210	0.845	6.365	7.094
	(0.954)	(0.821)	(0.157)	(0.168)
	[0.960]	[0.855]	[0.195]	[0.214]
Testosterone response	-0.456***	-0.475**	-0.124	-0.136
	(0.003)	(0.001)	(0.726)	(0.675)
	[0.002]	[0.025]	[0.844]	[0.725]
Stress * Testosterone response	0.338	0.299	-0.143	-0.161
	(0.289)	(0.322)	(0.761)	(0.740)
	[0.291]	[0.333]	[0.794]	[0.770]
Constant	35.008***	44.343***	71.587***	76.785***
	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:				
Session time	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes
N	195	195	195	195

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.13: Impact of acute stress, cortisol and testosterone response on food shopping

	Energy (kcal)		Saturated fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	-839.549	-599.281	-12.156	-8.971	-78.280	-78.783
	(0.157)	(0.325)	(0.434)	(0.612)	(0.132)	(0.153)
	[0.148]	[0.325]	[0.426]	[0.658]	[0.155]	[0.200]
Cortisol response	288.259	302.658	4.808	4.557	6.323	6.228
	(0.207)	(0.265)	(0.106)	(0.130)	(0.576)	(0.619)
	[0.141]	[0.191]	[0.140]	[0.208]	[0.650]	[0.657]
Stress * Cortisol resp.	-830.637**	-806.086	-6.320	-5.883	-37.169	-35.815
	(0.015)	(0.063)	(0.630)	(0.681)	(0.114)	(0.194)
	[0.036]	[0.117]	[0.660]	[0.734]	[0.161]	[0.234]
Testosterone response	-2.203	0.533	0.483	0.550	0.162	0.153
	(0.955)	(0.990)	(0.361)	(0.324)	(0.932)	(0.940)
	[0.949]	[0.991]	[0.377]	[0.300]	[0.937]	[0.937]
Stress * Testosterone resp.	29.438	23.037	0.361	0.254	-0.308	-0.387
	(0.496)	(0.634)	(0.582)	(0.730)	(0.883)	(0.867)
	[0.547]	[0.673]	[0.607]	[0.756]	[0.895]	[0.895]
Constant	17431.946***	17311.330***	213.980***	208.289***	780.103***	788.031***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:						
Session time	No	Yes	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes	No	Yes
N	195	195	195	195	195	195

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.14: Impact of acute stress and emotional eating on snack consumption

	Muffins (g)		Apples (g)	
	(1)	(2)	(3)	(4)
Stress	4.206	3.741	-3.238	-1.181
	(0.750)	(0.786)	(0.872)	(0.951)
	[0.762]	[0.784]	[0.871]	[0.947]
Emotional eating (DEBQ)	4.004	3.589	8.930	8.285
	(0.407)	(0.460)	(0.133)	(0.154)
	[0.423]	[0.609]	[0.192]	[0.243]
Stress * Emot. eating	0.132	0.207	1.646	1.898
	(0.979)	(0.969)	(0.837)	(0.804)
	[0.982]	[0.977]	[0.845]	[0.783]
Constant	28.254**	39.049***	50.608***	57.576***
	(0.019)	(0.005)	(0.001)	(0.001)
Controls for:				
Session time	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes
N	196	196	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.15: Impact of acute stress and emotional eating on food shopping

	Energy (kcal)		Saturated fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	822.685	966.618	-7.719	-3.345	116.061	110.854
	(0.689)	(0.637)	(0.890)	(0.952)	(0.150)	(0.189)
	[0.728]	[0.649]	[0.898]	[0.965]	[0.159]	[0.184]
Emotional eating (DEBQ)	304.946	286.068	-3.375	-3.763	40.935**	41.143**
	(0.663)	(0.685)	(0.853)	(0.836)	(0.026)	(0.024)
	[0.685]	[0.762]	[0.878]	[0.837]	[0.034]	[0.029]
Stress * Emot. eating	-450.344	-420.648	1.121	0.768	-64.217*	-64.116**
	(0.527)	(0.564)	(0.958)	(0.971)	(0.043)	(0.043)
	[0.549]	[0.577]	[0.960]	[0.976]	[0.051]	[0.046]
Constant	16380.662***	16356.524***	210.767***	208.913***	672.988***	681.088***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Controls for:						
Session time	No	Yes	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes	No	Yes
N	196	196	196	196	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.16: Impact of acute stress and time preferences on snack consumption

	Muffins (g)		Apples (g)	
	(1)	(2)	(3)	(4)
Stress	16.018	15.804	8.307	7.581
	(0.263)	(0.316)	(0.470)	(0.510)
	[0.271]	[0.340]	[0.450]	[0.482]
Patience (general)	-1.521	-1.436	-0.671	-1.167
	(0.307)	(0.300)	(0.712)	(0.482)
	[0.466]	[0.450]	[0.725]	[0.546]
Stress * Patience (general)	0.838	0.708	0.018	0.260
	(0.670)	(0.699)	(0.996)	(0.932)
	[0.707]	[0.729]	[0.995]	[0.933]
Patience (health)	1.516	1.566	0.467	0.508
	(0.451)	(0.407)	(0.822)	(0.824)
	[0.524]	[0.488]	[0.833]	[0.815]
Stress * Patience (health)	-2.708	-2.594	-0.935	-0.546
	(0.323)	(0.325)	(0.794)	(0.881)
	[0.339]	[0.336]	[0.821]	[0.876]
Constant	38.179***	47.268***	73.918***	82.216***
	(0.001)	(0.001)	(0.000)	(0.000)
Controls for:				
Session time	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes
N	196	196	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.17: Impact of acute stress and time preferences on food shopping

	Energy (kcal)		Saturated fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	152.480	459.685	2.492	-1.881	10.596	17.966
	(0.909)	(0.718)	(0.925)	(0.948)	(0.918)	(0.866)
	[0.912]	[0.714]	[0.928]	[0.931]	[0.927]	[0.881]
Patience (general)	-14.767	-12.180	-2.416	-2.991	-1.220	-0.148
	(0.929)	(0.936)	(0.315)	(0.245)	(0.934)	(0.993)
	[0.930]	[0.920]	[0.361]	[0.261]	[0.941]	[0.991]
Stress * Patience (general)	187.922	195.229	8.161	8.338	0.133	-0.453
	(0.525)	(0.491)	(0.271)	(0.276)	(0.995)	(0.982)
	[0.535]	[0.485]	[0.318]	[0.305]	[0.997]	[0.985]
Patience (health)	254.740	299.108	1.401	0.523	15.983	17.178
	(0.151)	(0.095)	(0.611)	(0.865)	(0.234)	(0.221)
	[0.193]	[0.178]	[0.627]	[0.859]	[0.444]	[0.442]
Stress * Patience (health)	-277.673	-296.092	-9.711*	-8.589	-10.605	-11.907
	(0.341)	(0.300)	(0.076)	(0.116)	(0.560)	(0.522)
	[0.363]	[0.329]	[0.099]	[0.155]	[0.572]	[0.563]
Constant	15792.446***	15476.369***	207.985***	212.565***	691.892***	689.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:						
Session time	No	Yes	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes	No	Yes
N	196	196	196	196	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.18: Impact of acute stress and risk attitudes on snack consumption

	Muffins (g)		Apples (g)	
	(1)	(2)	(3)	(4)
Stress	-6.278	-9.112	13.553	17.158
	(0.611)	(0.396)	(0.513)	(0.406)
	[0.627]	[0.413]	[0.532]	[0.423]
Risk aversion (general)	-3.190*	-3.134*	1.273	1.217
	(0.030)	(0.021)	(0.318)	(0.307)
	[0.077]	[0.098]	[0.343]	[0.306]
Stress * Risk aversion (general)	4.830*	4.788*	-2.098	-2.382
	(0.046)	(0.055)	(0.527)	(0.528)
	[0.058]	[0.080]	[0.554]	[0.548]
Risk aversion (health)	1.603	1.314	-1.754	-2.037
	(0.049)	(0.108)	(0.209)	(0.147)
	[0.156]	[0.245]	[0.220]	[0.208]
Stress * Risk aversion (health)	-1.285	-0.898	-0.207	-0.081
	(0.402)	(0.564)	(0.951)	(0.981)
	[0.440]	[0.599]	[0.956]	[0.984]
Constant	41.198***	52.899***	78.563***	86.287***
	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:				
Session time	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes
N	196	196	196	196

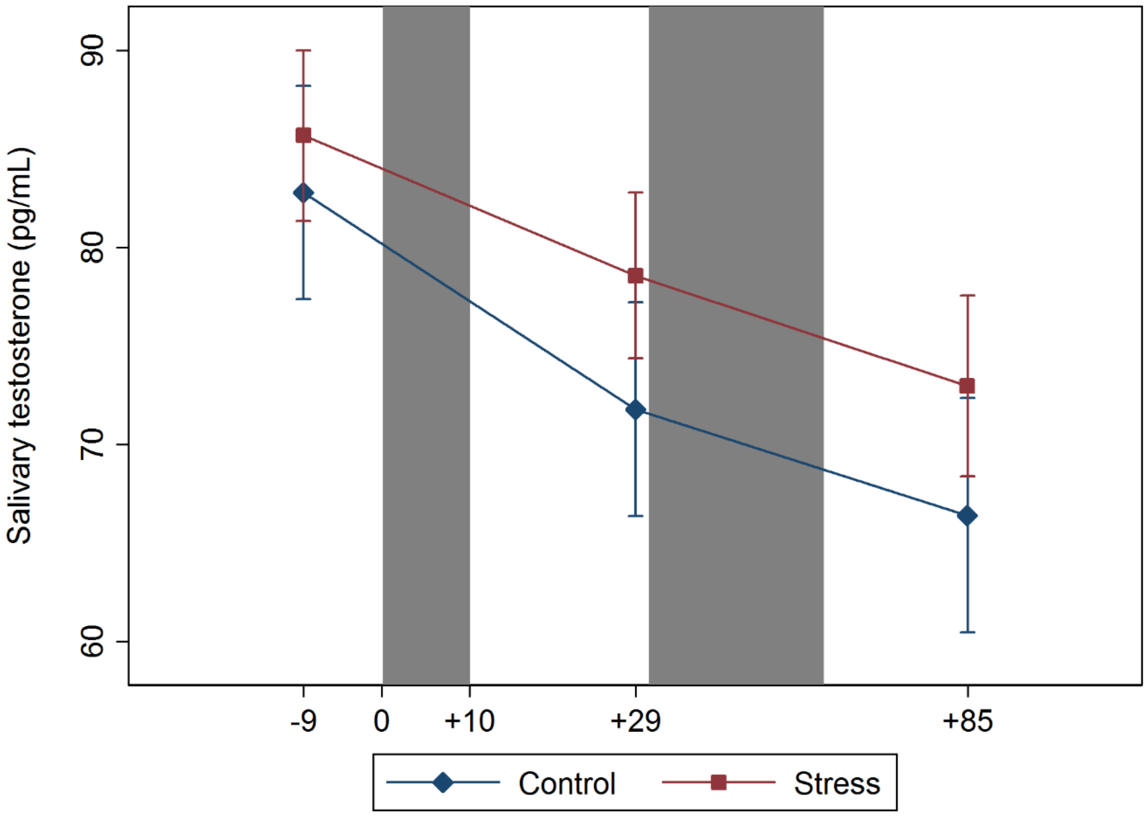
Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table C.19: Impact of acute stress and risk attitudes on food shopping

	Energy (kcal)		Saturated fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	368.281	743.754	-65.422	-63.875	-21.147	-31.241
	(0.844)	(0.684)	(0.112)	(0.096)	(0.793)	(0.681)
	[0.847]	[0.693]	[0.153]	[0.141]	[0.785]	[0.709]
Risk aversion (general)	217.069	234.869*	-7.182	-6.620	-9.632	-9.374
	(0.063)	(0.044)	(0.264)	(0.299)	(0.403)	(0.437)
	[0.138]	[0.093]	[0.315]	[0.301]	[0.428]	[0.475]
Stress * Risk aversion (general)	-656.131**	-696.041**	8.479	7.379	-18.285	-17.789
	(0.032)	(0.016)	(0.242)	(0.304)	(0.206)	(0.203)
	[0.026]	[0.026]	[0.275]	[0.365]	[0.195]	[0.203]
Risk aversion (health)	-92.555	-115.876	0.860	0.592	17.671	17.843
	(0.542)	(0.409)	(0.915)	(0.941)	(0.086)	(0.088)
	[0.528]	[0.469]	[0.899]	[0.916]	[0.153]	[0.157]
Stress * Risk aversion (health)	300.287	306.633	3.816	4.664	5.913	6.277
	(0.186)	(0.152)	(0.652)	(0.580)	(0.587)	(0.551)
	[0.161]	[0.169]	[0.686]	[0.594]	[0.623]	[0.568]
Constant	16831.276***	16825.043***	226.297***	223.548***	703.596***	709.320***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:						
Session time	No	Yes	No	Yes	No	Yes
Time since food/drink	No	Yes	No	Yes	No	Yes
N	196	196	196	196	196	196

Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Figure C.1: Salivary testosterone response to stress / control task



Appendix D: Pre-Test Results

Table D.1: Mean perceptions of stress / control task in the pre-test

	(1) Stressful	(2) Relaxing	(3) Easy	(4) Difficult	(5) Enjoyable	(6) Tiring	N
Stress	1.952	2.762	3.143	2.238	4.238	1.476	21
	(0.242)	(0.243)	(0.265)	(0.303)	(0.108)	(0.143)	
Control	1.350	3.300	4.650	1.200	3.250	1.250	20
	(0.174)	(0.100)	(0.116)	(0.135)	(0.126)	(0.126)	
Difference	0.602	-0.538	-1.507	1.038	0.988	0.226	
P	0.078	0.075	0.001	0.014	0.000	0.269	
P(Wild)	0.088	0.139	0.006	0.014	0.002	0.291	

Note: Perceptions of the stress / control task were scored from 1 for 'not at all' to 5 for 'very much'. Standard errors were clustered at the session level and are shown in parentheses. For the difference between treatment and control, p-values based on standard errors clustered at the session level and p-values based on a wild bootstrap clustered at the session level are shown.

Table D.2: Heart rate response to stress / control task in the pre-test

	(1) Baseline	(2) Task	(2)-(1) Diff	P	P(Wild)	N
Stress	81.537	88.495	6.958	0.000	0.125	16
	(1.790)	(2.476)				
Control	86.158	83.076	-3.082	0.011	0.063	15
	(2.425)	(1.777)				
Diff-in-Diff			10.041	0.000	0.008	31

Note: Means were calculated based on heart rate data collected every second. Standard errors were clustered at the session level and are shown in parentheses. For the difference between task and baseline, p-values based on standard errors clustered at the session level and p-values based on a wild bootstrap clustered at the session level are shown.

Table D.3: Salivary cortisol response to stress / control task in the pre-test

	(1) Baseline	(2) Post-Task	(3) End	(2)-(1) Diff	P	P(Wild)	N
Stress	4.564	5.661	3.189	1.098	0.179	0.313	21
	(0.324)	(0.865)	(0.381)				
Control	4.827	3.753	2.883	-1.073	0.010	0.031	20
	(0.461)	(0.332)	(0.296)				
Diff-in-Diff				2.171	0.028	0.033	41

Note: Standard errors were clustered at the session level and are shown in parentheses. For the difference between post-task and baseline, p-values based on standard errors clustered at the session level and p-values based on a wild bootstrap clustered at the session level are shown.

Table D.4: Impact of acute stress on snack consumption in the pre-test

	Croissants (g)		Strawberries (g)	
	(1)	(2)	(3)	(4)
Stress	-6.407	-8.962	-7.381	-4.118
	(0.237)	(0.150)	(0.566)	(0.766)
	[0.248]	[0.186]	[0.611]	[0.748]
Constant	33.550***	33.550***	66.000***	66.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:				
Endocrine disorder	No	Yes	No	Yes
N	41	40	41	40

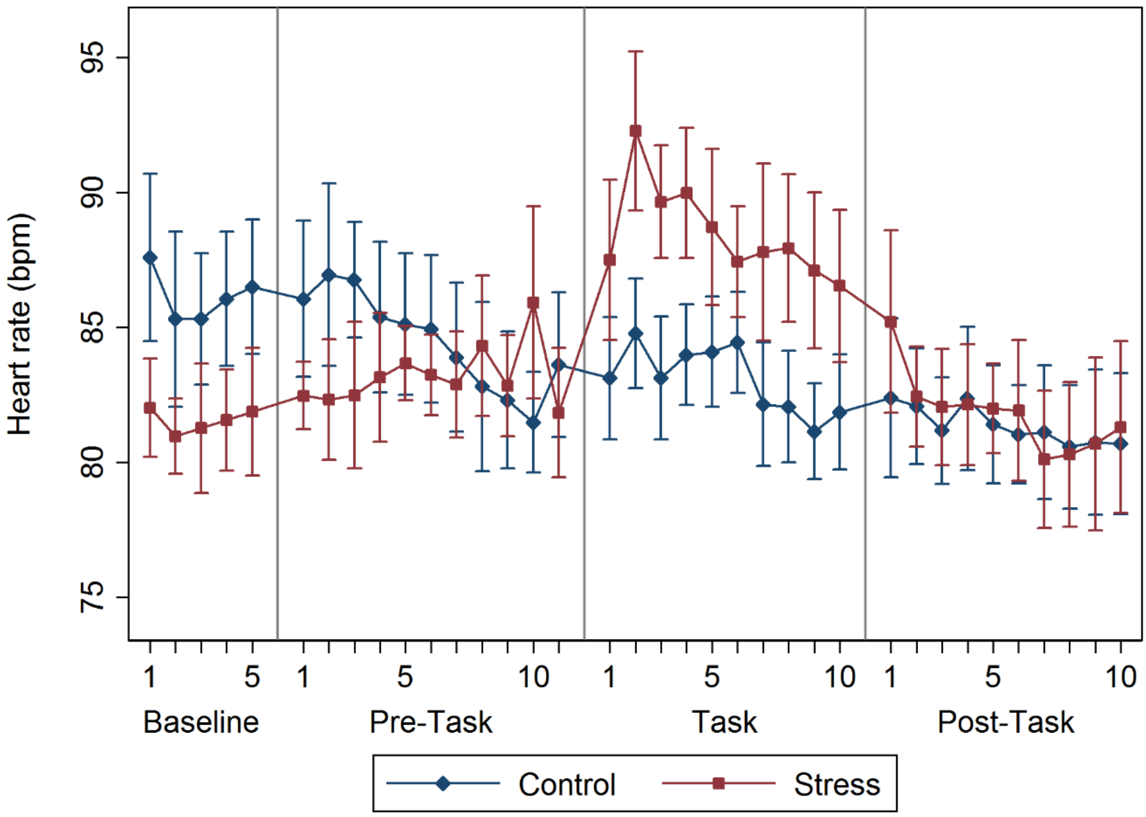
Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Table D.5: Impact of acute stress on food shopping of the pre-test

	Energy (kcal)		Saturated fat (g)		Sugar (g)	
	(1)	(2)	(3)	(4)	(5)	(6)
Stress	-1051.516	-1226.953	-20.329*	-20.927	51.096	31.856
	(0.254)	(0.221)	(0.077)	(0.186)	(0.285)	(0.591)
	[0.268]	[0.221]	[0.088]	[0.229]	[0.318]	[0.604]
Constant	10571.797***	10571.797***	117.105***	117.105***	375.647***	375.647***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls for:						
Endocrine disorder	No	Yes	No	Yes	No	Yes
N	41	40	41	40	41	40

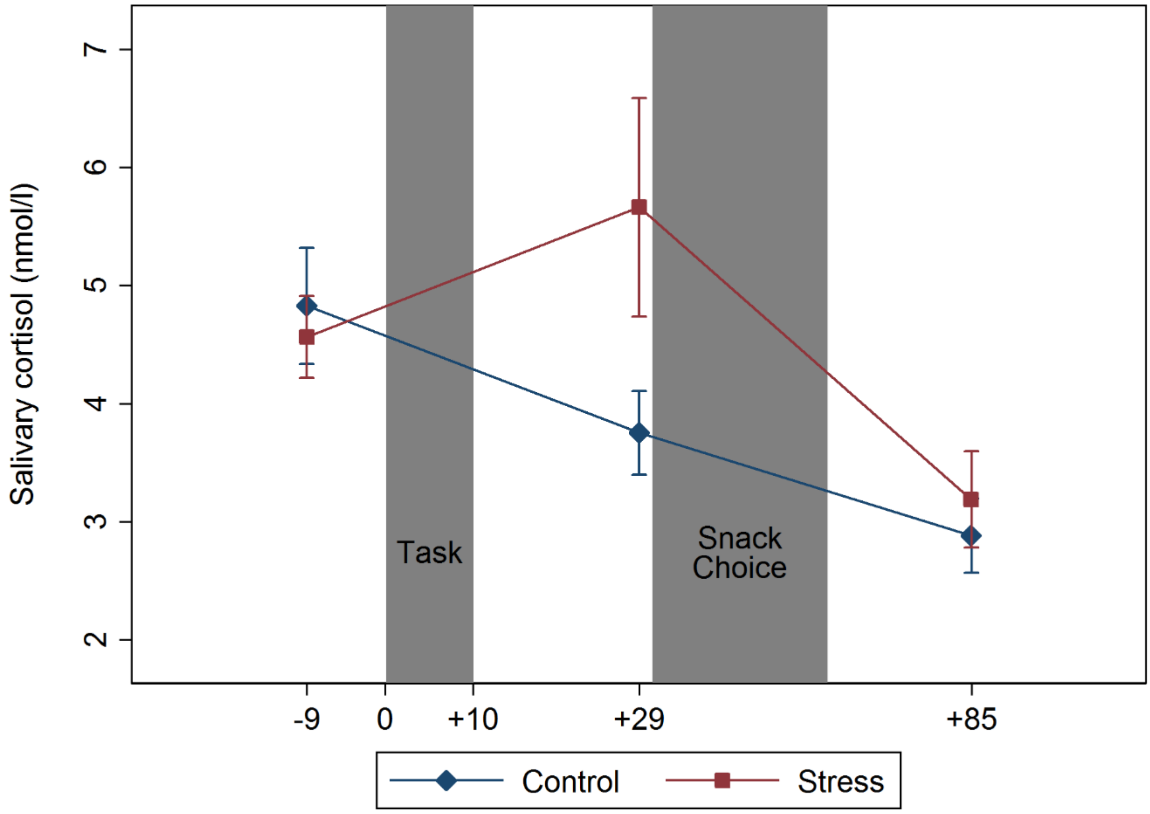
Note: P-values based on standard errors clustered at the session level are shown in parentheses. P-values based on a wild bootstrap clustered at the session level are shown in brackets. Significance levels correspond to the largest p-value obtained from both methods and are indicated as follows: * p<0.1, ** p<0.05, *** p<0.01

Figure D.1: Heart rate response to stress / control task in the pre-test



Note: Means were calculated for minute intervals based on heart rate data collected every second. Bands indicate +/- 1 standard error. The length of the pre-task period differed across sessions (between 9 min and 12 min), but it did not differ significantly between stress and control session.

Figure D.2: Salivary cortisol response to stress / control task in the pre-test



Note: Bands indicate +/- 1 standard error.