Stress and Temporal Discounting: Do Domains Matter?

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December 30, 2015

Abstract

Recent work in behavioral economics has asked whether stress affects economic choice. Here we focus on the effects of stress on temporal discounting, for which previous studies have produced inconsistent results. We hypothesize that different types of stress may differentially affect discounting. To test this hypothesis, we conducted laboratory experiments in Nairobi, Kenya, in which we induce stress in three domains: social (Trier Social Stress test); physical (Cold Pressor Task); and economic (Centipede Game). We find that the social stressor decreases temporal discounting; the physical stressor has no effect; and the economic stressor increases temporal discounting. However, these effects track those of the stressors on self-reported stress and negative affect: the economic stressor increased stress, while the physical stressor had no effect, and the social stressor actually *decreased* it. Together, these results suggest that different types of stress affects discounting in the same way, but different stress induction protocols may not affect stress in the same way in different populations.

We are grateful to the study participants for generously giving their time; to Justin Abraham, Jennifer Adhiambo, Marie Collins, Faizan Diwan, Amal Devani, Irene Gachungi, Colton Jang, Monica Kay, Joseph Njoroge, and James Vancel, for excellent research assistance. All errors are our own. This research was supported by NIH Grant R01AG039297 and 1UH2NR016378 and Cogito Foundation Grant R-116/10 to Johannes Haushofer.

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1 Introduction

Many important decisions, including economic choices, are made under stress. As a result, economists and psychologists have recently taken an interest in understanding the effects of stress on such choices Haushofer and Fehr (2014). However, the precise effects of stress on economic choice remain incompletely understood. Here we focus on the effects of acute stress on temporal discounting by comparing the results of three experiments that manipulated acute stress along three domains, social, physical and financial. In companion lab experiments, we induce acute stress and measure the resultant changes in temporal discounting.. In studying this question, we make two main contributions. The first is to extend the study of the effects of stress on economic choice beyond Western laboratory settings to a laboratory in a developing country. The effect of stress on economic choice has almost exclusively been studies using "WEIRD" participants (Western, Educated, Industrialized, Rich, and Democratic; Henrich et al., 2010), and it is therefore of interest to ask whether the effects found in these populations extend to other settings. In our view, these effects of particular interest in developing countries, where individuals are exposed to high degrees of stress, and where individual choices may have more dramatic consequences because individuals have less "slack" (Mullainathan and Shafir, 2013).

The second main contribution of this paper is that we directly compare the effect of different stress induction methods on temporal discounting. Specifically, we aimed to test the relative effects on temporal discounting of social stress, physical stress, and financial stress. To induce social stress, we use the well-known Trier Social Stress Test for Groups (TSST-G; Kirschbaum et al., 1993; von Dawans et al., 2011). To induce physical stress, we use the well-known Cold Pressor Task (CPT; e.g. Porcelli and Delgado, 2009), which involves immersion of a participant's hand in ice-cold water (0–4° C) for 2 minutes. Like the TSST-G, the CPT has been shown to reliably raise levels of subjective stress, as well as levels of the stress hormone cortisol (Lovallo, 1975; Schoofs et al., 2009). Finally, to induce economic stress, we employ a real-time version of the Centipede Game (Rosenthal, 1981), in which four players alternately get a chance to take a portion of an increasing amount of money. At each turn players can either pass, or end the game by taking the money. The four players are thus constantly trading off the motivation to wait until the available amount of money grows larger over time, and the risk that one of the opponents will take first and thus leave them with nothing; this tension is likely stressful. After stress induction along one of the three domains listed above, we measure stress and other negative affective states via self report on a visual analog scale. Finally, our outcome of interest, temporal discounting, is measured via a titration algorithm[1].

The motivation to compare the relative effect of these different methods of stress induction on temporal discounting is twofold. First, stress is a type of negative affect, and it has previously been shown that different types of negative affect differentially affect economic choice. For instance, Lerner and Keltner (2001) show that fear and anger, two affective states that are often thought to be similar, have differential effects on risk perception: fear, which is associated with lack of control,

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[1] Titration is considered one of the standard methods for identifying discount rates in the literature (Mazur, 1988; Green and Myerson, 2004; Kable and Glimcher, 2007; Rachlin et al., 1991).

increases risk aversion, while anger, which is associated with control, increases risk-seeking. We might thus expect that different types of stress have different effects on economic choice as well. In the context of the tasks described above, we might hypothesize that financial stress affects economic choice because the domain in which the stress is induced matches that in which the decision-making tasks takes place. Physical stress could affect economic choice by inducing a feeling of lack of control and physical pain. The effect of social stress is likely to depend on the degree to which the social interaction in question is stressful, and what behavioral motives arise from it; e.g., it has been argued that social stressors induce a "tend-and-befriend" motive (von Dawans et al., 2012), which might lead to more prosocial behavior, but might not affect individual behaviors such as risk and time preference.

The second motivation to compare the relative effect of different methods of stress induction on temporal discounting is that existing studies have produced inconclusive results, and part of these existing discrepancies could be explained by a different choice of methods. Delaney et al. (2014) find in increase in temporal discounting after exposure to the cold pressor task; participants in the stress condition make fewer patient choices than those in the control condition. Similarly, in a previous study, we found that oral administration of hydrocortisone – which raises cortisol levels – led to an increase in temporal discounting (Cornelisse et al., 2013). In contrast, in another previous study, we find that the Trier Social Stress Test does not affect temporal discounting (Haushofer et al., 2013b). One possibility for these discrepant findings is that social stress does not affect temporal discounting, while physiological stress and direct pharmacological manipulation of stress hormones do affect it.

Thus, existing studies on the effect of stress on intertemporal choice are inconclusive, and this might partly be the case due to differences in stress induction methods.[2] The present study therefore directly compares the effect of three stress induction methods on temporal discounting in the same population. We report two main findings. First, the different stress induction methods affect stress levels differentially, and in ways that differ from Western settings. In particular, we find no evidence of an increase in subjective stress levels through our social stressor, the TSST-G, in Kenya. This finding might be due to the fact that public speaking is less stressful to Kenyans than to Western undergraduates, who are traditionally tested on this task and for whom it was mainly developed. In contrast, the physical and financial stressors – the Cold Pressor Task and Centipede Game – produce strong increases in subjectively experienced stress in our setting, suggesting that physical and financial stressors may more universally induce stress than social ones. However, the effect of the Cold Pressor Task dissipates quickly over time and has declined back to baseline by the time participants perform the temporal discounting task, while the effect of the Centipede game is longer-lasting.

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[2] A number of other papers study the effect of stress on other economic outcomes; e.g. Angelucci and Cordova (2014). There exists a body of work on the effect of stress on risk preference, the results are similarly inconclusive. For instance, Kandasamy et al. (2014) find an increase in risk aversion following repeated hydrocortisone administration. Porcelli and Delgado (2009) find that the Cold Pressor Task increases risk aversion in the gains domain; in contrast, Delaney et al. (2014) find no effect using the same task.

In line with this first set of findings, we also find differential effects of the three stress induction methods on temporal discounting. In particular, the financial stressor leads to an increase in temporal discounting; in contrast, we find no such effect for the physical stressor. Surprisingly we find evidence that the social stressor leads to *decreases* in temporal discounting, (i.e. the stressor makes participants *more* patient). Importantly, this pattern of results tracks precisely the effect of the stress induction methods on stress.

Together, these results suggest that different participant populations may be differentially affected by different stressors, and that therefore the effect of stress on economic choice may differ across settings. In particular, findings with Western participants may not apply to developing country contexts, and researchers should therefore be wary of generalizations from one participant population to another.

The remainder of this paper is structured as follows. Section 2 details the stressors used in this study, Section 3 outlines the design of the experiment and measurement of outcome variables, Section 4 discusses the data and econometric approach, Section 5 reviews the results before a discussion in Section 5.4 and concluding in Section 6.

2 Stress induction

Our primary question was how stress in different domains affects temporal discounting. We therefore purposely chose paradigms designed to induce three types of stress: social, physical, and economic. Each method is described in greater detail below:

1. **The Trier Social Stress Test for Groups (TSST-G):** The Trier Social Stress Test for Groups (TSST-G) (von Dawans et al., 2011), is based on the single-participant Trier Social Stress Test (TSST) (Kirschbaum et al., 1993). The test involved 5 minutes of preparation for a mock job interview, which was followed by a 2-minute question and answer round where participants were quizzed about their suitability for the hypothetical job. Next, participants underwent a 2-minute mental arithmetic task, in which they performed serial subtractions of 16 from a four digit number, while being recorded by a video camera and evaluated by project staff who refrained from socially-supportive facial expressions. In the stress condition, at most five participants were tested at once. The control group exercise involved a 4-minute period of reading a magazine, in lieu of preparation. Instead of a job interview, control group participants spoke freely about the qualities of a friend; during this exercise, all respondents in the group spoke at the same time. The arithmetic task was the same as in the treatment group, but again participants performed it at the same time and were told that performance was not rated. In the control condition up to twenty participants were tested simultaneously. We randomly assigned sessions to receive the stressor or control during the invitation process.

2. **The Cold Pressor Test (CPT):** The Cold Pressor Test (Hines and Brown, 1932) consisted of immersing one's left hand in a container filled with ice water (0–4° C) for the duration of 30 seconds, followed by a second immersion lasting 60 seconds. Participants assigned to the

control group were asked to immerse their left hand in a container filled with water heated to body temperature (35-37° C) for the same duration. By means of an iron partitioner, two compartments were created inside the container, one containing 6 kg of ice cubes, and another in which participants immersed their hand in water up to their wrist with outstretched fingers. A waterproof RS-2001 electrical filter pump was used to circulate the water to avoid local heat build up around the hand (Mitchell et al., 2004). Commercial-grade submersible aquarium thermometers were used to monitor and measure water temperature. Random assignment of the stressor was conducted at the individual level via a double-blind procedure.[3]

3. **The Centipede Game (CENT):** We used a modified real-time version of the Centipede Game first introduced by Rosenthal (1981). In our case, the game lasted for 15 rounds of 21 seconds each. In each round of the game, a resource started at a low amount and doubled every three seconds. Player(s) were sequentially faced with a decision to "pass" or "take". The fact that the resource grows over time creates an incentive to "take" in the last round and "pass" in all others. However, when the game is played with others, the player who takes first ends the game, thus creating an incentive to take early.

   We used two versions of the game: a 1-player and a 4-player condition. Participants assigned to the 1-player condition played for themselves without partners, and their payoff depended only on when they themselves decided to "take". The starting resource was KES 1 (USD 1; at the time of the study the KES/USD rate was between 85/1 and 100/1), resulting in a maximum resource of KES 128. If a player did not make a decision within the decision period of 21 seconds, the default decision was to pass. If the player did not take in any of the 15 rounds, they received the maximum payout. Thus, the optimal strategy was simply to wait out the game.

   Participants in the 4-player condition competed with 3 other players. The starting resource was KES 4, resulting in a maximum resource of KES 512. Players decided sequentially to pass or take. If a players passed, the resource remained intact and the next player decided to pass or take. If a player took, the round ended, and that player earned the money in the pot. If more than one player took in the same 3-second interval, those players split the resource amongst themselves. If no player collected before the time ran out, everyone in the group split the maximum resource equally.

   After each round, participants were alerted of the resource they had collected, but not the resource levels of anyone else. At the end of the study, the computer randomly chose one of the 15 rounds to pay out to the participants.

   By backward induction, there exists a unique sub-game perfect equilibrium in the 4-player

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[3] Upon arrival at the lab, participants were randomly assigned seat numbers (between 1 and 8) by a research assistant who was not involved in the administration of the experimental session. Before each session, a different research assistant, who was also not involved in administration, randomly drew seat numbers from an envelope to assign respondents to seats. After positioning the containers at their respective seats, the containers were covered such that neither the research assistant(s) administering the session, nor the participants, could determine which seat was associated with which condition.

condition where the player moving first takes in the first round. We hypothesized that this unraveling would lead to stress. In contrast, in the one-player condition, no unraveling takes place, and as a result, stress levels should be lower. We therefore manipulated stress by randomly assigning, at the session level, some participants to the 4-player game as a stress inducer, and others to the 1-player game as the control.

It is important to note that total payoffs were carefully calibrated across the two conditions, ruling out the possibility that any differences in discounting behavior resulted from the income effect due to differential payoffs during titration.

Reverse Centipede Game: Identifying an effect of the Centipede Game on behavior, especially discounting, is potentially affected by the fact that in the "treatment" version of Centipede Game, the equilibrium strategy is to act immediately. This fact could generate a general belief that acting immediately is advantageous, and therefore spill over into the discounting task and induce participants to select the "sooner" option. We therefore generated a "reverse" version of the Centipede Game to control for this possibility.

In the reverse version of the Centipede Game, each round began with a large common-pool resource that decreased over time. Participants assigned to the 1-player condition individually played the game and decided how much to collect. If the player did not collect when the timer ran out, they received the minimum amount of points for that round (1). Thus, the profit maximizing strategy for an individual in the 1-player condition was to collect the resource immediately. Players in the 4-player condition competed with 3 other players. The incentives were now such that it was optimal to take as late as possible: players who collected before the interval in which *last* person collected received zero points. Players who collected in the same 3-second interval split the points among themselves. If no player collected before the time ran out, everyone in the group received the minimum number of points (1). In the 4-player version of this game, if each person collected immediately, the group would equally split the maximum resource (512). The reverse 1-player game contained 15 21-second rounds which began with a resource of 128 that halved every 3 seconds. The reverse 4-player game began with a resource of 512. The computer randomly chose one of the rounds to pay out to the participants at a conversion rate to KES of 1:1. In this version, as in the previous, the 4-player game was randomly assigned at the session level used to induce stress.

3 Outcome measures and design

3.1 Affective state inventory

We collected data on self-reported affective state using a 12-item questionnaire. The questionnaire consisted of subjective ratings of negative affect, as assessed using the 10-item negative mood scale of the PANAS (Watson et al., 1988),[4] self-reported stress ratings were collected in all experiments,

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[4] Subjective ratings were collected by means of a visual analogue scale (VAS) with answering options to the affect in question ranging from 0 "not at all" to 100 "very much".

and, in the cold pressor and centipede experiments, ratings of pain and frustration. Table 1 outlines the type of question and time point of administration for each of the experiments.

Table 1: Summary of Affective State Data

	Baseline	**Midline**	**Endline**
TSST-G	NA-10, Stress	NA-10, Stress	
CPT	NA-10, Stress, Pain	Stress, Pain	NA-10, Stress, Pain
CENT	NA-10, Stress, Frus	NA-3, Stress, Frus	NA-10, Stress, Frus

Notes: Overview of affective state inventory measures. Columns refer to when the measure was collected, where "midline" refers to directly after stress-induction and "endline" refers to the end of the experiment. "NA-10" refers to the 10-item negative affective scale, "NA-3" refers to ratings of "upset, hostile and irritable", and "Frus" refers to frustration. All items were collected by means of a visual-analog scale.

3.2 Temporal discounting

We measure temporal discounting using a titration paradigm, which is shared across all three stressors. On each trial of the task, participants are asked to choose between a larger amount of money available later, and a smaller amount available sooner. The delay combinations are "today vs. 3months", "today vs. 6months", "today vs. 12 months", and "6 months vs. 12 months".[5]For each time horizon, each participant made five decisions between smaller, sooner and larger, later rewards. The larger, later reward was fixed at USD 5.10 for TSST-G and CPT and at USD 25.30 for CENT. The smaller, sooner amount was systematically adjusted by means of a bisection algorithm based on the choices made by each participant. For each larger, later reward chosen, the smaller, sooner reward was increased by half the difference between it and the fixed larger, later reward. For each smaller, sooner reward chosen, the smaller, sooner reward was decreased by half the distance between it and the previously offered smaller, sooner award.

At the end of the experiment, the computer randomly selected one of the choices and paid that amount to the respondent; in the Centipede experiment payouts were realized with 20 percent probability. In line with standard protocol at the Busara Center for Behavioral Economics (Haushofer et al., 2013a), participants were paid later on the same day via M-Pesa, a mobile money platform in Kenya. This method allows us to offer intertemporal choices that can be realized as soon as the same day, while holding the transaction costs of receiving payment constant.

3.2.1 Temporal discounting variables

For each time horizon, the titration exercise determines an indifferent point to the larger, later reward, with respect to the sooner time point. From this indifference point, we can calculate a number of measures of temporal discounting. Table 3 lists the pre-specified variables we use in our

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[5] These delay combinations are shared across all experiments; other delay combinations were used in some experiments (cf. Table 2), but because time horizon may affect parameter estimates, we focus on the delay combinations that were shared. Descriptions of the other temporal discounting tasks are available in the Online Appendix.

Table 2: Summary of Titration Data

	Time Horizon									**Amount**	
t_1,t_2	0,1	0,2	0,3	0,6	0,9	0,12	1,2	6,9	6,12	LL	SS
Δt	1	2	3	6	9	12	1	3	6		
TSST-G			**x**	**x**	x	**x**		x	**x**	200	100
CPT			**x**	**x**	x	**x**		x	**x**	200	100
CENT	x	x	**x**	**x**		**x**	x		**x**	1000	500

Notes: Overview of time horizons for titration data. The first row lists in months the front and back end delay, in months, for smaller, sooner and larger, later payment, respectively. The second row lists the number of months between the smaller, sooner and larger, later payment. "LL" and "SS" refer to the larger, later and initial smaller, sooner amount in Kenyan Shillings, respectively.

analysis. Variables were measured at three different levels of observation: “Patient” is measured at the decision level, the highest resolution with 20 observations per individual (5 titration decisions x 4 time horizons). “Indifference”, “Proportion”, “Discount Rate”, and “Delta” are measured at the time horizon level, with 4 observations per individual. “Decreasing Impatience”, “Departure from Stationarity”, and “AUC” are measured at the individual level, with a single observation per individual. Different econometric approaches for each level of observation are described in Section 4.

Table 3: List of Temporal Discounting Measures

Variable Name	Variable Description
Patient	Indicates whether the larger, later reward was selected (trial level)
Indifference	Calculated indifference point (time horizon level)
Proportion	Proportion of responses choosing larger, later amount (time horizon level)
Delta	Exponential decay (time horizon level)
Decreasing Impatience	Extent to which delta changes with time horizon (individual level)
Departure from Stationarity	Extent to which delta changes with front end-delay (individual level)
AUC	Area under the curve (individual level)

Notes: Overview of temporal discounting measures.

Patient: For each decision in each titration exercise, an individual could choose the larger, later reward or the smaller, sooner reward. This variable simply captures whether an individual opted for the more patient choice.

Indifference: We use the indifference points implied by the titration exercise. The indifference point is calculated as midpoint of the interval that the decisions of the participant identify as containing the true indifference point. It represents the subjective value of the larger, later reward at a later time-point, as seen from an earlier time-point.

Proportion: Similar to “patient”, this variable measures the proportion of choices of the large-late rather than the small-soon amount.

Delta: To calculate an exponential decay for each participant i and each delay combination($t_1 = 0, t_2 = 3$),($t_1 = 0, t_2 = 6$), ($t_1 = 0, t_2 = 12$), and ($t_1 = 6, t_2 = 12$) we write:

$$x_1 = exp(-\delta_{t_1,t_2} \frac{t_2 - t_1}{12}) x_2$$

This implies:

$$\delta_{t_1,t_2} = -\frac{12}{t_2 - t_1} ln \frac{x_1}{x_2}$$

Decreasing impatience: Given δ, we can compute an index for decreasing impatience as an average of two factors:

$$\Delta_{DI_{03}} = \delta_{0,3} - \delta_{0,6}$$

$$\Delta_{DI_{06}} = \delta_{0,6} - \delta_{0,12}$$

This captures the extent to which impatience decreases as delay increases in decisions between the present and a later time-point. A low index for decreasing impatience (> 0) implies that discount rates do not vary with time horizon; a large index implies that an individual's discount rate falls as delay increases.

Departures from stationarity: We also compute an index for departures from stationarity (Halevy, 2015):

$$\Delta_{DS_2} = \delta_{0,6} - \delta_{6,12}$$

Thus, departure from stationarity measures the extent to which δ changes with a front-end delay. This index can be thought of as a measure of "static reversals", i.e. the extent to which an individual changes their mind when front-end delays are added.

Area under the curve: For each participant, we calculate the area under the curve described by their indifference points. This is calculated by plotting indifference points without a front-end delay on the Y-axis, with the delay in months on the X-axis, and then calculating the area under the indifference points and above the X-axis with a trapezoidal formula. This results in an individual-level measure that incorporates indifference points from multiple horizons.

3.3 Sampling and Identification Strategy

Using the participant pool of the Busara Center for Behavioral Economics[6], we recruited 705 participants from Kibera, Viwandani and Kawangware, informal settlements in Nairobi, Kenya to participate in the study. Recruitment was restricted to males (to minimize fluctuations in cortisol levels) who had not previously attended a study which induced stress. No participant attended more than one experimental session. For each stressor, a participant was assigned to the stress condition or the control condition, never both. Experimental sessions took place between February

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[6] Haushofer et al. (2013a) provides an overview of the infrastructure and processes of the the laboratory, and detailed recruitment and study protocols.

2013 and October 2015. Table 4 provides and overview of the participant numbers in each of the three experiments.

Table 4: Summary of Experiments

	Stress	**Control**	**Total**	**Dates**	**Sessions**	**Session Size**
TSST-G	47	50	97	02/13 - 03/13	14	2-5 (s), 12-20 (c)
CPT	118	117	235	06/13-08/13	39	4-12 (s, c)
CENT Total	172	196	368	11/13-10/15	28	8-20 (s, c)
(Reverse)	(76)	(97)	(173)			
TOTAL	342	363	705		81	

Notes: Overview of three experiments. The first three colums display the sample sizes for the stress and control conditions, as well as the total. "Session size" refers to the range of the number of participants in each session for stress (s) and control (c) conditions. Randomization to the stress and control group was done at the session level for the TSST-G and CENT experiments, and at the individual level for the CPT.

3.4 Data Collection Methods and Instruments

Upon arriving at the Busara Center, participants waited in a room where they gave informed consent. After this participants entered the computer lab and sat at a computer that was randomly assigned to them. Generally the tasks within the experiment proceeded as follows. First, participants were given a set of examples to acquaint them with using touchscreen computers. Next, the first measurement of negative affect was taken, followed by "baseline" tasks to be used for controls in the analysis. After baseline tasks were complete, the participants underwent the stressor or control condition. The assignment was not known to participants *ex ante* and no reference was made to the idea that the task be deemed stressful. After the administration of the stressor, a midline questionnaire on affective state was administered. The primary tasks related to temporal discounting followed. Next, the endline affective state inventory was administered, followed by a demographic questionnaire. Finally, participants were made aware of the earnings from the experiment that they would be receiving later in the day via M-Pesa.

4 Data and Econometric Approach

In the following sections we outline the outcome variables of interest and the econometric specifications we will use to analyze the data. Critically, this paper assesses the effect of stress on decision-making for each experiment individually and jointly. For joint analysis, we combine the data from all three experiments, we refer to this as testing "across domains of stress". The econometric approach was pre-specified and registered prior to any analysis.

4.1 Manipulation Check

To test for the effectiveness of the stressors in changing our stress and affect outcomes, we analyze the effect of stress vs. control conditions, separately for the three experiments, on responses to our affective state inventory using the following linear model:

$$y_{is} = \alpha + \beta T_{is} + \sigma' \mathbf{X_{is}} + \omega y_{isB} + \varepsilon_{is} \tag{1}$$

Here, y_i is the outcome variable of interest for individual i in experiment s, T_i is a dummy for the stress treatment, $\mathbf{X}_i$ is a vector of control variables, and ε_i is the residual. Where possible, we condition on the baseline value of the outcome, y_{isB}, to improve power (McKenzie, 2012). Standard errors are clustered at the session level where the randomization was done at that level, and at the individual level otherwise.

4.1.1 Manipulation across domains of stress

To assess whether the effects of different stressors on stress and negative affect are different across stress induction methods, we conduct cross-experimental analyses, we examine the following linear model:

$$y_i = \alpha + \beta T_i + \gamma_1' \mathbf{S}_i + \gamma_2' T_i \mathbf{S}_i + \omega y_{iB} + \sigma' \mathbf{X}_i + \varepsilon_i \tag{2}$$

Here, y_i is the outcome variable of interest (stress or affective state, measured at the individual level) for individual i, T_i is a dummy for the acute-stress treatment, $\mathbf{S}_i$ is a vector of indicators whose elements take a value of 1 depending on the stress induction method, and $T_i\mathbf{S}_i$ is a vector of their interactions with T_i, $\mathbf{X_i}$ is a vector of control variables, and ε_{ik} is the residual. Where possible, we condition on the baseline value of the outcome y_{iB} to increase power. This model will be estimated using OLS with standard errors clustered at the session level.

To further improve power, we additionally estimate the following model, in which each item on the affective state inventory enters individually:

$$y_{ij} = \alpha + \beta T_i + \gamma_1' \mathbf{S}_i + \gamma_2' T_i \mathbf{S}_i + \gamma_3' \mathbf{J}_j + \omega y_{iB} + \sigma' \mathbf{X}_i + \varepsilon_{ij} \tag{3}$$

Here, y_i is the outcome variable of interest for individual i and item j, T_i is a dummy for the acute-stress treatment, $\mathbf{S}_i$ is a vector of indicators whose elements take a value of 1 depending on the stress induction method, $\mathbf{J}$ is a vector of indicators whose elements take a value of 1 depending on the item of the scale, $\mathbf{X}_i$ is a vector of control variables, and ε_{ij} is the residual. Again, where possible, we condition on the baseline value of the outcome y_{iB} to improve power.

4.2 Temporal Discounting

To test the effect of stress on temporal discounting, we estimate the following linear model:

$$y_i = \alpha + \beta T_i + \gamma_1' \mathbf{U}_i + \gamma_2' T_i \mathbf{U}_i + \sigma' \mathbf{X}_i + \varepsilon_i \tag{4}$$

Here, y_i is the outcome variable of interest for individual i, T_i is a dummy for the acute-stress treatment, $\mathbf{U}_i$ is a vector of indicators whose k-th element takes the value of 1 for a given delay combination, $\mathbf{X}_i$ is a vector of control variables, and ε_{ik} is the residual. This model is estimated using OLS with standard errors clustered at the level of randomization. We impose minimal *ex ante* structure on y_i by fully saturating the model with respect to all combinations of payoff and time horizons (Ifcher and Zarghamee, 2011).

In addition, we estimate the following model to analyze those outcome variables which are aggregated by time horizon:

$$y_i = \alpha + \beta T_i + \gamma_1' \mathbf{U}_i + \gamma_2' T_i \mathbf{U}_i + \sigma' \mathbf{X}_i + \varepsilon_i \tag{5}$$

This model will be estimated using OLS with standard errors clustered at the session level.

Finally, for outcomes that are estimated at the individual level, we use the following specification:

$$y_i = \alpha + \beta_1 T_i + \omega y_{iB} + \sigma' \mathbf{X}_i + \varepsilon_{ik} \tag{6}$$

Here, y_i is the outcome variable of interest for individual i, T_i is a dummy for the acute-stress treatment, $\mathbf{X_i}$ is a vector of control variables, and ε_{ik} is the residual. Where possible, we condition on the baseline value of the outcome y_{iB} to increase power. This model will be estimated using OLS, as pre specified.

4.2.1 Temporal discounting across domains of stress

We are interested in examining how the effect of stress on temporal discounting might vary depending on the nature of the stressor. We might expect, for instance, that the impact of social stress is different from the impact of physical stress. To this end, we compare treatment effects across stress induction methods using the following linear model:

$$\begin{aligned} y_i = {} & \alpha + \beta T_i \\ & + \gamma_1' \mathbf{U}_i + \gamma_2' T_i \mathbf{U}_i \\ & + \theta_1' \mathbf{S}_i + \theta_2' T_i \mathbf{S}_i + \theta_3' \mathbf{V}_i \\ & + \sigma' \mathbf{X}_i + \varepsilon_i \end{aligned} \tag{7}$$

Here, y_{ik} is the outcome variable of interest for individual i and temporal discounting delay combination k, T_i is a dummy for the acute-stress treatment, $\mathbf{S}_i$ is a vector of indicators whose elements take a value of 1 depending on the stress induction method, $\mathbf{U}_i$ is a vector of indicators whose k-th element takes the value of 1 for a given delay combination, $\mathbf{X_i}$ is a vector of control variables, and ε_{ik} is the residual. $\mathbf{V}_i$ is a 16×1 vector of all possible interactions between the elements of $\mathbf{U}_i$ and $\mathbf{S}_i$. This model will be estimated using OLS with standard errors clustered at the session level.

We estimate the following model to analyze those outcome variables which are aggregated by time horizon:

$$y_i = \alpha + \beta T_i + \gamma_1' \mathbf{U}_i + \gamma_2' T_i \mathbf{U}_i + \theta_1' \mathbf{S}_i + \theta_2' T_i \mathbf{S}_i + \theta_4' \mathbf{V}_i + \sigma' \mathbf{X}_i + \varepsilon_i \tag{8}$$

This model will be estimated using OLS with standard errors clustered at the session level.

Finally, for outcomes that are estimated at the individual level, we use the following specification for analysis:

$$y_i = \alpha + \beta_1 T_i + \beta_2' \mathbf{S}_i + \beta_3' T_i \mathbf{S}_i + \omega y_{iB} + \sigma' \mathbf{X}_i + \varepsilon_{ik} \tag{9}$$

Here, y_i is the outcome variable of interest for individual i, T_i is a dummy for the acute-stress treatment, $\mathbf{S}_i$ is a vector of indicators whose elements take a value of 1 depending on the stress induction method, and $T_i\mathbf{S}_i$ is a vector of their interactions with T_i, $\mathbf{X_i}$ is a vector of control variables, and ε_{ik} is the residual. Where possible, we condition on the baseline value of the outcome y_{iB} to increase power. This model will be estimated using OLS with standard errors clustered at the level of randomization.

4.3 Control Variables

The preferred econometric specification that we will present in this paper includes a number of control variables. The control variables we will focus on are the following:

Table 5: List of Demographic Control Data

Variable Name	Variable Description
Education	Highest level of education attained
Age	Age in years
Children	Number of children
Income	Self reported monthly income
Disposable Income	Self reported monthly disposable income
Debt	Binary debt status (self-reported)
Unemployed	1 if unemployed

5 Results

5.1 Balance

Table 6 shows baseline characteristics for demographic variables and the baseline affective state inventory. Randomization was successful in balancing baseline affect; there are no significant differences in any of the experiments between treatment and control groups on baseline measures of frustration, stress, pain, and negative affect. Unexpectedly, we observe significant differences between treatment and control individuals in the Cold Pressor experiment in age, marital status, and number of children. However, our pre-specified preferred analysis includes control variables for these outcomes; we thus proceed following the pre-analysis plan, and include all possible control variables.

Table 6: Summary statistics – Baseline demographics

	TSST-G		CPT		CENT		Overall	
	Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.
	SD	N	SD	N	SD	N	SD	N
Age	30.32	1.47	31.10	-3.51***	30.15	0.02	30.47	-0.74
	(10.24)	159	(11.04)	235	(10.57)	348	(10.64)	742
Married or co-habitating	0.39	0.04	0.50	-0.19***	0.40	0.06	0.43	-0.03
	(0.49)	164	(0.50)	235	(0.49)	348	(0.50)	747
Children	1.18	0.18	1.52	-0.62***	1.28	-0.10	1.33	-0.20
	(1.74)	164	(2.01)	235	(1.99)	348	(1.95)	747
School	1.00	0.00***	0.88	0.06	0.95	-0.00	0.94	0.02
	(0.00)	164	(0.33)	235	(0.21)	348	(0.24)	747
Unemployed	0.20	0.01	0.34	0.07	0.29	0.03	0.29	0.04
	(0.40)	164	(0.48)	235	(0.46)	348	(0.45)	747
Frustration					27.83	2.36	27.83	2.36
					(31.08)	336	(31.08)	336
Stress	40.84	-7.65	30.57	5.66	27.91	-4.56	30.55	-0.70
	(34.52)	97	(30.03)	235	(30.54)	336	(31.16)	668
Pain			13.71	1.11			13.71	1.11
			(24.82)	235			(24.82)	235
Negative affect (std.)	0.20	-0.27	-0.00	0.17	-0.05	-0.08	0.00	-0.01
	(1.11)	97	(0.96)	235	(0.99)	336	(1.00)	668
Pre-titration endowment	6.72	0.11	4.38	-0.29*	8.82	-3.00***	7.16	-1.86***
	(1.00)	67	(1.25)	227	(2.38)	336	(2.86)	630

Notes: This table presents control group means by experiment with SD in parentheses. The second subcolumns report the difference of means between the treatment and control with N on the second line. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct. for a difference of means t-test.

5.2 Effect of Stress Induction on Stress and Affect

5.2.1 Experiment-by-experiment treatment effects

Table 7 summarizes the treatment effect of the stressors on affective state variables, separately for the individual stressors. Column headers denote the stressor type (TSST-G, CPT, CENT), while rows correspond to individual outcome variables. Each cell in the table represents the treatment effect of a particular stressor on a particular outcome, using separate regressions for each cell. Because each of the variables are standardized to their respective control group means, the coefficients can be interpreted as the difference in standard deviations from the control group mean.

Surprisingly, the TSST-G stressor does not significantly affect any of our stress and affect variables, and the p-value for the joint significance across all variables is 0.18. In contrast, the CPT significantly increased self-reported stress (1.80 SD, $p < 0.01$), but this effect was observed only *during* stress, and dissipated quickly and became insignificant at endline (0.19 SD). Similarly, there was no significant effect of the CPT on negative affect (0.09 SD) at endline (this variable was not measured at midline). Finally, we find large and highly significant treatment effects of the Centipede Game on both self-reported stress (0.52 SD at midline, 0.51 SD at endline) and negative affect (0.45 SD at midline, 0.66 SD at endline), all significant at the 0.01 level. Thus, the CPT induces a strong stress response that dissipates over time, while the Centipede Game induces a milder, but longer-lasting affective response. In contrast to many experiments run in Western settings, the TSST-G failed to induce any changes in negative affect or stress.

5.2.2 Treatment effect across the domains of stress

Table 8 shows the results of the pooled analysis, which combines all data available from the three experiments using equations 2-3. This set of specifications allows us to test whether the treatment effect differs by stress induction method. Column 4 displays the effect of each stressor on midline stress levels. We see from the estimate on the interaction terms that the effect of the Cold Pressor and Centipede Game on midline stress levels relative to the effect of TSST-G are significant at the 1% level. Furthermore, we see that there is a significant difference in effect between these the Cold Pressor and the Centipede Game ($p < 0.01$), evidence that the Cold Pressor induces a stronger stress response at midline compared to the Centipede Game. Columns 5 and 6 are our preferred specifications for comparing affect across the domains of stress. Here, we take the unit of observation to be each available individual response to an affect question, with associated controls for the exact affective item (Hostile, Upset, Irritated, etc). This specification allows us to use all possible data across experiments. Column 6 shows midline results. Note here, that there are no midline observations for the CPT experiment (as we only measured negative affect at endline). We fail to see any significant effect of the TSST-G stressor on negative affect, but the direction of the estimate suggests that the stressor may *reduce* negative affect (-0.036 SD). Like our results in Table 7, an F-test on the treatment effect in the CPT experiment reports a significant positive effect on endline stress at the 1% level. Moreover, the estimate on the interaction term is significant at the 1% level, indicating a differential effect negative affect induced by the Centipede Game versus the TSST-G. Column 5 shows a similar story, this time comparing the CPT to the Centipede Game. Although we fail to find evidence that the Cold Pressor induces negative affect at endline, the Centipede Game significantly increases negative affect against its control condition and that the effect is significantly higher than that of the CPT ($p < 0.1$). Columns 4 and 5 show qualitatively

Table 7: Domain-specific treatment effects – Stress and negative affect

	TSST-G		CPT		CENT	
	Effect	N	Effect	N	Effect	N
Negative affect (std.) (endline)			0.09 (0.12)	235	0.66*** (0.15)	348
Negative affect (std.) (midline)	0.16 (0.29)	97			0.45*** (0.13)	336
Std. stress (endline)			0.19 (0.13)	235	0.51*** (0.10)	348
Std. stress (midline)	-0.26 (0.16)	97	1.80*** (0.21)	235	0.52*** (0.12)	336
Std. NAS item (endline)			0.02 (0.09)	2350	0.53*** (0.12)	3480
Std. NAS item (midline)	0.14 (0.13)	970			0.68*** (0.17)	1008
Joint p-value	0.18		0.00***		0.00***	

Notes: This table summarizes the treatment effect of stressors on self-reported stress and negative affect by experiment. Each cell reports the estimate and standard error from a regression of the row variable on the treatment. The second subcolumns report number of observations of each regression. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct.

similar results, this time aggregating negative affect to the individual level. In general, we see that the Centipede Game consistently increases stress and negative affect, and that the effect is significantly different than the estimates from TSST-G and CPT.

5.3 Effect of Stress Induction on Temporal Discounting

5.3.1 Experiment-by-experiment treatment effects

We now investigate the effect of the three stressors on temporal discounting. Table 9 shows the results of the experiment-by-experiment analysis. Each cell shows the effect of one type of stressor (relative control) on an outcome variable. First, we observe a large effect of the TSST-G on temporal discounting. Despite evidence that the stressor failed to induce stress or negative affect, participants

Table 8: Treatment effects – Stress and negative affect

	(1) Affect	(2) Affect	(3) Stress	(4) Stress	(5) Affect	(6) Affect
Treatment	0.060	0.073	0.120	-0.376	0.036	-0.036
	(0.109)	(0.117)	(0.112)	(0.310)	(0.089)	(0.178)
CPT	0.000		0.000	-0.600***	0.000	
	(.)		(.)	(0.207)	(.)	
CENT	-0.075	0.058	-0.031	-0.384**	-0.090	-0.273
	(0.094)	(0.124)	(0.097)	(0.189)	(0.085)	(0.165)
Treatment × CPT	0.000		0.000	1.656***	0.000	
	(.)		(.)	(0.358)	(.)	
Treatment × CENT	0.602***	0.482**	0.387**	0.881**	0.459***	0.684***
	(0.171)	(0.179)	(0.150)	(0.335)	(0.141)	(0.235)
Observations	583	433	583	668	5830	1978
Unit	Individual	Individual	Individual	Individual	Item	Item
Phase	Endline	Midline	Endline	Midline	Endline	Midline
Adjusted R^2	.41	.2	.37	.4	.24	.26
CPT p-value				0		
CENT p-value	0	0	0	0	0	0
CPT v. CENT p-value				0		

Notes: This table reports the coefficient estimates of the interaction between the treatment and experiment group. Standard errors are in parentheses. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct. level. We report the CPT and CENT p-values from an F-test of the treatment effect restricted to each experiment. We also report the p-value of an F-test comparing the treatment effect in CPT against the effect in CENT.

assigned to the TSST-G treatment condition are significantly more patient than those in the control condition: five of the six measures of temporal discounting show a significant effect in this direction. Specifically, the stress group in the TSST-G is 15 percentage points more likely to make patient choices; their indifference points are on average USD 0.5 higher than those of the control group; their yearly discount rate is 10 percentage points lower; their area under the curve is 0.4 units larger; and the difference between short-run and long-run discount rates (decreasing impatience) is 0.06 percentage points. We conduct an F-test across models using the method of seemingly unrelated regressions and find the treatment effect on all temporal discounting variables to be significant at the 1% level. Thus, our social stressor significantly reduces temporal discounting. The effect is driven both by changes in patience (exponential discounting) and decreasing impatience ("present bias").

The CPT shows limited evidence of a stress effect on temporal discounting; the overall joint p-value is insignificant and most of the estimates are close to zero. This finding may be due to the fact that the paradigm only affects our manipulation checks temporarily; recall that the increase in negative affect we observe during immersion completely disappears after immersion and hence during the temporal discounting task.

We finally turn our attention to the CENT Game. Recall that this stressor showed the most reliable increases in both stress and negative affect, with large and significant changes at midline and endline. We find that temporal discounting as also strongly affected, with participants in the treatment condition being less patient than those in the control condition. Specifically, they are 6 percentage points less likely to choose the "patient" option, have indifference points that are on average USD 1.67 lower; and an area under the curve lower by 1.59 units. Interestingly, the effect appears to be driven not by changes in the exponential discount rate or decreasing impatience, but by departures from stationarity. Recall that decreasing impatience measures how discount rates vary with time horizon in decisions between the present and the future (e.g. 0–6 months vs. 0–12 months), while departures from stationarity measure how discount rates change as front-end delays are added to decisions between two options with a fixed time difference (e.g. 0–6 months vs. 6–12 months). The CENT game appears to increase departures from stationarity specifically.

Table 10 clarifies how the stressors affect temporal discounting at each time horizon. In the TSST-G, all time horizons appear similarly affected by the manipulation, with the largest effects for decisions between "today vs. 6 months". The Centipede Game significantly increases temporal discounting for decisions between "today vs. 3 months", "today vs. 6 months", and "today vs. 12 months", while there are no significant differences between treatment and control for "6 months vs. 12 months". This finding mirrors with the departure from stationarity result discussed above, which implies that participants in the stress condition make more impatient choices over a 6 month delay, but only when that delay begins immediately.

5.3.2 Treatment effect across the domains of stress

Finally, we pool all data to compare results across experiments using equations 7-9. Results are reported in Table 11. .

The "Treatment" row reports the effect of the TSST-G stressor on the temporal discounting outcomes. The "CPT p-value" row and "CENT p-value" row report the effects of the CPT and Centipede stressor on temporal discounting outcomes, respectively. Importantly, this framework allows us to directly compare the treatment effects across experiments. The "Treatment X CPT" and "Treatment X CENT" rows report the treatment effects of the CPT and CENT experiments against that of the TSST treatment effect. And the "CPT vs. CENT p-value" report whether the treatment effect of those stressors are different from one another. In other words, these three rows allow us to ask whether a given stressor has a significantly smaller or larger effect on discounting than another. Column 1 reports that the stress effect on patient responses in the Centipede Game is significantly different than that of the TSST-G ($p \leq 0.01$), but not significantly different from

Table 9: Domain-specific treatment effects – Temporal discounting

	TSST-G		CPT		CENT	
	Effect	N	Effect	N	Effect	N
Patient choice	0.15^{***}	1940	-0.02	4700	-0.06^{**}	6960
	(0.04)		(0.04)		(0.03)	
Indiff. point	0.53^{**}	388	0.01	940	-1.67^{**}	1392
	(0.20)		(0.18)		(0.72)	
Exponential decay	-0.10^{**}	388	0.02	940	0.04	1392
	(0.04)		(0.03)		(0.02)	
Area under the curve	0.37^{**}	97	0.10	235	-1.59^{**}	348
	(0.17)		(0.15)		(0.58)	
Decreasing impatience	0.06	97	-0.04	235	-0.03	348
	(0.04)		(0.03)		(0.03)	
Dept. from stationarity	-0.00	97	0.03^{*}	235	-0.05^{***}	348
	(0.03)		(0.02)		(0.01)	
Joint p-value	0.00^{***}		0.38		0.00^{***}	

Notes: This table summarizes the treatment effect of stressors on temporal discounting by experiment. Each cell reports the estimate and standard error from a regression of the row variable on the treatment. The second subcolumns report number of observations of each regression. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct.

that of the CPT ($p = 0.33$). We also see that the effect on the TSST-G for patient response is significantly different than the effect on the CPT ($p \leq 0.10$). Results for exponential decay are largely similar. In general, we see that the treatment effects on the Centipede Game is statistically different than that of the TSST-G. The centipede and CPT treatment effects are more similar, in some cases (e.g. patient response and exponential decay) the treatment effect of the Centipede Game is significant on its own, but not significantly different from the treatment effect generated by the CPT.

Table 10: Treatment effects on temporal discounting by time horizon

	0 mo. – 3 mo.	0 mo. – 6 mo.	0 mo. – 12 mo.	6 mo. – 12 mo.	N	Joint p-value
TSST-G						
Patient choice	0.10^{*}	0.26^{***}	0.15^{**}	0.09^{*}	485	0.00^{***}
	(0.05)	(0.05)	(0.06)	(0.05)		
Indiff. point	0.44	0.72^{**}	0.19	0.75^{**}	97	0.00^{***}
	(0.30)	(0.28)	(0.33)	(0.27)		
Exponential decay	-0.16	-0.14^{***}	-0.05^{*}	-0.06^{**}	97	0.00^{***}
	(0.10)	(0.04)	(0.03)	(0.02)		
Area under the curve	0.37^{**}	0.37^{**}	0.37^{**}	0.37^{**}	97	0.02^{**}
	(0.17)	(0.17)	(0.17)	(0.17)		
Dept. from stationarity	-0.00	-0.00	-0.00	-0.00	97	0.97
	(0.03)	(0.03)	(0.03)	(0.03)		
Decreasing impatience	0.06	0.06	0.06	0.06	97	0.18
	(0.04)	(0.04)	(0.04)	(0.04)		
CPT						
Patient choice	-0.03	-0.01	0.01	-0.03	1175	0.82
	(0.04)	(0.04)	(0.05)	(0.05)		
Indiff. point	-0.11	0.17	0.21	-0.23	235	0.38
	(0.22)	(0.22)	(0.25)	(0.23)		
Exponential decay	0.08	-0.01	-0.01	0.03	235	0.24
	(0.06)	(0.03)	(0.02)	(0.02)		
Area under the curve	0.10	0.10	0.10	0.10	235	0.49
	(0.15)	(0.15)	(0.15)	(0.15)		
Dept. from stationarity	0.03^{*}	0.03^{*}	0.03^{*}	0.03^{*}	235	0.07^{*}
	(0.02)	(0.02)	(0.02)	(0.02)		
Decreasing impatience	-0.04	-0.04	-0.04	-0.04	235	0.11
	(0.03)	(0.03)	(0.03)	(0.03)		
CENT						
Patient choice	-0.08^{*}	-0.07^{**}	-0.09^{**}	0.01	1740	0.01^{**}
	(0.04)	(0.03)	(0.03)	(0.03)		
Indiff. point	-2.14^{**}	-1.90^{**}	-2.44^{**}	-0.19	348	0.00^{***}
	(0.78)	(0.87)	(0.89)	(0.78)		
Exponential decay	0.09	0.04	0.03^{**}	-0.01	348	0.00^{***}
	(0.06)	(0.02)	(0.01)	(0.01)		
Area under the curve	-1.59^{**}	-1.59^{**}	-1.59^{**}	-1.59^{**}	348	0.01^{***}
	(0.58)	(0.58)	(0.58)	(0.58)		
Dept. from stationarity	-0.05^{***}	-0.05^{***}	-0.05^{***}	-0.05^{***}	348	0.00^{***}
	(0.01)	(0.01)	(0.01)	(0.01)		
Decreasing impatience	-0.03	-0.03	-0.03	-0.03	348	0.26
	(0.03)	(0.03)	(0.03)	(0.03)		

Notes: This table summarizes the treatment effect of stressors on temporal discounting by experiment and by time horizon. Each cell reports the estimate and standard error from a regression of the row variable on the treatment conditional on the time horizon indicated by the column. The last two columns report the number of observations of each regression and a joint test across of the treatment effect across time horizons. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct.

Table 11: Treatment effects – Temporal discounting

	(1) Patient choice	(2) Indifference point	(3) Exponential decay	(4) AUC	(5) Dept. from stationarity	(6) Decr. impatience
Treatment	0.095^{*}	0.142	-0.069^{*}	-0.008	0.058	-0.026
	(0.051)	(0.324)	(0.040)	(0.284)	(0.036)	(0.020)
CPT	-0.016	0.197	0.044	0.034	-0.064	-0.039
	(0.048)	(0.344)	(0.039)	(0.307)	(0.046)	(0.034)
CENT	0.027	6.892^{***}	0.022	4.547^{***}	-0.041	-0.013
	(0.047)	(0.766)	(0.038)	(0.618)	(0.046)	(0.031)
Treatment ×	-0.111^{*}	-0.264	0.089^{*}	-0.024	-0.091^{**}	0.051^{*}
CPT	(0.062)	(0.423)	(0.047)	(0.353)	(0.045)	(0.026)
Treatment ×	-0.154^{***}	-1.857^{**}	0.110^{**}	-1.588^{**}	-0.090^{**}	-0.023
CENT	(0.056)	(0.722)	(0.044)	(0.605)	(0.044)	(0.024)
Unit	Item	Delay	Delay	Individual	Individual	Individual
Adjusted R^2	.03	.23	.36	.18	.01	.05
CPT p-value	.64	.64	.44	.88	.24	.15
CENT p-value	.02	.02	.07	.01	.2	0
CPT vs. CENT p-value	.33	.04	.55	.01	.99	0
N	13600	2720	2720	680	680	680

Notes: This table reports the coefficient estimates of the interaction between the treatment and experiment group. Standard errors are in parentheses. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct. level. We report the CPT and CENT p-values from an F-test of the treatment effect exclusive to each experiment. We also report the p-value of an F-test comparing the treatment effect in CPT against the effect in CENT.

5.4 Robustness

We find that the three stressors induce differential stress responses and, concomitantly, differential effects on temporal discounting. One potential concern is that this result might be caused by an imbalance in the sample sizes, and thus power, across experiments. A first piece of evidence against this possibility is the fact that the TSST-G, despite its relatively smaller sample size and lack of induced stress response, in fact produced significant effects on temporal discounting; a simple story in which only stressors that in fact increase stress or negative affect have an impact on temporal discounting can therefore not account for the pattern of results. However, we nevertheless conduct a simple exercise to "control" for the different sample sizes across experiments. In this exercise, we artificially *increase* the sample sizes of the TSST-G and CPT experiments to that of the CENT ($N = 348$), and artificially *decrease* the sample sizes of the CENT to that of the TSST-G ($N = 97$). This procedure increases or decreases the standard error of the estimates and allows us to ask what the results would have been if the sample sizes in the TSST-G and CPT been larger, or that of the CENT had been smaller.

Table 12 shows the results on negative affect and stress, with the normally estimated standard errors in parentheses and adjusted standard errors in brackets. For the TSST-G, we observe that the impact of the stressor on negative affect does not change when we introduce the hypothetical increase in power; in contrast, the effect on stress becomes significant at the 5 percent level. Recall that the direction of this estimate means that the TSST-G *reduces* self-reported stress. The effects of the CENT treatment on negative affect and stress remain significant when the sample size is reduced to that of the TSST-G, often at the 1 percent level, suggesting that the results are robust to sample size.

Finally, Table 13 presents the results of repeating the same exercise for the temporal discounting outcomes. Quite naturally, the TSST-G results, most of which were significant to begin with, become more significant with the increase in power. The CPT benefits somewhat from the modest increase in hypothetical power, with the indices for decreasing impatience and the departure from stationarity becoming significant at the 1 percent level; however, because the effects are in different directions, this still does not amount to a convincing effect of the CPT on temporal discounting. Finally, for the CENT game, all treatment effects except the departure from stationarity index become insignificant after a simulated decrease in power, suggesting that the effects of this stress induction method on discounting may be noisier than those of the TSST-G, which are significant even with the smaller sample size.

Together, these results suggest that the different sample sizes across studies did not significantly alter the results: the TSST-G produces a robust effect on discounting even with the small sample size; the CENT game also produces a robust effect but requires a large sample size (which we have); and the CPT produces no consistent effect on discounting regardless of sample size.

Table 12: Domain-specific treatment effects – Stress and negative affect (Robustness)

	TSST-G		CPT		CENT	
	Effect	N	Effect	N	Effect	N
Negative affect (std.) (endline)			0.09 (0.12) [0.10]	235	0.66^{***} (0.15) $[0.21]^{***}$	348
Negative affect (std.) (midline)	0.16 (0.29) [0.16]	97			0.45^{***} (0.13) $[0.19]^{**}$	336
Std. stress (endline)			0.19 (0.13) $[0.10]^{*}$	235	0.51^{***} (0.10) $[0.15]^{***}$	348
Std. stress (midline)	-0.26 (0.16) $[0.09]^{**}$	97	1.80^{***} (0.21) $[0.18]^{***}$	235	0.52^{***} (0.12) $[0.17]^{***}$	336
Std. NAS item (endline)			0.02 (0.09) [0.03]	2350	0.53^{***} (0.12) $[0.05]^{***}$	3480
Std. NAS item (midline)	0.14 (0.13) [0.08]	970			0.68^{***} (0.17) $[0.07]^{***}$	1008
Joint p-value	0.18		0.00^{***}		0.00^{***}	

Notes: This table summarizes the treatment effect of stressors on self-reported stress and negative affect by experiment. Each cell reports the estimate and standard error from a regression of the row variable on the treatment. The second subcolumns report number of observations of each regression. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct. The number in the parentheses represents the actual standard error while the bracketed number represents the artificially inflated or defalated standard error.

6 Conclusion

There exists a growing literature on the effects of stress on temporal discounting, but previous studies have reported inconsistent effects, with some finding no effects (Haushofer et al., 2013b) and others finding increases in discounting under stress Delaney et al. (2014); Cornelisse et al. (2013). In this paper, we attempt to resolve this contradictory pattern of evidence by asking whether different types

Table 13: Domain-specific treatment effects – Temporal discounting (Robustness)

	TSST-G		CPT		CENT	
	Effect	N	Effect	N	Effect	N
Patient choice	0.15^{***} (0.04) $[0.02]^{***}$	1940	-0.02 (0.04) [0.03]	4700	-0.06^{**} (0.03) [0.05]	6960
Indiff. point	0.53^{**} (0.20) $[0.11]^{***}$	388	0.01 (0.18) [0.15]	940	-1.67^{**} (0.72) [1.36]	1392
Exponential decay	-0.10^{**} (0.04) $[0.02]^{***}$	388	0.02 (0.03) [0.02]	940	0.04 (0.02) [0.04]	1392
Geometric disc.	-1.83e+05 (466585.39) [246335.71]	388	452160.42^{**} (216323.59) $[177765.79]^{**}$	940	86264.76 (265523.51) [502929.06]	1392
Area under the curve	0.37^{**} (0.17) $[0.09]^{***}$	97	0.10 (0.15) [0.12]	235	-1.59^{**} (0.58) [1.09]	348
Decreasing impatience	0.06 (0.04) $[0.02]^{**}$	97	-0.04 (0.03) $[0.02]^{*}$	235	-0.03 (0.03) [0.05]	348
Dept. from stationarity	-0.00 (0.03) [0.01]	97	0.03^{*} (0.02) $[0.02]^{**}$	235	-0.05^{***} (0.01) $[0.02]^{**}$	348
Joint p-value	0.00^{***}		0.41		0.00^{***}	

Notes: This table summarizes the treatment effect of stressors on temporal discounting by experiment. Each cell reports the estimate and standard error from a regression of the row variable on the treatment. The second subcolumns report number of observations of each regression. * denotes significance at 10 pct., ** at 5 pct., and *** at 1 pct. The number in the parentheses represents the actual standard error while the bracketed number represents the artificially inflated or defalated standard error.

of stressors differentially affect temporal discounting. We use a physical (Cold Pressor Task), social (Trier Social Stress Test), and financial stressor (Centipede Game) to assess how these stressors affect both temporal discounting and self-reported stress and affect. Our study is conducted with residents of informal settlements in Nairobi, Kenya, increasing external validity and contributing to moving behavioral economics away from student participant pools.

We find that the physical stressor (CPT) induces a strong but quickly dissipating increase in stress, while the financial stressor produces a milder but longer-lasting increase in negative affect. Surprisingly, the TSST-G does not affect stress or affect, contradicting previous evidence establishing it as an effective stress induction protocol. In fact, we find evidence that the TSST-G *reduced* stress in our sample, a result possibly explained by the difference in social context and in particular different attitudes towards public speaking in Kenya.

The differential effects of the manipulations on stress and affect are reflected in their effects on temporal discounting. We find strong evidence that the financial stressor increases temporal discounting. In contrast, the stress induction of the CPT, which is strong while it lasts but has reverted to baseline by the time participants perform the temporal discounting task, has no robust effects on temporal discounting. The social stressor *reduces* temporal discounting, in line with its negative effects on stress.

Thus, our finding suggest that the domain in which stress is induced matters only inasmuch as different stress induction protocols may have different effects on stress, and these effects may differ across settings: in Western settings, the TSST-G produces robust increases in stress, while in our setting it produces a decrease. In contrast, CENT game increased stress as expected, as did the CPT, but only temporarily. Together, these findings are consistent with a unitary effect of stress on discounting: it appears that increased stress increases discounting, and decreased stress decreases it, regardless of how the stress was induced.

Our evidence demonstrates the importance of context in studies of stress and economic choice, and the usefulness of going beyond "WEIRD" samples to study non-standard populations. It further highlights the importance of manipulation checks in assessing whether stress induction protocols work as intended for different populations. Future work might test systematically which stressors work in which contexts, and which other economic behaviors are affected by stress.

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