Effects of Stress on Economic Choice*

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Abstract

We implement a randomized laboratory experiment examining the effects of stress, induced using four methods, on temporal discounting, self-efficacy, and executive control. Our study includes 1141 subjects from the informal settlements in Nairobi, Kenya. Respondents are randomly administered either a control or a treatment (stress) protocol for seven consecutive days. We measure outcomes related to economic decision-making on day 1 and 7, resulting in 2155 subject-day observations. This allows us to estimate the causal impacts of stress on

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decision-making after one and seven days of administration. We find that the stressors do not have statistically significant effects on the behavioral measures of temporal discounting, self-efficacy and executive control. The findings may be the result of the fact that we study the effects of stress with a population that faces substantial chronic stress in their day-to-day lives.
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1. Introduction

Stress is thought to have pervasive effects on a host of physiological and psychological outcomes, but its impacts on economic choice remain incompletely understood. In particular, we identify three gaps in our understanding. First, existing studies of the effect of stress on economic choice have produced conflicting results, e.g. on time preferences (Koppel et al. 2017; Riis-Vestergaard et al. 2018; Haushofer, Jang, and Lynham 2015; Delaney, Fink, and Harmon 2014; Haushofer et al. 2013), risk preferences Kandasamy et al. (2014, Cahlíková and Cingl (2017, Porcelli and Delgado (2009, Koppel et al. (2017, Delaney, Fink, and Harmon (2014), and competitiveness (Cahlikova, Cingl, and Levely 2017; Buser, Dreber, and Mollerstrom 2017). These differences may partly be explained by differential effects of different stress induction methods (Haushofer, Jang, and Lynham 2015). Second, previous work has usually studied a small nunber of outcome variables, increasing the difficulty of comparing across studies. Finally, the relative effects of acute and chronic stress on economic outcomes are incompletely understood. The stress literature has long distinguished between these two types of stress (McEwen and Sapolsky 1995), but existing studies do not differentiate between them, which is especially relevant given the pervasiveness of chronic stress. An exception is Kandasamy et al. (2014), who found that risk aversion is increased by chronic but not acute stress. However, little is known about the relative effects of acute and chronic stress on other outcomes.[1]

The present study attempts to address these three related concerns by studying the effect of both acute and chronic stress, induced through four separate induction methods, on a broad range of economic behaviors. We

[1] We hasten to add that we cannot hope to mimic the effects of truly chronic stress (over years) with this manipulation; however, it has been shown that the effects of stress differ, both behaviorally and neurobiologically, even over short periods such as several hours (Joëls, Fernandez, and Roozendaal 2011; Henckens et al. 2010; Henckens et al. 2011) or weeks (Kandasamy et al. 2014).

assigned a sample of 1141 participants from Nairobi's informal settlements into one of four stressors or a corresponding control condition. This feature allows us to compare the effects of different stress induction methods on behavior within the same study. The stressors spanned a broad range of domains: we included a social stressor, the Trier Social Stress Test, which consists of a mock job interview and mental arithmetic; a physical stressor, the Cold Pressor Task, which consists of holding one's hand in cold water; an economic stressor, which consists of playing a "centipede" game for money with others in which it is difficult to win; and a neurobiological stressor, hydrocortisone administration, whcih mimics the biological effects of stress.

Importantly, each stressor was administered for seven consecutive days, and behavioral measures were taken on the first and last day, enabling us to distinguish the effects of acute and chronic stress.

Finally, we measured a broad range of behavioral outcomes. In particular, we endeavored to cover the basic motives for behavior in economics, i.e. preferences and beliefs, and in addition cognitive constraints on economic behavior. In the domain of prefrences, we study time and risk preferences. For beliefs, we focus on subjective beliefs about participant's ability to achieve their goals. In the psychology literature, this motive is known as "self-efficacy". It is closely related to stress through its intimate relationship with depression, and is therefore plausibly affected by stress. We operationalize self-efficacy in terms of participants' beliefs about their ability to perform an effort task. Finally, to study cognitive costriants on economic behavior, we focus on executive control. Executive control refers to the ability for individual to inhibit responses and make and execute high-level plans. We measure the inhibition aspect of executive control through participants' ability to perform a Stroop task.

We find that stress largely has no consistent effects on temporal discounting, self-efficacy, and executive control. We find consistent evidence across the different stress induction protocols that stress does not affect executive control. We find suggestive evidence that the stress induction methods have differing effects on temporal discounting; in particular, the Cold Pressor Task may decrease present bias. In contrast, the other stressors have no effects on discounting. Finally, we find that that hydrocortisone may increase self-efficacy; the other induction methods suggest that there is no effect. We also find that different stress induction protocols have different effects on stress. Specifically, only treatment in the TSST study successfully increases self-report stress, and salivary cortisol, a stress hormone, is only higher for treated participants in the Hydrocortisone study. Thus, we find limited evidence for an effect of stress on preferences, beliefs, and cognitive constraints.

This study contributes to a growing literature in economics and psychology studying the effects of stress on economic choice. First, a number of studies have previously tested the effect of stress on temporal discounting, finding inconclusive results: Koppel et al. (2017) find increases in discounting after inducing physical stress in the form of thermal pain; Riis-Vestergaard et al. (2018) after hydrocortisione administration; and (Delaney, Fink, and Harmon 2014) find increases in temporal discounting after exposure to the "cold pressor task", a physical stressor consisting of holding one's hand in cold water. In contrast, we have previously found no effects of the cold pressor task and a social stressor, the Trier Social Stress Test, on temporal discounting (Haushofer et al. 2013; Haushofer, Jang, and Lynham 2015). To our knowledge, the effects of stress on self-efficacy have not been extensively studied in the economics literature, but a small number of papers assess the effect of stress on performance in real effort tasks such as the one we use here (Cahlikova, Cingl, and Levely 2017; Buser, Dreber, and Mollerstrom 2017). While they largely find little impact on performance, they do find effects on willingness to compete. Our interest in beliefs about one's ability to perform the task can potentially provide a mechanistic explanation for these impacts. Finally, and perhaps surprisingly, the study of the effects of stress on executive function in humans is still in its infancy. Preliminary evidence suggests negative treatment effects (Starcke et al. 2016), but the evidence is not conclusive, and the comparison of different stressors and acute vs. chronic stress has not been undertaken. More broadly, our study contributes to the literature studying the effects of emotion on decision-making (e.g. see Lerner, Li, and Weber 2013.

The remainder of the paper is structured as followed. Section 2 describes the design, and Section 3 presents the econometric approach. Section 4 presents results, and Section 5 concludes.

2. Design

2.1 Sampling strategy

We study a sample of Nairobi residents registered as subjects with the Busara Center for Behavioral Economics. Busara's participant pool is broadly representative of Nairobi and Kenya (Haushofer et al. 2014). To be registered in the Busara subject pool, respondents must be over the ages of 18 years old, have access to a mobile phone, and have access to MPesa, a mobile money system used for payment of respondents. The study took place between February and December 2017.[2]

Participants were screened for inclusion/exclusion criteria both over the phone and in person. We restricted participation to respondents in the Busara subject pool between the ages of 18 and 40 with education greater than Standard 8. In addition, we excluded participants who did not meet the requirements of a health screening to ensure all participants could safely receive the stressors.[3]

To mitigate factors that might affect measurement of salivary cortisol, we asked participants not to drink alcohol, coffee, or smoke on the days of the study and the day before the study began. We also asked participants not to eat, drink any liquids other than water, or engage in strenuous physical activity, including sexual activity, during the 2 hours before the study.

[2] Prior to the full study, we completed a number of pilot studies to perfect logistics, refine the relatively complicated protocol, and identify potential difficulties in the main experiment. Due to the resulting changes in protocol for the main study, no treatment effects were analyzed in the pilot studies.

[3] Detailed exclusion criteria are available upon request. For the TSST, cold pressor and centipede tasks, we excluded all participants that might be pregnant. For hydrocortisone we had a more extensive list of medical exclusion criteria.

2.2 Treatment and Data Collection

The treatments, tasks, and questionnaires were administered using touch screen computers and the zTree experimental interface (Fischbacher 2007) to enable computer-illiterate respondents to participate. Enumerators read instructions to the respondents in Kiswahili to maximize comprehension.

Prior to stress induction, subjects on days 1 and 7 completed a baseline questionnaire, and provided baseline measures of self-reported stress and salivary cortisol. All sessions were completed in the afternoon to minimize the effects of cortisol's natural variation during the day. After stress induction, salivary cortisol and self-reported stress were measured six times in approximately 25 minute intervals. Figure 1 shows the overall structure of sessions across all studies. [4] Throughout this period, subjects completed tasks and questionnaires. The primary purpose of days 2-6 is to re-administer treatment/control. On days 2-6, subjects arrive, treatment/control protocols are implemented, and we implement brief series of surveys.

2.2.1 Hydrocortisone Administration

Hydrocortisone is a stable version of cortisol and is metabolized into cortisol upon ingestion. It is a standard approved drug used against rheumatoid and inflammatory diseases. The study was a placebo-controlled randomized controlled trial in which we administered either placebo or 20 mg hydrocortisone for 7 consecutive days. This dose and treatment regimen are very mild and therefore side effects were rare.

Before sessions began, we randomly assigned participants to treatment and control groups. Both the laboratory administrators and subjects were unaware of their treatment status; therefore the design is double-blind. At the end of the session, we included a guessing module in which participants were asked which pill they thought they received, and indicated how confident they were that they received that pill.

[4] In the TSST, Centipede, and Cold Pressor studies, we also measure heart rate throughout the session.

We conducted laboratory sessions with a maximum of 20 respondents per session. There are 317 respondents in the "acute condition", who were present on day 1 of the study. There are 257 respondents in the "chronic condition", who were present for day 7 of the study. The number of day 7 participants is lower than that of day 1 participants due to attrition.

2.2.2 Cold Pressor Task

The Cold Pressor task is a physical stressor. The Cold Pressor Test (Hines and Brown 1936) consisted of immersing one's non-dominant hand in a container filled with ice water (0–4° C). Participants assigned to the control group were asked to immerse their non-dominant hand in a container filled with water heated to body temperature (37–40° C). By means of a metal 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. Participants in both conditions submersed their hands for 60 seconds at the beginning of the session, as well as a second time for 120 seconds at the end of the session on days 1 and 7. We include a second repetition of the submersion to induce anticipatory stress and maximize the effect of the treatment (stressor) condition.

We conducted laboratory sessions with a maximum of 16 respondents per session. There are 278 respondents in the "acute condition", who were present on day 1 of the study. There are 247 respondents in the "chronic condition", who were present for day 7 of the study. The number of day 7 participants is lower than that of day 1 participants due to attrition. Treatment and control groups alternated across sessions.[5]

[5] Specifically, the first two sessions were control, the second two sessions were treatment, the third two session were control, etc.

2.2.3 Trier Social Stress Test

The TSST is designed to induce stress using two socially evaluative situations – a speech task and a mental arithmetic task. The protocol as detailed below includes slight changes to the original TSST design.[6]

Before the task began, all participants were fitted with a heart rate measurement strap that was worn throughout the session. For the treatment group, stress induction began with a panel of two judges, dressed in white, entering the room and turning on the video camera. Throughout both tasks, the judges maintained neutral expressions, remained stern, and provided little to no feedback. The speech task was a simulated job interview. The first five minutes were an anticipatory stress phase, during which participants were instructed to prepare a two-minute speech describing why they would be a good candidate for a fictitious job. Each participant then delivered their 2-minute speech without the use of their notes, immediately followed by a question-answer phase. Predesigned questions were randomly posed to the four participants in a random order, such that each participant was asked on average 4-5 questions. Participants were given 60 seconds to answer each question. The judges then exited the room for several minutes and returned for the mental arithmetic task. For this task, participants were asked to count backward from a given four-digit number (e.g. 4878, 4494, 3678) in steps of a specific number (varied based on day; see below) for two minutes. If a mistake was made, the participant was asked start again from the beginning. The start number and order in which the participants performed were both randomized. Throughout both tasks, participants in the treatment group had a language restriction such that they were permitted to speak in English only. If they began speaking in Kiswahili or another language, they were stopped

[6]Slight changes were made to the design to adapt to the Kenyan setting, and to develop a "chronic" condition in which the TSST is administered repeatedly over the course of a week. Each group consisted of five participants. The speech delivery was decreased from 5 minutes per participant to 2 minutes per participant with the addition of the question-answer phase. For the arithmetic task, instead of using the same start number and subtraction instructions, we randomized the start number for each participant and assigned different subtraction instructions per day to decrease the probability of learning effects. All protocols are available upon request.

and reminded of this requirement.

For the control group, the test began when a panel of two persons entered the room. Throughout both tasks, the panel maintained positive expressions, provided friendly nonverbal feedback, and created a comfortable environment. In the speech task, participants were asked to describe themselves, activities they enjoy, and their usual daily routine. The task began with a five-minute preparation phase, followed by a two-minute speech. Participants were allowed to use their notes during their speech. The speech was followed by a 20-30 minute question and answer phase, during which predesigned questions were randomly posed to the participants. They were told that if a question was difficult, they could use the 60-second answer period to talk about anything they like that would help the panel get to know him/her better. During the mental arithmetic task, the participants were asked to count forward from a particular number (e.g. 0, 5, 10) in steps of five for two minutes. The participants were neither stopped nor corrected for any mistakes. The given start number and order in which the participants perform were both randomized. Throughout both tasks, participants in the control group had the flexibility to speak in whichever language they were most comfortable, English or Kiswahili. They were reminded of this fact throughout the study.

Participants in both conditions completed both the speech preparation and mental arithmetic tasks at the start of the session, as well as the arithmetic task a second time at the end of the session on days 1 and 7. We included a second repetition of the arithmetic task to induce anticipatory stress and maximize the effect of the treatment (stressor) condition. At the end of each session we also include a guessing module in which we ask all participants about their rank on each task, overall, and their confidence about their rating.

Since we implemented the treatment or control protocol over seven days, we adapted the protocol across days. While participants prepared their speech on each of the seven days, only on the first or seventh day (randomized at the cohort level) were they unexpectedly asked to deliver the speech to the panel. The question-answer phase and mental arithmetic task occurred on all seven days. In addition, the starting numbers and intervals in which participants count backwards in the math task changed each day in the treatment group according to a predetermined sequence.

We conducted laboratory sessions with a maximum of 10 respondents per session. There are 268 respondents in the "acute condition", who were present on day 1 of the study. There are 261 respondents in the "chronic condition", who were present for day 7 of the study. The number of day 7 participants is lower than that of day 1 participants due to attrition. Treatment and control groups alternated between sessions.

2.2.4 Centipede Task

We used a modified real-time version of the Centipede Game first introduced by (Rosenthal 1981) to implement our financial stressor. In our case, the game lasted for 30 rounds of 21 seconds each. In each round, a resource started at a low amount and doubled every three seconds. Player(s) were faced with a decision to "pass" or "take" the resource in each of these three-second intervals. The fact that the resource grows over time creates an incentive to pass in all three-second intervals until reaching the final interval, and to "take" in that interval. However, when the game is played with others, the player who takes first ends the round and receives the entire resource available in that three-second interval, while the other players receive nothing. This rule creates an incentive to take early. We used two versions of the game: a 1-player (control condition) and a 4-player condition (treatment condition). Participants assigned to the 1-player condition played for themselves without partners, and their payoff thus depended only on when they themselves decided to "take" or whether they decided to wait out the round. The starting resource was KES 10, resulting in a maximum resource of KES 640. If a player did not decide to collect within the decision period of 21 seconds, they received the maximum amount of KES 640 for that round. Thus, the optimal strategy was simply to wait out each round.

Participants in the 4-player condition competed with 3 other players. The starting resource was KES 40, resulting in a maximum resource of KES 2560. Players decided simultaneously to pass or take within each three-second interval. The default decision was to pass. If all players passed, the resource remained intact. If a player took, the round ended, and that player earned the entire resource available in that three-second interval, while the other players earned nothing. If more than one player took in the same 3-second interval, those players split the resource evenly amongst themselves. If no player collected in the final round, everyone in the group split the maximum resource equally. After each round, participants were informed about their own payoff, but not that of anyone else. At the end of the study, the computer randomly chose one round as the payment for this task.

By backward induction, there exists a unique sub-game perfect equilibrium in the 4-player condition where each player takes in the first three second interval. We hypothesized that this unraveling would lead to stress. In contrast, in the one-player condition, no unraveling is predicted to take 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. As described above, payoffs and endowments were carefully calibrated across the two conditions to make total payout similar in treatment and control conditions and thus mitigate income effects.

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. For the "control" version, the equilibrium strategy is reversed and may generate a general belief that waiting is advantageous. 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 (KES 640 for the 1-player and KES 2560 for the 4-player game). Participants assigned to the 1-player condition individually played the game and decided how much to collect. Thus, the profit-maximizing strategy for an individual in the 1-player condition was to collect the resource immediately. If the player did not collect in the final round, they received the minimum amount (1 KES). Players in the 4-player condition competed with 3 other players. The incentives were now such that it was individually optimal to take as late as possible: players who collected before the three second interval in which the last person collected received KES 0. If all players collected in the same three second interval, they split the resource among themselves. If no player collected before the time ran out, the group split the minimum amount (KES 40) evenly. In the 4-player version of this game, if each person collected immediately, the group would split the maximum resource (KES 2560) evenly. If three people took in the first interval and the fourth player took in the second three second interval, the fourth player would receive the resource of 1280, and everyone else would receive nothing; etc. The computer randomly chose one of the rounds as the payment for the game. The number of players (4 vs. 1) and direction of the game (foward vs. reverse) was randomly assigned at the session level.

Respondents in all conditions played a second series of the centipede game at the end of the session on Day 1 and 7. The second series included 15 rounds each lasting 14 seconds, and the pot of money doubled every 2 seconds. We included this repetition of the game to induce anticipatory stress and maximize the effect of the treatment (stressor) condition.

We conducted laboratory sessions with a maximum of 30 respondents per session. There are 278 respondents in the "acute condition", who were present on day 1 of the study. There are 249 respondents in the "chronic condition", who were present for day 7 of the study. The number of day 7 participants is lower than that of day 1 participants due to attrition. Treatment and control groups alternated across sessions.

2.2.5 Incentives

In the Hydrocortisone study, participants received a cash compensation of KES 350 on each day. In addition, participants received KES 300 on the first day of participation, another KES 300 on the seventh day of participation, and another KES 500 if they attend all seven days of the study. For each day of the study, respondents received an additional KES 50 for arriving on time. In addition, participants could receive an additional KES 100 for correctly guessing their treatment status on the first and the last day. Finally, respondents had the opportunity to earn additional money from their choices in a series of tasks completed on Day 1 and Day 7, described in Section 3.1. The compensation and bonus were transferred to the respondents via MPesa.[7]

In the Cold Pressor task, respondents received a cash compensation of KES 350 on each day. In addition, participants received KES 300 on the first day of participation, another KES 300 on the seventh day of participation, and another KES 300 if they attended all seven days of the study. For each day of the study, respondents received an additional KES 50 for arriving on time. In addition, participants were incentivized to keep their hand in the water for the full time period, resulting in an expected payout of KES 250.[8]

In the TSST study, participants received a cash compensation of KES 350 on each day. In addition, participants received KES 300 on the first day of participation, another KES 300 on the seventh day of participation, and another KES 300 if they attended all seven days of the study. For each day of the study, respondents received an additional KES 50 for arriving on time. In addition, participants could receive an additional payout based on performance on the Trier Social Stress Test, resulting in an expected payout of KES 250. The recipients of this bonus were determined as follows: In the treatment condition, each participant was given a score from 1 to 6 for their performance on each of the tasks (interview and arithmetic) for each day of participation. For any day a participant did not show up, he/she received a score of zero for both tasks for that day. Once data collection was complete, we randomly chose one day for payment, and one of the two tasks to be paid out. The two

[7]USD 1 was equivalent to approximately KES 100 at the time of the study.

[8]On each day, respondents submersed their hands twice. For each instance that they kept the hand in the water for the full time period, they were entered in a lottery. At the end of the 7 days, two (if the total number of participants in the session was less than 12) or three (if the total number of participants in the session was between 12-16) of all participants were randomly chosen to receive a bonus of KES 1250 each. We varied the number of lottery winners across sessions as described above to keep the expected payout as close to KES 250 as possible.

participants with the highest performance scores on the randomly chosen day and task received the bonus: the highest performer on the specific task and day received KES 1500, and the second highest performer received KES 1000. In the control condition, each participant was given a "ticket" for each task that was completed on each day of participation. For any day a participant did not show up, he/she did not receive a ticket for either task. Once data collection was complete, we randomly chose one of the days and tasks to be paid out. Two persons whose tickets were picked for the randomly chosen task received the bonus. The first person picked for a specific day and task received KES 1500 and the second person picked received 1000 KES. This bonus was explained to all participants at the beginning of each day, and they were reminded of it several times during the sessions.

In the Centipede task, participants received a cash compensation of 350 KES on each day. In addition, participants received KES 300 on the first day of participation, another KES 300 on the seventh day of participation, and another KES 300 if they attend all seven days of the study. For each day of the study, respondents received an additional KES 50 for arriving on time. In addition, participants could receive an additional payout from the Centipede game, resulting in an expected payout of KES 250.[9]

3. Econometric strategy

3.1 Outcomes

We measured behaviors relating to three constructs: self-efficacy; temporal discounting; and executive control. Each construct was measured using both behavioral tasks and self-report questionnaires. The order in which the three constructs were measured was randomized at the session level; however, within

[9]We varied endowments across conditions to ensure that the expected payout from the centipede game was KES 250. In the treatment condition, the endowment was KES 1240. In the control conditions, the endowment was KES 610. In each session, 20% respondents were randomly selected for payment, and the payout from one randomly selected round of the centipede game was paid.

each construct, the behavioral tasks were always administered before the questionnaires.

3.1.1 Manipulation check: self-reported stress and salivary cortisol

To measure whether our treatments successfully induced stress, we measure self-reported stress and salivary cortisol throughout the experiment.

To measure salivary cortisol, we use the Salivette sampling device (Sarstedt, Germany). This method has been used extensively in psychological and medical research (Kirschbaum and Hellhammer 1989) and more recently in developing countries in our own work and that of others (Fernald and Gunnar 2009; Haushofer, Jang, and Lynham 2015)). It consists of a plastic tube containing a cotton swab, on which the respondent chews lightly for one minute to fill it with saliva. Due to the non-invasive nature of this technique, we encountered no apprehension among respondents. The saliva samples were labeled with barcodes and stored in a freezer, and were later centrifuged and assayed for salivary free cortisol using a standard radioimmunoassay (RIA) on the cobas e411 platform at Lancet Labs, Nairobi. Lower detection limits for the cortisol are 0.5 nmol/L. Salivary cortisol was measured immediately before administration of the pills, and 6 additional times following administration of the treatment/control protocol in approximately 25 minute intervals. For our analysis, we report results for each salivette separately, and report area under the curve (AUC), which is the area under the curve in a plot of salivary cortisol against time.

Self-reported stress is measured as the response to the statement “In the present moment, I feel stressed” on a scale of 0 to 100 after each sample of salivary cortisol is taken. Similarly to salivary cortisol, we report the results for each self-report separately, and average stress across the session relative to baseline stress.

3.1.2 Self-Efficacy

The concept of self-efficacy was developed by (Bandura 1982; Bandura 1986), who defined self-efficacy as the belief that one can perform well in specific situations (Bandura 1982). Self-efficacy represents a belief about performance on a particular task. Here we used the "*slider task*" (Gill and Prowse 2012). Participants were shown an on-screen "slider," a horizontal line which represents the integers from 0 to 20. They were then instructed to click the point on the line which corresponds to a randomly selected specific integer on the line (i.e. if the integer on the screen is 19, the participant must position the slider to the corresponding integer 19). The corresponding slider integer selected was then shown on the screen, and the participant could elect to move on if they correctly matched the slider or keep trying until they had made a match.

Once participants had selected the correct number, or elected to move on, they were presented with another randomly chosen integer to match. This "slider matching" process has the advantage of simulating effort which is purely mechanical and therefore should be not be related to age and education. After a 60-second practice round, participants proceed to a three-minute round during which they were paid KES 10 for each slider matched.

After this incentivized round, participants were asked to estimate their performance in the first round (in terms of total sliders matched), with a correct guess worth KES 50, as well as how confident they were of their estimate (unincentivized). Participants did not receive feedback on their performance to avoid changes in self-efficacy due to feedback.

Next, participants were asked to set a goal for how many sliders they wanted to match in the following two minute round, as well as their confidence level concerning that goal. Participants were informed that the task payment consisted of KES 20 times the number of sliders indicated by the goal if they achieved they goal, and zero otherwise. Thus, a participant who set a goal of

x sliders and completed at least that many sliders was paid $x \times$ KES 20, even if they completed more sliders. Lastly, the final round was played and payment calculated.[10]

To compute a compound self-efficacy measure, we operationalized self-efficacy as having "high" beliefs about one's ability to complete a task, and being approximately correct about these beliefs. The rationale is as follows: first, core to the self-efficacy concept is the ability to achieve desired outcomes; hence the measure should increase in actual performance. Second, self-efficacy is distinct from overconfidence (and underconfidence): a person who has "high" beliefs about their ability, but actually has low ability, is better characterized as overconfident than has having high self-efficacy. The converse argument applies for "low" beliefs.

We define our compound measure of self-efficacy as:

$$SX = \frac{y_a}{1 + |y_a - y|}$$

Here, the goal set is denoted by y_a, and actual performance by y. Note that this measure increases in the goal set, in performance, and in accuracy about the goal.

We also measure self-efficacy using the Pearlin Mastery Scale (PMS). The PMS is a canonical measure in self-efficacy research. It is defined by its author as measuring *mastery*, or "the extent to which one regards one's life-chances as being under one's own control in contrast to being fatalistically ruled" (Pearlin and Schooler 1978). Participants are asked to rate seven statements about self-efficacy on a scale ranging from "strongly disagree" (0) to "strongly agree" (5). Of these, five statements are negative (e.g. "I have little control over the things that happen to me") and two positive (e.g. "what happens to

[10] We tested for comprehension of the task by analyzing three multiple-choice comprehension questions about the task and incentive scheme that were asked between round one and goal setting for round two. In addition, if a participant kept track of the number of sliders completed, she had no incentive to keep engaging the task after their goal is met.

me in the future mostly depends on me"), and adjusted accordingly in analysis. We use an index generated from the PMS, reverse-scoring relevant items such that they are all positive (corresponding to increased mastery) and weighing each question equally, as our primary outcome measure.

To summarize, we use the following measures as outcomes for self-efficacy:

1. Performance in the first round of the slider task
2. Beliefs about performance in the first round of the slider task
3. Goal set for the second round of slider task
4. Compound self-efficacy measure
5. Pearlin Mastery Scale Index

3.1.3 Temporal Discounting

We use three of temporal discounting based on Mutiple Price List (MPL) tasks: monetary gains, monetary losses and using a real-effort task.

We use Multiple Price List tasks in both gain and loss domains to measure temporal discounting. Participants were asked to make 48 choices between payments at earlier or later dates. The payment at the early date was always equal to KES 400, while the option at the later date changed in either ascending or descending order between eight values (KES 340, 400, 440, 600, 700, 800, 1200 and 1600). We employed three payment date combinations: today vs. two weeks from today; today vs. four weeks from today; and two weeks from today vs. four weeks from today. The loss versions of the MPL tasks were symmetric to the gains domains, with only the signs of payments reversed.

Participants were endowed in all four tasks with KES 1600 at both earlier and later dates, to equalize reference points across domains and time and avoid negative payment outcomes. The order of the three time frames within each task was randomized at the session level. Across individuals within session, we randomly varied whether the different delayed outcomes were shown in ascending or descending order. Participants were provided with task-specific training on the interface, and encouraged to ask questions, immediately before this portion of the experiment. If the monetary MPL task was chosen, participants received an earlier or later payment based on one of the randomly chosen decisions made during the experiment.

A common criticism of monetary discounting tasks is that money is fungible and therefore these tasks may not capture time preferences over consumption in the presence of functioning credit markets (Augenblick, Niederle, and Sprenger 2015) We therefore also implemented a task of choices over time-dated effort. In a framework similar to the MPL for money, participants had to choose between an earlier and later amount of effort, in the form of a specific number of phone calls to the Busara Center in 10 minute intervals at particular hours in the evening. A subset of participants could choose to make two phone calls on the earlier date, or a number of between 1 and 6 at the later date, depending on the decision; the remainder of participants could choose to make either two or six phone calls on the earlier date, or a number between 1 and 12 calls at a later date. Respondents were told they would be paid a fixed amount of KES 500 one month from the date of the session, conditional on completion of the task.

Standard MPL parameter estimates assume linear utility. For both the MPL and the effort task, we estimate β and δ in the quasi-hyperbolic discounting model (Laibson 1997), (Laibson, 1997). Following the notation of (Andreoni and Sprenger 2012) and expository theory in (Balakrishnan, Haushofer, and Jakiela 2015), we let each participant's preferences over consumption $c$in a given time period t be defined by a constant relative risk aversion (CRRA) utility function:

$$u(c_t) = c_t^{\sigma}$$

In this experimental design, effort or payment on two separate dates – the first $t \geq 0$ days in the future and the later $t + k > 0$ days away. We refer to t as the front-end delay and k as the delay between completion of the real effort task. The participant receives utility from money and effort today and in the future, but utility from money and disutility from effort in the future is "discounted" relative to the present. This could arise because people are myopic, because they have uncertainty about the future, or because they expect to be richer and therefore less in need of money at a future date. We assume that the pattern of discounting over time follows the "quasi-hyperbolic" model (Laibson 1997):

$$u(c_t, c_{t+k}) = \begin{cases} u(c_t) + \beta\delta^k u(c_{t+k}) & t = 0 \\ u(c_t) + \delta^k u(c_{t+k}) & t > 0 \end{cases}$$

The purpose of the MPL task to elicit the parameters β and δ for each person. Forcing participants to choose between consumption or effort earlier and later imposes a "budget constraint." This can be express algebraically as

$$(c_t, \frac{c_{t+k}}{r}) \in \{(m, 0), (0, m)\}$$

Within a frame, t and k are unchanged while r varies with each decision. For the MPL task over money, the $m = 400$ and $r = \{0.85, 1, 1.1, 1.25, 1.5, 2, 3, 4\}$. For the MPL task over effort, $m = \{2, 6\}$ and $r = \{0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6\}$. For both the monetary and effort MPL tasks, t is either 0 (so that the earlier payment is today) or 14 days (in two weeks), k can be equal to 14 or 28 days.

Consider a participant who, in a frame of fixed $t > 0$ and k, elects to real effort $(m, 0)$ at interest rate r' and $(0, m(1+r''))$ at interest rate $r'' > r'$. Under standard economic assumptions, this implies that

$$u(m_{t+k}(1 + r'')) \geq u(m_t) \geq u(m_{t+k}(1 + r'))$$

In other words, the first choice implies that the utility of m at the earlier time in better than receiving $m \times (1 + r')$ at the later time $t + k$, and $m \times (1 + r'')$ is worth more at time $t + k$ than m at t. By substituting these values into the utility function above, we produce an interval of δ which can rationalize these choices:

$$\left[\frac{1}{1 + r'}\right]^{\sigma} \geq \delta^k \geq \left[\frac{1}{1 + r''}\right]^{\sigma}$$

Now consider the case of $t = 0$ with k fixed. The switch between earlier and later payments in a participant's decisions implies inequalities of the form

$$\left[\frac{1}{1+a}\right]^\sigma \geq \beta\delta^k \geq \left[\frac{1}{1+b}\right]^\sigma$$

Since the the interval of possibilities for the δ^k is already known, β is bounded by

$$\frac{1+r''}{1+a} \geq \beta \geq \frac{1+r'}{1+b}$$

Estimating δ requires making an assumption about the value of σ, known as the "curvature" or "risk aversion" parameter. In the results presented, we assume that $\sigma = 1$, i.e. that utility is linear in money and use the equations above to generate numeric values for δ. Thus we obtain granular intervals for β and δ at the participant level. We compute β and δ both algebraically and using nonlinear least squares; in this paper we present the results from the algebraic method.

We define an individual i as exhibiting **present bias** if $\beta_i < 1$. Intuitively, this means that they are more willing to discount consumption (or at least income) over the time period starting today than any other day in the future.

We also measure time discounting using the Consideration of Future Consequences (CFC) scale (Strathman et al. 1994). Participants were asked to indicate how much the behavior described in a statement is characteristic of them, from "not at all like me" (0) to "very much like me" (5). There are nine statements representative of forward thinking (e.g. "I am ready to sacrifice my current happiness or wellbeing in order to achieve future results") and five reverse statements (e.g. "I only act to satisfy immediate needs, thinking the future will take care of itself"), which are scored accordingly. We use an index generated from the CFC, reverse-scoring relevant items such that they are all positive (corresponding to increased patience) and weighing each question equally.

To summarize, we use the following measures as outcomes for time discounting:

1. Estimates of β and δ in the gains domain (MPL)

2. Estimates of β and δ in the losses domain (MPL)

3. Estimates of β and δ from the real-effort task (MPL)

4. Consideration of Future Consequences Index

3.1.4 Executive Control

Executive function refers to "a set of inter-related higher-order cognitive abilities involved in self-regulatory functions" (Roth et al. 2013) such as insight, judgement, working memory, or planning (Royall et al. 2002; Baddeley et al. 1996; Van der Linden, Frese, and Meijman 2003). We measured executive function using a 3 minute spatial version of the Stroop task, using congruent and incongruent directional signals (arrows) rather than words (Wühr 2007) . On each screen, participants saw a colored arrow that pointed either left or right, and responded by pressing a box on the left or right side of the screen. Importantly, when the arrow was red, participants were required to select the side of the screen towards which it pointed ("congruent" trials); if the arrow was blue, they were required to select the opposite side of the screen ("incongruent" trials). The sequence of arrows was randomized. Participants earned KES 25 for each correct response, but lost KES 3 for every second they took to complete the task (although the total payment for this task could not go below zero). We recorded correct and incorrect responses and reaction times by trial type.

We expect the results from the spatial Stroop task to exhibit the "Stroop effect": participants should take longer, on average, to select the correct direction for incongruent stimuli (MacLeod 1991), and/or make more mistakes (Wühr 2007). Since our task is time-incentivized, participants may attempt to answer the incongruent items equally quickly and therefore sacrifice accuracy. We define overall performance on the Stroop task as the ratio of number of correct responses to total time in seconds. Significantly higher response time and lower probability of correct response to incongruent stimuli will be interpreted as evidence of a Stroop Effect.[11]

We also measured executive control using a subset of the Behavior Rating Inventory of Executive Function - Adult Version (BRIEF-A). The BRIEF-A questionnaire is composed of 75 items which are grouped into two indices: behavioral regulation and metacognition. Within the indices, the items are further grouped into a total of nine subscales. We use four of the subscales within the metacognition index: (1) ability to initiate, (2) working memory, (3) ability to plan and organize, and (4) ability to monitor oneself in tasks. Together, these subscales have 32 items, but we added an additional two items with repeated content and reversed wording, for a total of 34 items.

The items consist of questions such as "I have trouble starting anything on my own" or "I don't plan early for future activities." The response choices range from "never" (scored as 0) to "always" (6). We reverse-score items with reversed wording. We use an index generated from the BRIEF-A, reverse-scoring relevant items such that they are all positive (corresponding to improved behavioral regulation and metacognition) and weighing each question equally, as our primary outcome measure.

To summarize, we will use the following outcomes for executive control:

1. Overall performance on Stroop task, taking into account speed and accuracy
2. Performance on Stroop task: number of correct responses
3. Total time to complete Stroop task
4. BRIEF-A Index

3.2 Main Treatment Effects

We use the following main specification:

[11] We will also access comprehension of the task using seven factual multiple-choice questions about the rules and payment calculation that participants were asked after the instructions and practice round but prior to the beginning of the task. We report the proportion of questions answered correctly.

$$y_{it} = \beta_0 + \beta_1 T_i \cdot Day1 + \beta_2 Day7 + \beta_3 T_i \cdot Day7 + \varepsilon_{it} \quad (1)$$

Here, y_i is the outcome of interest for respondent i at time t. T_i is a treatment indicator that takes value 1 for respondents that received treatment (stressor) and 0 for respondents that received the control protocol. $Day7$ indicates whether the observation is from day 7 of the study (as opposed to Day 1); similarly, $Day1$ indicates whether the observation is from day 1 of the study. Thus, β_1 estimates the treatment effect of stress on Day 1, β_2 measures the day 7 fixed effect, and β_3 the treatment effect on Day 7. We will also test the whether the effect of treatment is different on day 1 and day 7, i.e. whether $\beta_1 = \beta_3$, and report the corresponding p-value. Standard errors are clustered at the level of randomization: at the individual-day level for the Hydrocortisone study, and at the session level for the Centipede, Cold Pressor and TSST studies. We implement the main specification for each stressor separately and pool all stressors. In the regressions with all stressors, we include study fixed effects.

4. Results

4.1 Manipulation Check

In this subsection we explore whether respondents report increased levels of stress and have higher levels of cortisol as a result of treatment.

Table 1 shows the results on self-reported stress. In the TSST study, we find that average stress is higher for the treatment group on day 1 than for the control; specifically, stressed individuals on day 1 of the TSST report 12.73 points higher stress levels (on the scale of 0-100) than the control group, corresponding to a 53.8% effect (p-value 0.06). As can be seen in Figure 1 and Table 1, the effect is largest immediately following administration of treatment on both days 1 and 7 and diminishes over the course of the sessions. Baseline stress (Column 1) on Day 7 of the TSST study is 34% higher in the treatment group than in the control group; this effect corresponds to a p-value of 0.10.

For the other stress induction methods, we do not find statistically significant evidence that treated subject consistently report higher levels of stress than control subjects. Qualitatively, we find that subjects experiencing the stressor condition of the Cold Pressor Task report lower levels of stress on day 7; while the effects are statistically significant following the induction of stress on day 7 (Figure 2), they are not statistically significant once we account for baseline self-reported stress on day 7 (Column 8 Table 1). Qualitatively, subjects in the treatment condition of the Centipede Game report lower levels of self-reported stress. Subjects treated with hydrocortisone in the Hydrocortisone study report higher levels of self-reported stress. For both the Centipede and Hydrocortisone studies differences between treatment and control are not statistically significant at any level. The fact that hydrocortisone does not correspond to increased self-reported stress is consistent with previous work (Riis-Vestergaard et al. 2017).

Table 2 and Figure 3 show the effects of treatment on salivary cortisol levels. (Note that this data is not complete at the time of writing, and the results are therefore preliminary.) Consistent with the results from self-reported stress, we find that subjects in the stressor condition of the Cold Pressor Task experience lower levels of salivary cortisol, but the effects are not statistically significant at any level. In the Centipede Game, treatment and control subjects experience different levels of salivary cortisol midway through the session (Cortisol 4–Cortisol 6); however, the direction of the effect is not consistent throughout the session. In addition, we do not see that cortisol, measured across the session using area under the curve, is statistically different for treated and control subjects in the Centipede Game (Column 8). In the Hydrocortisone study, we find that subjects in the treated condition have significantly higher levels of salivary cortisol than in the control condition. The effect across the session is statistically significant at the 1% level for both days 1 and 7, corresponding to more than twenty-fold increase in cortisol on day 1 and a fifteen-fold increase on day 7. We also find qualitative evidence that the effect of hydrocortisone on salivary cortisol on day 7 is smaller in magnitude than on day 1. Finally, we do not find significant differences between treatment and control groups in the TSST study.

These results indicate limited success in inducing stress across all four studies. If anything, we should expect strongest effects on our outcomes of interest in the TSST study, since we find effects on self-reported stress, and in the Hydrocortisone study, since we find effects on salivary cortisol.

4.2 Self-Efficacy

In this subsection we explore the effects of treatment on self-efficacy. Table 3 shows the results for our five outcomes measures of self-efficacy. Column 1 shows the results for the compound measure of self-efficacy that takes into account both the goal set as well as performance relative to the goal. We find that subjects treated with hydrocortisone have a higher self-efficacy score on day 1; the effect is statistically significant at the 10% level and corresponds to an economically meaningful (39%) effect. The results in Column 2 suggest that this is primarily the result of improved performance, since the effect of treatment on the goal set is not statistically significant or economically large.

While we do not find statistically significant effects treatment on the compound self-efficacy measure in the Cold Pressor Task, the Centipede Game, or the TSST, the results suggest that there are effects on the goal set. Specifically, we find that subjects treated across seven days in the Cold Pressor Task set higher goal in the sliders task; the effect is statistically significant at the 5% level and corresponds to a 25% effect. Treated subjects on day 1 of the Centipede Game set lower goal in the sliders task; the effect is statistically significant at the 5% level and corresponds to 15% effect. The pattern of the effects on goal setting is not consistent across stressors and days.

Overall we do not find statistically or economically significant effects of treatment on baseline performance in the self-efficacy task or beliefs of own performance. We find that treated subjects on day 7 of the Hydrocortisone study report lower mastery, corresponding to lower scores on the Pearlin Mastery Scale; the effect is statistically significant at the 10% level and corresponds to a 5% effect.

To conclude, we do not find consistent and statistically significant evidence across all stressors that stress affected self-efficacy.

4.2.1 Temporal Discounting

In this subsection we explore the effects of treatment on temporal discounting, shown in Table 4. δ measures (consistent) time discounting. We do not find consistent and statistically significant effects of treatment on time discounting across all stressors. For the Cold Pressor Task, we find that discounting decreases for treated subjects on day 1 in the losses domains (statistically significant the 5% level). We find a statistically significant (at the 5% level) difference for treated participants on day 1 and day 7 in the gains domain. It is also worth noting all effects on δ are economically small, corresponding to less than a 2% effect, across measures of obtained from the different discounting tasks and across all stressors.

Recall that β measures hyperbolic preferences, indicating present bias if $\beta < 1$ and future bias if $\beta > 1$. We do not find consistent evidence across all stressors that treatment affects present bias. In Column 1, we find that treated subjects on day 7 of the Cold Pressor Task exhibit less future bias in the gains domain; the effect is statistically different from day 1 at the 5% level and significantly different from the control group on day 7 at the 10% level. The decrease in future bias corresponds to approximately a 15% effect, which is economically meaningful.[12]

Finally, we find that treated respondents across all four stresors report higher levels of patience on day 1, as measured by higher scores on the Consideration of Future Consequences scale (Column 7). This is primarily due to treated subjects in the Cold Pressor Task, Centipede Game, and Hydrocortisone study; in all three studies, respondents on day 1 are significantly more likely (at least at the 10% level) to score higher on the scale, corresponding

[12]We find similar results using nonlinear least squares estimation. Specifically, we find statistically insignificant and economically small effects of treatment on time discounting across all stressors and outcomes. We find day effects on present bias for the cold pressor task. Otherwise, we similarly find no other statistically significant effects of treatment on present-bias.

to approximately a 3–6% effect. In the Centipede game, the effect is larger in magnitude and statistically significant at the 1% level on day 7. As a result, when we pool all studies, we find that treatment corresponds to a 4% increase in patience (statistically significant at the 1% level) on day and 3% increase in patience on day 7 (statistically significant at the 10% level).

To conclude, while we find mixed results regarding the effect of stress on temporal discounting with our behavioral outcomes, we do find consistent evidence across the four stressors that stress increase patience as measured by the Consideration of Future Consequences scale.

4.3 Executive Control

In this subsection we explore the effects of treatment on executive control. Table 5 shows the results for our four measures of executive control. Column 1 shows the results for the compound measure of executive control, taking into account both performance and speed on the Stroop task. Across all four stress induction methods, we do not find statistically significant evidence that treatment affected executive control; the effects are also economically small, corresponding to less than a 6% effect across all stressors. When we break down the compound measure to examine effects on speed on the task (Column 2) and performance (Column 3), we do not find statistically significant effects of treatment on either measures for any of the four stress induction methods. It is worth noting that the magnitudes in Column 3 suggest that, if anything, treated individuals are consistently slower to complete the task on Day 1 for all stressors except hydrocortisone.

Finally, in Column 4 we examine the effects on the BRIEF-A Scale. Higher values indicates that subjects reported less difficulty with implementing tasks. While the effects of treatment on the score of the BRIEF-A is not statistically significant at the study level, we find that treatment has a statistically significant effect (at the 10% level) on increasing difficulties with control across all studies, as measured by the BRIEF-A scale and corresponding to approximately a 2% effect.

To conclude, we do not find statistically significant evidence that stress affects executive control, as measured by the Stroop task. However, we do find evidence that stress increases reports that participants experience difficulty implementing tasks, as measured using the BRIEF-A scale.

5. Conclusion

There is a growing literature on the effects of stress on economic decision-making. The literature thus far has focused on temporal discounting, risk preferences, and competitiveness. In this paper, we contribute to this literature in three ways. First, we study a wider range of economic outcomes than has been previously examined by focusing on temporal discounting, self-efficacy, and executive control. Second, we attempt to resolve the mixed results found in the literature regarding the effects of stress by inducing stress in four different ways across subjects and carefully design the study to maximize comparability: the Trier Social Stress Task (TSST) which induces psychosocial stress (Kirschbaum, Pirke, and Hellhammer 1993), physical stress using the Cold Pressor Task (Hines and Brown 1936), financial stress using the Centipede Game (Haushofer, Jang, and Lynham 2015; Rosenthal 1981), and hydrocortisone administration to induce the neurobiological consequences of stress (Cornelisse et al. 2013). Finally, we test whether "acute" and "chronic" stress have different effects on our outcomes by administering the stressor or control for 7 consecutive days and comparing behavioral responses on the first vs. the seventh day.

Consistent with (Haushofer, Jang, and Lynham 2015), we find that different stress induction protocols have different effects on stress. We find that only treatment in the TSST study successfully increases self-report stress, and that salivary cortisol, a stress hormone, is only higher for treated participants in the Hydrocortisone study. The fact that the Centipede study and Cold Pressor study do not affect self-reported stress or salivary cortisol may be the result of the fact that our respondents are non-standard.

We find that the stressors do not have consistent and statistically significant effects on the behavioral measures of temporal discounting, self-efficacy and executive control. Across all four stressors, stress weakly increases patience and the likelihood that participants experience difficulty implementing tasks based on scale measures. The findings may be the result of the fact that we study the effects of stress with a population that faces substantial chronic stress in their day-to-day lives.

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Figure 1: Timeline for sessions

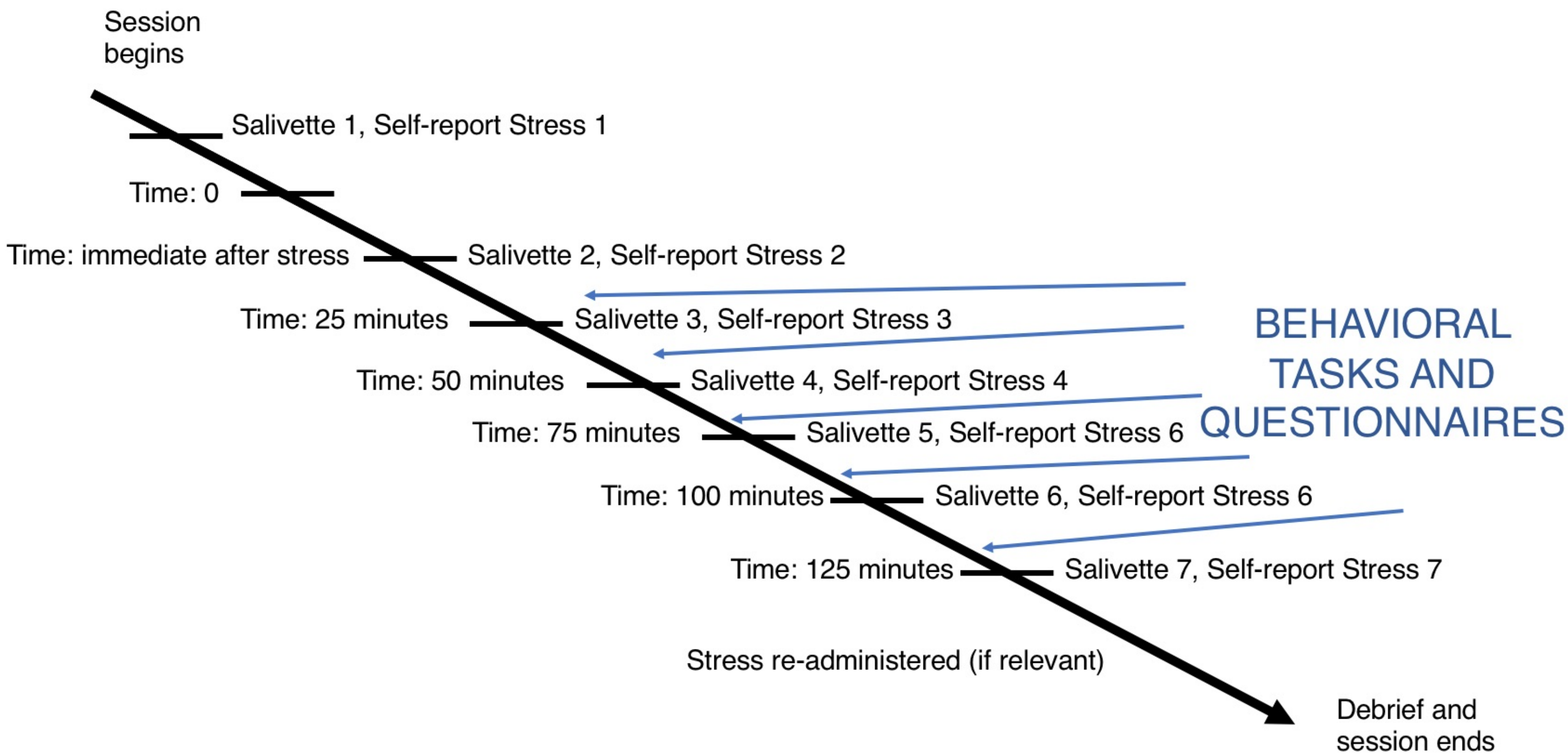

Figure 2: Self-reported stress by study

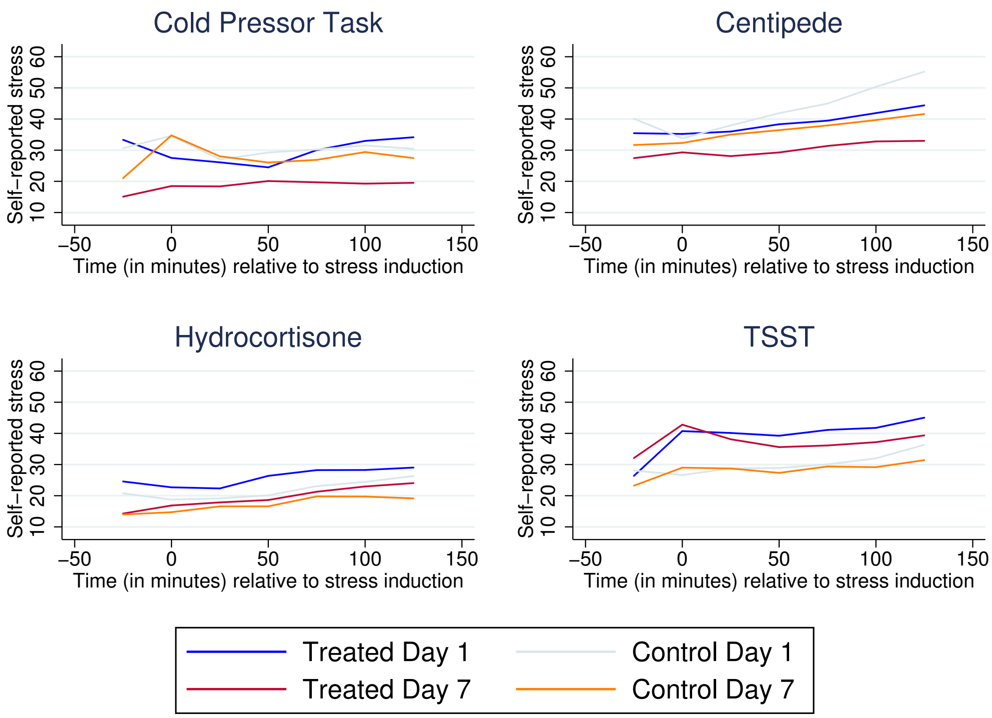

Figure 3: Salivary cortisol by study

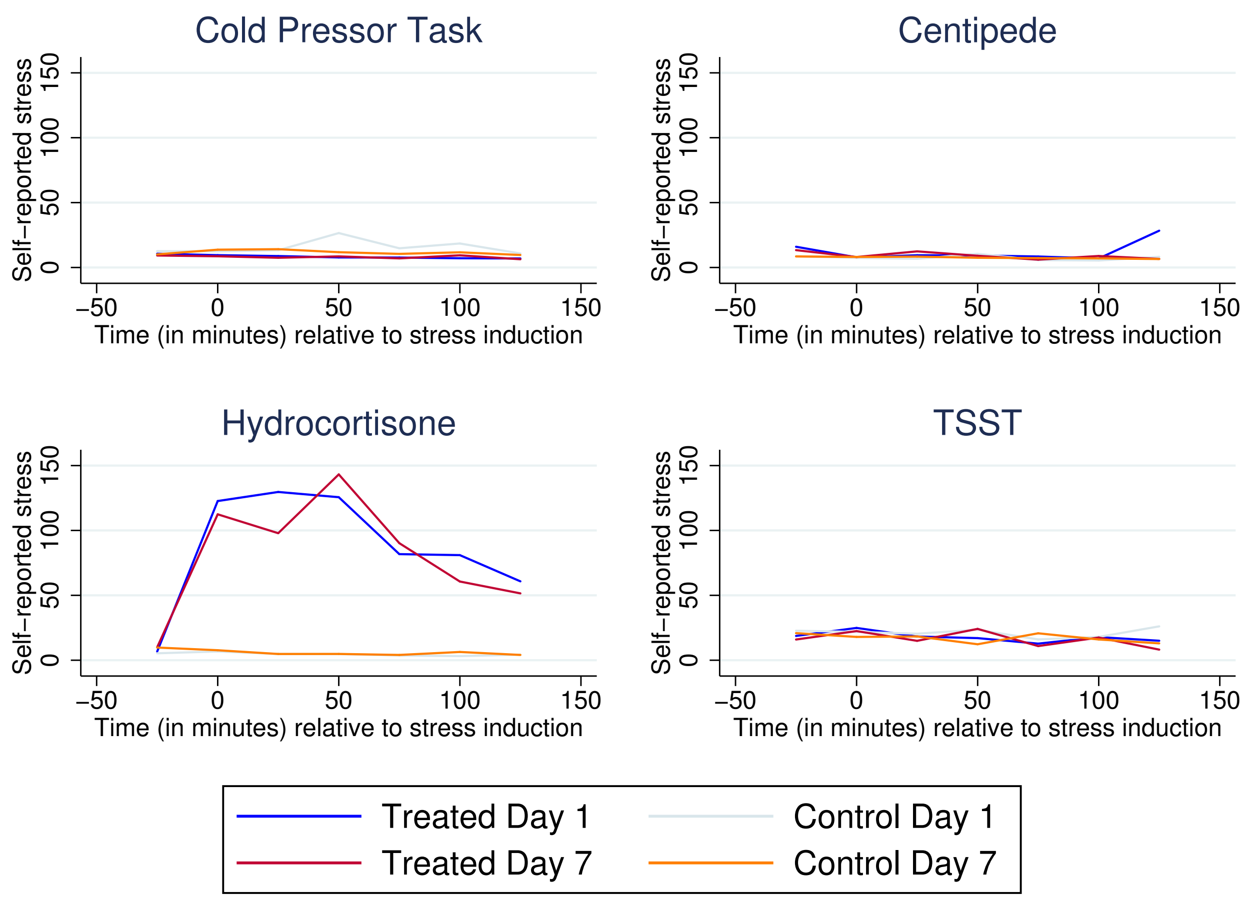

Table 1: Perceived Stress

	(1) VAS1	(2) VAS2	(3) VAS3	(4) VAS4	(5) VAS5	(6) VAS6	(7) VAS7	(8) Average Stress VAS2 to VAS7 minus VAS1
Cold Pressor Task								
Day 1	2.70	−7.14	−0.91	−4.75	−0.19	1.46	3.72	−4.00
	(4.30)	(4.22)*	(4.28)	(4.85)	(4.77)	(4.74)	(5.47)	(4.18)
Day 7	−5.93	−16.27	−9.66	−5.95	−7.20	−10.13	−7.93	−3.60
	(3.54)	(5.26)***	(3.54)***	(3.49)*	(3.73)*	(3.98)**	(3.43)**	(3.39)
Difference p-value	0.13	0.18	0.12	0.84	0.25	0.07*	0.08*	0.94
Control mean	26.23	34.70	27.49	27.78	28.71	30.55	29.08	3.49
Control sd	(28.93)	(34.16)	(30.61)	(31.63)	(32.99)	(33.65)	(33.53)	(28.62)
N	525	525	525	525	525	525	525	525
Centipede Game								
Day 1	−4.64	1.41	−1.97	−3.55	−5.49	−8.44	−10.80	−0.17
	(2.95)	(4.44)	(5.12)	(3.82)	(4.29)	(5.03)	(5.81)*	(3.38)
Day 7	−4.20	−3.01	−6.91	−7.16	−6.57	−6.87	−8.61	−2.32
	(4.54)	(5.56)	(5.90)	(6.35)	(6.26)	(6.12)	(6.93)	(2.27)
Difference p-value	0.94	0.54	0.53	0.63	0.89	0.84	0.81	0.60
Control mean	36.10	33.10	36.56	39.30	41.64	45.29	48.75	4.67
Control sd	(31.67)	(30.07)	(31.83)	(31.85)	(34.16)	(36.00)	(38.43)	(25.78)
N	527	527	527	527	527	527	527	527
Hydrocortisone								
Day 1	3.79	3.96	3.20	6.25	5.15	3.84	2.71	0.71
	(3.10)	(3.10)	(3.02)	(3.23)*	(3.38)	(3.47)	(4.00)	(2.98)
Day 7	0.30	2.15	1.27	2.02	1.50	3.23	4.92	2.06
	(2.61)	(2.76)	(2.69)	(2.87)	(3.21)	(3.34)	(3.76)	(2.72)
Difference p-value	0.39	0.66	0.63	0.33	0.43	0.90	0.69	0.74
Control mean	17.71	16.92	17.99	18.54	21.59	22.26	23.02	2.26
Control sd	(24.56)	(23.80)	(23.36)	(24.59)	(27.26)	(26.86)	(30.07)	(26.46)
N	567	567	567	567	567	551	513	567
Trier Social Stress Test								
Day 1	−1.72	14.10	11.36	10.35	11.07	9.76	8.72	12.73
	(4.02)	(4.40)***	(4.44)**	(4.24)**	(5.22)**	(5.18)*	(5.53)	(5.02)**
Day 7	8.87	13.81	9.38	8.27	6.75	8.03	7.94	0.16
	(4.81)*	(5.48)**	(3.64)**	(3.63)**	(4.61)	(5.80)	(5.40)	(4.11)
Difference p-value	0.10*	0.97	0.73	0.71	0.54	0.82	0.92	0.06*
Control mean	25.67	27.81	28.76	28.12	29.72	30.59	33.80	4.09
Control sd	(31.22)	(32.45)	(32.42)	(32.10)	(33.71)	(34.22)	(37.32)	(29.86)
N	516	516	516	516	516	516	506	516
All Studies								
Day 1	0.19	2.91	2.79	2.06	2.58	1.57	0.91	2.08
	(1.82)	(2.11)	(2.14)	(2.09)	(2.26)	(2.38)	(2.75)	(2.01)
Day 7	−0.16	−0.68	−1.36	−0.61	−1.29	−1.32	−0.90	−0.89
	(2.05)	(2.66)	(2.15)	(2.21)	(2.34)	(2.56)	(2.64)	(1.60)
Difference p-value	0.90	0.29	0.17	0.38	0.23	0.41	0.63	0.25
Control mean	26.05	27.80	27.36	28.02	30.01	31.75	33.44	3.59
Control sd	(29.80)	(31.07)	(30.36)	(30.93)	(32.78)	(33.70)	(36.15)	(27.76)
N	2135	2135	2135	2135	2135	2119	2071	2135

Notes: Due to the level of randomization, standard errors are clustered at the session level for the Cold Pressor, Centipede, and TSST studies, at the individual level for the Hydrocortisone study. Regressions with all studies include study fixed effects.

Table 2: Cortisol

	(1) Cortisol1	(2) Cortisol2	(3) Cortisol3	(4) Cortisol4	(5) Cortisol5	(6) Cortisol6	(7) Cortisol7	(8) AUC Cortisol
Cold Pressor Task								
Day 1	−1.98	−2.96	−4.53	−18.79	−7.15	−11.36	−3.85	−59.26
	(3.46)	(5.52)	(3.50)	(19.46)	(7.78)	(11.63)	(4.65)	(63.73)
Day 7	−0.84	−5.10	−6.64	−3.24	−3.48	−2.32	−3.28	−67.23
	(2.72)	(6.01)	(4.64)	(3.52)	(4.15)	(4.23)	(2.66)	(44.82)
Difference p-value	0.80	0.80	0.72	0.44	0.68	0.47	0.92	0.92
Control mean	11.57	13.00	13.62	20.81	13.13	15.79	10.32	109.66
Control sd	(17.84)	(33.08)	(24.65)	(100.58)	(41.74)	(61.24)	(24.22)	(339.45)
N	179	162	168	171	177	174	172	110
Centipede Game								
Day 1	7.30	0.39	2.73	−1.23	2.72	1.57	20.18	−1.03
	(6.04)	(0.90)	(1.52)*	(4.19)	(1.17)**	(0.36)***	(17.14)	(9.37)
Day 7	4.86	−0.08	4.04	1.51	−1.19	1.83	0.07	1.75
	(2.67)*	(0.92)	(4.48)	(0.44)***	(0.26)***	(0.74)**	(0.83)	(4.59)
Difference p-value	0.72	0.72	0.79	0.52	0.01***	0.76	0.26	0.80
Control mean	8.62	7.74	7.47	9.18	6.37	6.12	7.46	46.04
Control sd	(3.39)	(3.85)	(3.15)	(26.61)	(2.91)	(2.42)	(16.75)	(40.58)
N	193	194	197	209	194	204	199	138
Hydrocortisone								
Day 1	1.31	115.97	124.81	120.86	78.10	77.82	56.49	534.12
	(0.82)	(24.14)***	(19.46)***	(18.57)***	(13.24)***	(19.11)***	(15.84)***	(110.93)***
Day 7	0.23	104.75	93.09	138.39	86.16	54.32	47.44	384.15
	(4.25)	(32.41)***	(13.36)***	(33.01)***	(19.26)***	(9.90)***	(9.68)***	(54.36)***
Difference p-value	0.80	0.78	0.18	0.64	0.73	0.28	0.63	0.23
Control mean	7.18	7.11	4.83	4.80	3.84	4.54	4.20	22.86
Control sd	(23.69)	(22.80)	(4.98)	(12.11)	(3.00)	(18.22)	(5.86)	(13.85)
N	458	446	436	439	459	435	430	300
Trier Social Stress Test								
Day 1	−3.99	3.06	−2.15	−6.45	−3.21	−0.14	−11.10	−7.57
	(8.05)	(9.13)	(7.48)	(7.21)	(4.75)	(7.72)	(10.14)	(34.24)
Day 7	−4.93	4.51	−3.39	11.85	−9.85	1.50	−4.81	−6.74
	(7.92)	(9.21)	(6.50)	(6.54)*	(8.44)	(6.41)	(3.64)	(34.71)
Difference p-value	0.93	0.91	0.90	0.07*	0.50	0.87	0.56	0.99
Control mean	21.82	19.82	19.36	17.84	18.39	16.97	19.47	113.76
Control sd	(50.17)	(45.05)	(56.79)	(47.95)	(58.32)	(49.22)	(57.15)	(196.11)
N	392	393	394	385	391	390	395	296
All Studies								
Day 1	0.22	48.45	49.35	44.17	30.14	28.90	21.78	211.41
	(2.64)	(11.47)***	(9.77)***	(9.87)***	(6.60)***	(8.61)***	(7.97)***	(56.02)***
Day 7	−1.01	35.95	29.14	48.93	26.02	18.82	13.18	108.33
	(3.24)	(12.20)***	(6.40)***	(12.27)***	(8.30)***	(4.62)***	(3.95)***	(29.38)***
Difference p-value	0.77	0.46	0.08*	0.76	0.70	0.30	0.33	0.10
Control mean	12.86	12.30	11.25	11.87	10.22	10.38	10.69	68.91
Control sd	(33.75)	(32.47)	(34.92)	(46.94)	(37.10)	(37.78)	(35.75)	(166.89)
N	1222	1195	1195	1204	1221	1203	1196	844

Notes: Due to the level of randomization, standard errors are clustered at the session level for the Cold Pressor, Centipede, and TSST studies, at the individual level for the Hydrocortisone study. Regressions with all studies include study fixed effects.

Table 3: Self Efficacy Score

	(1) Self Efficacy Measure	(2) Effort Goal	(3) Effort Round 1 Performance	(4) Effort Belief Performance	(5) Pearlin Mastery Scale
Cold Pressor Task					
Day 1	0.05	0.04	−14.67	−0.18	0.23
	(0.35)	(1.87)	(12.29)	(3.80)	(0.85)
Day 7	0.13	4.46	1.45	4.02	0.10
	(0.79)	(1.93)**	(4.78)	(2.44)	(0.92)
Difference *p*-value	0.92	0.11	0.23	0.36	0.92
Control mean	1.84	18.15	41.52	22.73	24.30
Control sd	(3.59)	(13.05)	(31.33)	(17.03)	(5.19)
N	525	525	525	525	525
Centipede Game					
Day 1	−0.24	−2.55	−1.65	0.10	−0.56
	(0.44)	(1.17)**	(3.10)	(2.01)	(0.54)
Day 7	0.59	−0.45	−1.69	−1.11	0.14
	(0.49)	(1.09)	(3.29)	(1.58)	(0.71)
Difference *p*-value	0.22	0.20	0.99	0.64	0.44
Control mean	2.19	17.19	26.83	19.08	24.49
Control sd	(3.13)	(12.97)	(9.88)	(16.66)	(4.44)
N	481	481	481	481	527
Hydrocortisone					
Day 1	0.62	0.65	0.46	−0.84	−0.57
	(0.34)*	(0.95)	(1.25)	(1.32)	(0.55)
Day 7	0.02	0.60	1.18	0.46	−1.28
	(0.44)	(1.14)	(1.33)	(1.37)	(0.66)*
Difference *p*-value	0.28	0.98	0.69	0.50	0.41
Control mean	1.59	14.60	27.37	16.49	24.72
Control sd	(2.98)	(8.29)	(11.65)	(12.26)	(4.91)
N	567	567	567	567	551
Trier Social Stress Test					
Day 1	−0.14	−0.21	0.66	2.70	−0.78
	(0.40)	(1.64)	(2.32)	(2.23)	(0.83)
Day 7	−0.19	−0.18	−0.03	−0.54	−1.48
	(0.44)	(2.18)	(2.49)	(2.67)	(0.89)
Difference *p*-value	0.93	0.99	0.84	0.36	0.57
Control mean	2.19	18.93	32.98	21.84	26.43
Control sd	(3.38)	(12.10)	(12.33)	(16.33)	(5.64)
N	516	516	516	516	516
All Studies					
Day 1	0.10	−0.45	−3.79	0.37	−0.42
	(0.19)	(0.72)	(3.29)	(1.23)	(0.35)
Day 7	0.12	1.13	0.27	0.73	−0.64
	(0.28)	(0.87)	(1.59)	(1.07)	(0.41)
Difference *p*-value	0.94	0.16	0.27	0.82	0.67
Control mean	1.95	17.20	32.19	20.02	25.02
Control sd	(3.28)	(11.79)	(19.24)	(15.80)	(5.16)
N	2089	2089	2089	2089	2119

Notes: Due to the level of randomization, standard errors are clustered at the session level for the Cold Pressor, Centipede, and TSST studies, at the individual level for the Hydrocortisone study. Regressions with all studies include study fixed effects. The Self-Efficacy Measure is a compound measure derived from the sliders goal and actual performance in Round 2.

Table 4: Discounting (Algebraic Method)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	β^{MPL}_{Gains}	δ^{MPL}_{Gains}	β^{MPL}_{Losses}	δ^{MPL}_{Losses}	β^{Effort}_{Gains}	δ^{Effort}_{Gains}	Consideration Future Consequences Scale
Cold Pressor Task							
Day 1	0.24	−0.01	0.17	−0.01	−0.14	0.01	1.98
	(0.17)	(0.01)	(0.14)	(0.01)**	(0.22)	(0.01)	(0.97)**
Day 7	−0.29	0.01	−0.10	−0.00	0.20	−0.01	0.06
	(0.15)*	(0.01)	(0.13)	(0.00)	(0.21)	(0.01)	(1.14)
Difference p-value	0.03**	0.05**	0.15	0.27	0.28	0.28	0.21
Control mean	1.96	0.95	2.33	0.94	0.95	1.04	41.20
Control sd	(1.29)	(0.05)	(1.45)	(0.05)	(1.14)	(0.04)	(6.88)
N	525	525	525	525	525	525	525
Centipede Game							
Day 1	0.01	0.00	−0.21	0.00	0.41	−0.02	3.49
	(0.20)	(0.01)	(0.17)	(0.00)	(0.39)	(0.01)	(1.20)***
Day 7	0.17	−0.00	−0.14	−0.00	0.08	−0.00	3.94
	(0.15)	(0.01)	(0.12)	(0.00)	(0.24)	(0.01)	(1.33)***
Difference p-value	0.50	0.94	0.72	0.23	0.48	0.47	0.80
Control mean	1.98	0.94	2.43	0.94	0.93	1.04	40.40
Control sd	(1.15)	(0.05)	(1.37)	(0.05)	(1.08)	(0.04)	(7.15)
N	527	527	527	527	461	461	527
Hydrocortisone							
Day 1	0.18	−0.00	−0.06	0.00	−0.11	−0.01	0.99
	(0.15)	(0.01)	(0.15)	(0.01)	(0.22)	(0.01)	(0.76)
Day 7	−0.00	−0.00	0.08	−0.00	−0.37	0.00	0.54
	(0.15)	(0.01)	(0.14)	(0.00)	(0.22)	(0.01)	(0.93)
Difference p-value	0.40	0.78	0.48	0.54	0.40	0.43	0.71
Control mean	1.98	0.94	2.39	0.93	2.36	0.98	40.07
Control sd	(1.24)	(0.05)	(1.23)	(0.05)	(1.89)	(0.06)	(7.26)
N	551	551	551	551	551	551	551
Trier Social Stress Test							
Day 1	−0.11	0.00	−0.19	0.00	−0.20	0.01	0.53
	(0.15)	(0.01)	(0.17)	(0.01)	(0.32)	(0.01)	(0.94)
Day 7	−0.17	−0.00	0.06	−0.00	0.22	−0.00	0.96
	(0.14)	(0.01)	(0.14)	(0.00)	(0.27)	(0.01)	(0.82)
Difference p-value	0.78	0.81	0.24	0.54	0.32	0.56	0.73
Control mean	2.23	0.94	2.55	0.93	1.15	1.03	40.44
Control sd	(1.30)	(0.05)	(1.29)	(0.04)	(1.32)	(0.05)	(7.17)
N	516	516	516	516	516	516	516
All Studies							
Day 1	0.08	−0.00	−0.07	−0.00	−0.02	−0.00	1.75
	(0.08)	(0.00)	(0.08)	(0.00)	(0.14)	(0.01)	(0.51)***
Day 7	−0.07	0.00	−0.02	−0.00	0.03	−0.00	1.36
	(0.08)	(0.00)	(0.07)	(0.00)	(0.12)	(0.00)	(0.57)**
Difference p-value	0.17	0.32	0.64	0.52	0.77	0.90	0.61
Control mean	2.04	0.94	2.43	0.93	1.37	1.02	40.52
Control sd	(1.25)	(0.05)	(1.34)	(0.05)	(1.52)	(0.06)	(7.12)
N	2119	2119	2119	2119	2053	2053	2119

Notes: Due to the level of randomization, standard errors are clustered at the session level for the Cold Pressor, Centipede, and TSST studies, at the individual level for the Hydrocortisone study. Regressions with all studies include study fixed effects.

Table 5: Executive Control

	(1) Stroop score	(2) Total Stroop time	(3) Stroop correct answers	(4) BRIEF-A Scale
Cold Pressor Task				
Day 1	0.01	−4.64	−0.30	−2.44
	(0.04)	(6.29)	(0.97)	(3.18)
Day 7	−0.04	1.70	−0.43	−0.76
	(0.06)	(6.17)	(0.83)	(2.92)
Difference p-value	0.45	0.48	0.92	0.70
Control mean	0.46	66.28	26.84	160.77
Control sd	(0.19)	(26.40)	(6.22)	(24.68)
N	525	525	525	525
Centipede Game				
Day 1	0.01	−3.89	0.85	−0.54
	(0.05)	(10.91)	(0.82)	(4.55)
Day 7	−0.05	16.37	1.02	−2.65
	(0.07)	(12.53)	(0.66)	(4.81)
Difference p-value	0.43	0.23	0.87	0.75
Control mean	0.38	81.86	27.19	159.47
Control sd	(0.17)	(29.43)	(5.95)	(27.33)
N	527	527	527	527
Hydrocortisone				
Day 1	−0.00	0.03	0.05	−3.76
	(0.02)	(1.93)	(0.76)	(2.78)
Day 7	−0.01	0.38	−0.13	−4.25
	(0.02)	(1.56)	(0.72)	(2.72)
Difference p-value	0.79	0.89	0.86	0.90
Control mean	0.50	57.02	27.03	166.21
Control sd	(0.16)	(14.96)	(6.19)	(20.96)
N	548	548	548	551
Trier Social Stress Test				
Day 1	0.04	−1.28	1.00	−4.20
	(0.04)	(2.56)	(0.72)	(3.25)
Day 7	0.01	1.41	0.38	−4.38
	(0.04)	(2.17)	(0.47)	(3.06)
Difference p-value	0.55	0.43	0.47	0.97
Control mean	0.67	45.17	28.11	164.92
Control sd	(0.20)	(13.05)	(5.22)	(23.79)
N	516	516	516	516
All Studies				
Day 1	0.02	−2.43	0.38	−2.73
	(0.02)	(3.21)	(0.41)	(1.74)
Day 7	−0.02	4.90	0.21	−3.03
	(0.02)	(3.56)	(0.35)	(1.72)*
Difference p-value	0.20	0.13	0.75	0.90
Control mean	0.51	61.75	27.31	163.00
Control sd	(0.21)	(25.44)	(5.91)	(24.31)
N	2116	2116	2116	2119

Notes: Due to the level of randomization, standard errors are clustered at the session level for the Cold Pressor, Centipede, and TSST studies, at the individual level for the Hydrocortisone study. Regressions with all studies include study fixed effects.