Competitiveness and Stress

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This study experimentally investigates the relationship between competitiveness and stress. We examine cortisol response, a biomarker of stress, in the laboratory tasks of Niederle and Vesterlund (2007). We find that the more competitive tournament task induces higher cortisol responses than the less competitive piece-rate task. Moreover, more competitively inclined subjects exhibit higher task-induced cortisol responses as well as higher cortisol awakening response. Subsequently, we examine an additional biomarker for stress – alpha-amylase, and similarly find that more competitive subjects exhibit higher task-induced alpha-amylase response. These results demonstrate a robust relationship between competitiveness and stress.

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1. Introduction

Competitiveness and stress are ubiquitous in modern living. In school, in the workplace, and in our social networks, we compete for attention, for promotion, for recognition and for dominance. In so doing, and to varying extent, we may experience a feeling of being stressed. According to last year's *The Stress in America* survey by the American Psychological Society (2014), adults are living with stress that is higher than what they believe to be healthy, and they are not having much success at managing or reducing their stress. Alongside high blood pressure and smoking, stress is the leading cause of heart disease in most developed economies (Sapolsky, 1994; Juster et al., 2010). Anecdotal evidence suggests that the level of stress that comes with prospective employment opportunities can be a significant consideration often on par with financial compensations and other more tangible rewards and benefits (Jex, 1998). The increasing awareness of the adverse consequence of stress has spawned a burgeoning industry dedicated to stress reduction (Schwartz, 2004).

Decades of research in biology has greatly enhanced our understanding of the mechanisms of the stress response, which is often characterized by a fight-or-flight response, a physiological reaction that occurs following a perceived harmful event, attack, or threat to survival (Cannon, 1932). Stressful situations activate the two main physiological systems: the sympathetic adrenal-medullary (SAM) and the hypothalamic-pituitary-adrenal (HPA) axes. The SAM axis, part of the autonomic nervous system maintaining homeostasis of the body, represents the fast reaction to stress. Stressors activate the SAM axis via the hypothalamus, which in turn stimulates the adrenal medulla to secrete the main catecholamine hormones, including adrenaline and noradrenaline. Catecholamine hormones facilitate fast physical reactions associated with a preparation for an immediate fight or flight response, including decreasing digestion and increasing sweating, heart rate and blood pressure. The HPA axis reflects a relatively slow actor in response to stress. The initial reaction in the hypothalamus stimulates the pituitary gland to secrete adrenocorticotropic hormone, which subsequently stimulates the adrenal gland to release cortisol, the primary stress hormone in humans. By increasing blood pressure and blood sugar as well as suppressing the immune system, cortisol enables steady supplies of energy to meet the emergent challenge presented by the stressor.

Hundreds of studies have been pointed to cortisol as the paramount biomarker for stress and have examined how the mechanisms underlying various acute stressors elicit a robust cortisol response. It has been shown that cortisol response exhibits substantial variability across situations. In a meta-analysis of 208 laboratory studies, Dickerson and

Kemeny (2004) review whether and how cortisol responds to different acute situational stressors, including public speaking where participants are given instructions to verbally interact with other persons, cognitive tasks (e.g., solving puzzles or performing mental arithmetic calculations), emotion induction procedures (e.g., emotion-eliciting films or recalls of affective states), and noise exposure tasks where participants experience either intermittent or continuous loud noises. Among these acute stressors, public speaking and cognitive tasks induce substantial cortisol response, and a combination of both elicits an even higher cortisol response. Dickerson and Kemeny theorize that cortisol response is elicited only under a restricted set of conditions in which the motivated performance is either uncontrollable or characterized by social-evaluative threats, for example, poor performance that could be negatively judged by others. It has also been shown that cortisol response exhibits substantial variability across individuals. In a meta-analysis of 358 studies on individual differences in cortisol response, Campbell and Ehlert (2012) suggest that individuals with higher social desirability, motivational engagement and aggression exhibit higher cortisol response. For instance, subjects who try to preserve a positive image appear to be more physiologically aroused and have a higher cortisol response.

Interestingly, the secretion of cortisol from the adrenal glands follows a diurnal cycle with a marked increase after awakening, termed the cortisol awakening response, which is itself a reliable measure of HPA axis sensitivity (Fries et al., 2009). It has been suggested that cortisol awakening response may reflect an individual's anticipation of the demands of the upcoming day and hence the magnitude of cortisol secretion varies according to the degree of anticipated demands. For example, cortisol awakening response is higher in a working day compared to a weekend day, which reflects the working-day anticipation of worry and stress. Moreover, individuals with more stressful past life-events also tend to have higher cortisol awakening response (Pruessner et al., 1999). In sum, decades of research in neuroendocrinology has suggested that cortisol secretion is a robust biomarker to index stress (Dickerson and Kemeny, 2004).

Notwithstanding its impact on almost all facets of modern living, and advancements made in the field of biology, stress has been a relatively neglected subject of research in economics. It remains unclear whether and how different economic environments would induce different levels of stress, and whether and how different individuals would response differently to stressful economic environments. In this paper, we investigate experimentally the relationship between competitiveness and stress using the design of Niederle and

Vesterlund (2007). Specifically, we examine whether more competitive environments would induce greater levels of stress indexed by cortisol, and whether more competitive individuals would have higher cortisol awakening response, as well as stress response indexed by cortisol response during the tasks. In the experiment, 197 subjects perform two 5-minute calculation tasks adding 5 two-digit numbers, one under a noncompetitive piece-rate compensation scheme and one under a competitive tournament compensation scheme with monetary incentive. After the two tasks, subjects choose whether they prefer to be compensated using piece-rate or tournament prior to performing a further calculation task. This measures our variable of interest - competitiveness. Lastly, in the final task, they choose whether they prefer to be compensated using piece-rate or tournament for their performance in the piece-rate task that they have already completed. Niederle and Vesterlund (2007) suggest that the tournament choice for the past performance could serve as a control for general factors related to competitiveness such as aversion to negative feedback, overconfidence, and risk attitude. After these four tasks, we include a number of questionnaires measuring confidence about performance, risk attitude and psychological stress. We measure the responses of cortisol in saliva samples induced by the piece-rate and tournament tasks separately, in addition to cortisol awakening response on the day of the experiment.

Firstly, we observe that cortisol responds to both piece-rate and tournament tasks, indicating that significant levels of stress are experienced in performing each task. This observation is interesting, as we demonstrate that simple laboratory tasks used in experimental economics could indeed induce substantial cortisol release, which could not be robustly induced by some laboratory methods including emotion inductions and noise exposures. Moreover, the cortisol response is higher in the tournament than the piece-rate task, indicating that more competitive environment induces a higher stress response than the less competitive one in the laboratory setting. This also echoes the view that adding a social evaluation component to the arithmetic task could induce a higher cortisol response (Dickerson and Kemeny, 2004).

Secondly, we find that more competitive subjects, those choosing tournament over piece-rate for subsequent performance, exhibit higher level of cortisol response in the tournament task. We further examine alternative channels that may mediate this observation including performance, confidence and risk attitude. Firstly, we show that the observed relationship between competitiveness and cortisol response remains significant after controlling for a number of behavioral factors which may be related to competitiveness.

These include performance in the tournament, performance differences between the tournament and the piece-rate, confidence in the tournament, confidence differences between tournament and piece-rate, risk attitude, and tournament choice for past performance reflecting other general factors such as feedback aversion. Secondly, in separate analyses, we do not find cortisol response to be significantly associated with any of these behavioral factors related to competitiveness.

Subsequently, to examine whether the observation is specific about tournament induced cortisol response, we test whether more competitive subjects would also have higher piece-rate induced cortisol response. Here, similarly, we find that piece-rate induced cortisol response is significantly correlated with competitiveness, and that the results remain marginally significant after we further control for the aforementioned behavioral factors. This suggests the notion that competitively inclined individuals, who choose tournament over piece-rate for the subsequent performance, would experience higher levels of stress with correspondingly higher cortisol responses in either tournament or piece-rate task. This is consistent with the observations that individuals with higher social desirability, motivation engagement and aggression have higher cortisol response (Campbell and Ehlert, 2012).

Moreover, we find that more competitive individuals have significantly higher cortisol awakening response, while we do not observe significant association between competitiveness and the level of baseline cortisol immediately preceding the task. In examining potential mechanisms through the effect on behavioral factors related to competitiveness, the results do not support these alternatives channels. Adam et al (2006) suggest that cortisol awakening response may be viewed as a flexible response intended to give an individual that extra mental and physical energy "boost" required to deal with the foreseen and unforeseen concerns of the approaching day. This suggestion is consistent with our observation that more competitive individuals have higher cortisol awakening response.

Overall, these results point to more competitive individuals having higher cortisol response, which indexes higher stress level. In order to check the robustness of the relation between stress and competitiveness, we further examine a second biomarker for stress, salivary alpha-amylase, which has been proposed as a useful biomarker for the sympathetic stress system of the SAM axis (Nater and Rohleder, 2009). In a seminal study of Chatterton et al (1996), increases in salivary alpha-amylase are observed in response to a variety of stressful conditions. Subsequent studies show robustly that the patterns of salivary alpha-amylase response to both physical and psychological stressors characterize the sympathetic nervous system (Nater and Rohleder, 2009). For example, in a study on salivary alpha-amylase and competition, Kivlighan and Granger (2006) demonstrate that salivary alpha-amylase increases in response to participation in an ergometer competition, and it is positively associated with performance as well as interest in team bonding. Following the approach employed for cortisol, we measure the response of alpha-amylase during both piece-rate and tournament tasks, and observe that more competitive subjects have higher alpha-amylase response in both tasks, and that the results are robust after controlling for other behavioral factors related to competitiveness. In sum, our results suggest a robust relationship between competitiveness and stress, that is, more competitive individuals have higher physiological stress response indexed by both cortisol and alpha-amylase responses.

As our observations are based on the stress response of cortisol and alpha-amylase, we could not rule out the influence of potential confounding hormones, in particular testosterone. Long hypothesized to index aggression and response to challenge across species, especially among males, testosterone has been suggested as an important component of the neuroendocrine patterns in response to social stress (Archer, 2006). Given that cortisol response is the primary stress hormone in our study, we do not directly measure the response of testosterone during the tasks, although we do include a baseline measure of testosterone levels. We find that baseline testosterone level is not significantly correlated with competitiveness, and the association between competitiveness and response of cortisol and alpha-amylase remains significant after we further control for baseline testosterone. These results suggest that baseline testosterone level is unlikely to be a confounding factor for our observations linking competitiveness and stress.

Our results do not directly demonstrate the direction of the observed effects. One possible direction is that more competitive subjects have a trait-like heightened cortisol response, perhaps signifying the relationship between high levels of cortisol response and motivation to compete. Put differently, more competitive subjects may be physiologically more motivated when performing the specific tasks leading to higher stress response, and they may also be more prepared for the challenge of the day resulting in higher cortisol awakening response. This possibility is consistent with the observations that the cortisol response is more sensitive to situations involving social evaluation, and that individuals with higher social desirability, motivation, engagement and aggression have higher cortisol response (Campbell and Ehlert, 2012). The reverse possibility that subjects experience higher stress response in the tasks leading to more competitive behavior subsequently seems less likely. Individuals do not normally perceive their own cortisol response, which is known to be uncorrelated to self-reported psychological stress (Dickerson and Kemeny, 2004). To study this possibility further, we examine the role of self-reported anxiety. Firstly, we find that self-reported anxiety is not significantly correlated with the stress response of cortisol and alpha-amylase, and is also not significantly correlated with competitiveness after controlling for a number of behavioral factors which are potentially related to competitiveness. Secondly, we show that the association between competitiveness and response of cortisol and alpha-amylase remains significant after controlling further for self-reported anxiety.

Our study contributes to the understanding of the relationship between stress-related hormone systems and competitiveness.[2] In an earlier study, Apicella et al (2011) report no significant association between competitiveness and a number of hormone measures, including baseline levels of testosterone and cortisol, facial masculinity and 2D:4D digit ratio. In a study of menstrual cycle, Buser (2012b) shows that competitiveness is correlated with the self-reported intake of hormone contraceptives, suggesting a negative effect of the sex hormone progesterone on competitiveness. Wozniak et al (2014) find that women in the high-hormonal phase of the self-reported menstrual cycle are more willing to compete than those in the low phase, and differences between choices are not significant after subjects receive feedback of their performance. From the perspective of methodology, our study advances the literature by directly determining the task-induced acute stress responses of repeated measures of both cortisol and alpha-amylase, in addition to cortisol awakening response, and hence, providing a more contoured and richer picture of the system of stress response under competition. We replicate *inter alia* the absence of significant relation between competitiveness and pretest baseline cortisol as well as testosterone as reported in Apicella et al. (2011). Our results reveal that simple experimental tasks such as piece-rate and tournament could robustly induce significant stress response in subjects, and that it is the dynamic physiological stress responsiveness, rather than baseline cortisol or testosterone levels, that is linked to competitiveness. Overall, ours represents the first study of how the stress system responds directly to competitiveness as measured through incentivized

[2] There is an increasing literature on the role of hormone systems on decision making including cortisol (Apicella et al., 2011; Coates et al., 2009; Coates and Herbert, 2008), testosterone (Burnham, 2007; Coates and Herbert, 2008; Eisenegger et al., 2009; Sapienza et al., 2009; Zethraeus et al., 2009), 2D:4D as proxy of prenatal testosterone exposure (Apicella et al., 2008; Brañas-Garza and Rustichini, 2011; Buser, 2012a; Coates et al., 2009; Pearson and Schipper, 2012; Sapienza et al., 2009; Van den Bergh and Dewitte, 2006), and self-reported menstrual cycle (Buser, 2012a; Chen et al., 2012; Pearson and Schipper, 2012).

behavioral games. Follow-up research investigating the direction of the causal effect more comprehensively would make a meaningful contribution to this emerging literature.

The rest of the paper is organized as follows. Sections 2 and 3 present our experimental design and findings, respectively. Section 4 concludes.

2. Experimental Design

Behavioral tasks. We adopt the behavioral tasks in Niederle and Vesterlund (2007) designed to assess competitiveness. In the experiment, subjects perform calculation tasks by adding up sets of five randomly generated two-digit numbers. Subjects are allowed to use scratch papers but not calculators. Each problem is presented in the following manner, and subjects are required to indicate the sum in the blank box:

14	54	91	23	87	

Once the subject has submitted an answer, a new problem appears on the computer screen with information about whether or not the former answer is correct or not. A record of the numbers of correct and wrong answers is kept on screen. Each subject has five minutes to solve as many problems as they can manage. The final score is determined by the number of correctly solved problems. Subjects are asked to complete the following four tasks.

– *Piece-rate Task*. Subjects are given five minutes to calculate the sums of sets of five randomly generated two-digit numbers. Subjects do as many calculations as they can within five minutes and earn SG$1.50 (about US$1.20) per correct answer. This task provides a behavioral measure of performance under a piece-rate condition.

– *Tournament Task*. Similar to the piece-rate task, subjects are given five minutes to calculate the sums of sets of five randomly generated two-digit numbers. In each session, we have an even mix of both genders. We do not explicitly tell the subjects that subjects are randomly divided into groups of four with two men and two women, as this could have potential priming effects of the gender role. Within each group, the subject who solves the highest number of problems receive SG$6.00 per correct answer, whereas the other three participants receive no payment. Subjects only know their own performance and not the performance of the other subjects. This task provides a behavioral measure of performance under a tournament condition.

– *Tournament choice for the subsequent performance (competitiveness)*. Subjects select whether they want to be paid according to a piece-rate or a tournament as described above. If subjects choose piece-rate, they receive SG$1.50 for their score in their subsequent performance. If participants choose the tournament, he or she receives SG$6.00 per correct answer if the score in this task exceeds the score in the previous tournament task of the other group members; otherwise she/he receives no payment. This task provides a behavioral measure of competiveness (i.e., choosing to enter a competitive environment with subsequent performance).

- *Tournament choice for the past performance*. Subjects' compensation depends on their performance, i.e., the number of correct answers, provided in the piece-rate task. Participants choose which compensation scheme – piece-rate or tournament – to apply to their performance in the piece-rate task. If subjects choose piece-rate, they receive SG$1.50 per correct answer in the task. If subjects choose tournament, they receive SG$6.00 per correct answer if their performance in the task exceeded those of other group members regardless of their choice of compensation scheme; otherwise, they receive no payment. Niederle and Vesterlund (2007) suggest that tournament choice for past performance reflects general factors that might affect competitiveness such as overconfidence, risk attitude and feedback aversion. Thus, tournament choice for past performance provides an important control variable in the analysis of the relationship between competitiveness and stress.

The first two tasks are presented in a counter balanced order followed by a tournament choice for subsequent performance (competitiveness) and a tournament choice for past performance (general factors related to competitiveness). Subjects are compensated based on their performance in one of four tasks randomly chosen at the end of the experiment. In paying for one task, subjects have the appropriate incentive to perform well in the chosen task without the possibility of hedging across tasks.

After performing the four tasks, we elicit participants' beliefs about their relative performance in both piece-rate and tournament tasks among a group of four. Each participant makes a guess of her relative performance in terms of ranking between 1 and 4, and is paid SG$5.00 for each correct guess. This scheme provides a measure of the level of confidence in performance for both piece-rate and tournament. In addition, to test whether stress-related hormone response is specific to competitiveness or relate more generally to risk attitude, we include a measure of risk attitude using a price-list design. Subjects choose between an even-chance lottery paying either SG$10 or SG$0, and 10 levels of sure amounts ranging from SG$2.50 to SG$7.00. At the end, subjects complete a questionnaire on psychological anxiety and provide demographic information. The detailed instructions are presented in Appendix B.

Procedure. We measured cortisol levels from saliva samples. The procedure of the experiment is summarized in Figure 1. On Day 0, subjects arrived at the lab and were informed that the study was about the biological basis of decision making. They were given instructions to refrain from physical activity, eating or drinking (except water) for 90 minutes prior to their participation in the experiment on Day 1. To measure subjects' cortisol awakening response, they were then given a kit with specific instructions to provide three saliva samples on the morning of Day 1 to assess cortisol awakening response. Subjects were instructed to provide saliva samples at 0, 30, and 60 minutes post-awakening. Subjects kept the samples in the refrigerator until delivery to the experimenter on the morning of Day 1, using a cool box containing ice-packs.

Later on Day 1, subjects arrived at the lab at 14:00 to perform the experimental tasks from 14:00 to 16:00 to minimize the effect of circadian rhythm of cortisol. In addition, cortisol response is usually delayed after stressor termination. From the onset of the stressor, cortisol response reaches the peak in 15 to 20 minutes and returns to the baseline level about 40 to 60 minutes later (Dickerson and Kemeny, 2004). Due to this temporal profile of cortisol response, seven saliva samples were collected during the 90-minute session as follows (see Figure 1). The first saliva sample was collected 5 minutes after arrival (indicated as the "0 minute"), to be used to assess baseline cortisol level. Subjects were then given instructions for the first task (piece-rate or tournament depending on the assigned order). After the 5-minute task, a 40-minute break was given, wherein subjects sat by themselves and had the option to engage in light reading but not to speak with each other. In addition, three salivary samples were taken at 0 minute (immediately after the task), 15 minutes, and 40 minutes post-task to document the slow activity of the cortisol, anticipating that cortisol begins rising at 0 minute, peaks at about 15 minutes, and returns to its baseline at around 40 minutes. These three samples measure cortisol response induced by the first task. Subjects were then given instructions to perform the second 5-minute task, followed by a second 40-minute break. Three saliva samples were collected at 0 minutes (immediately after performing the second task), 15 minutes, and 40 minutes after second task. These second three samples measure cortisol response induced by the second task. Subjects then continued with the rest of the tasks without breaks until the end of the experiment.

We recruited 197 undergraduate Chinese participants, including 98 men (mean age: 22.75, SD = 1.31) and 99 women (mean age: 21.01, SD = 1.23),[3] from the National University of Singapore. Selection criteria stipulated that subjects must have no history of or current psychiatric disorder, past or present use of drugs including oral contraceptives, and not pregnant nor had given birth in the past year (compliance with these criteria was assessed by a self-report questionnaire). Informed consent was obtained for each subject using a form approved by the Internal Review Board at the National University of Singapore. Subjects received SG$30 as a show-up fee and additional payment depending on their performance during the experiment. The experiment was conducted at the laboratory of Center of Behavioral Economics, National University of Singapore.

Sampling and biochemical analysis. Saliva samples – three in the morning and seven in the afternoon (see Figure 1) – were collected in sterile tubes by passive drool using a short plastic straw for expectorating. Immediately after performing the experimental tasks, the seven salivary samples along with the three morning salivary samples (initially stored in ice boxes) were refrigerated and stored at –80 ℃ until assayed. Salivary cortisol concentration (nmol/ml) was determined using SalimetricsTM salivary cortisol enzyme immunoassay kit. All samples were measured twice and we took the mean as the measure.

The first sample (C_0) is taken at the beginning of the experiment, which measures the baseline cortisol (Cortisol: B). For the three samples collected at 0 minutes (C_1), 15 minutes (C_2), and 40 minutes (C_3) post the piece-rate task, we use the area-under-the-curve-with-respect-to-ground (AUCG) formula to compute the cortisol response for piece-rate (Cortisol: P) given by $\frac{15(C_1 + C_2)}{2} + \frac{25(C_2 + C_3)}{2}$. The AUCG formula is widely used in endocrinology to integrate information contained in repeated measurements over time (Pruessner et al., 2003). In our context, AUCG provides a measure of total cortisol release induced by the task. Similarly, we have three samples collected at 0 minutes (C_4), 15 minutes (C_5), and 40 minutes (C_6) post the tournament task and likewise compute the cortisol response (Cortisol: T) given by $\frac{15(C_4 + C_5)}{2} + \frac{25(C_5 + C_6)}{2}$. We further compute the differential response (Cortisol: T-P), given by the difference between tournament and piece-rate. We also use AUCG to compute cortisol

[3] Originally, we had 200 subjects composed of 100 men and 100 women. We noticed subsequently that three subjects participated in the experiment a second time due to screening errors and the data from their second participation were excluded. Due to the mandatory military service in Singapore for men starting at age 18, our male subjects were generally two years older than our female subjects.

awakening response (Cortisol: A). We shall be using these nomenclatures when we tabulate our results.

Salivary alpha-amylase. Besides measuring cortisol response, we also examine another stress biomarker, alpha-amylase, which can serve as a robustness check. It is known that alpha-amylase response peaks 10 to 15 minutes after the onset of the stressor, and returns to baseline in about 20-30 minutes. In our experiment, we measure alpha-amylase at 0 minutes (A_1), and 15 minutes (A_2) subsequent to the piece-rate task, mindful that these may not be the most accurate timing. Similarly, we measure alpha-amylase at 0 minutes (A_4), and 15 minutes (A_5) after the tournament task. The salivary alpha-amylase activity (U/ml) was determined using salivary alpha-amylase kinetic enzyme assay kit, and all samples were measured in duplicates. We similarly make use of the AUGG formula to compute the alpha-amylase response for piece-rate (Amylase: P), given by $\frac{15(A_1 + A_2)}{2}$, and the alpha-amylase response for tournament (Amylase: T), given by $\frac{15(A_4 + A_5)}{2}$. We also compute the differential response (Amylase: T-P), given by the difference between tournament and piece-rate.

Testosterone. We measured baseline testosterone from the first saliva sample collected 5 minutes after arrival. Salivary testosterone concentration (pg/ml) was determined using testosterone enzyme immunoassay kit, and all samples were measured in duplicates. We do not measure the response of testosterone after the task.

3. Results

We analyze the data and report our results in five steps. First, we summarize the behavioral observations, including competitiveness, performance, confidence, and risk attitude. Second, we summarize the cortisol response upon awakening and when induced by performing the experimental tasks in the same afternoon. Third, we investigate whether the observed cortisol response predicts competitiveness. Fourth, we examine whether alpha-amylase response could also predict competitiveness. Lastly, we consider the possible confounding factors of baseline testosterone, self-reported anxiety, and examine the potential interaction between stress response and gender.

3.1. Behavioral observations

Table 1A summarizes the aggregate behavioral observations.[4] 36% of the subjects choose tournament over piece-rate for the subsequent performance as in Task 3, and 29% of the subjects choose tournament over piece-rate for the past performance as in Task 4. On average, subjects solve 12.5 questions in the tournament and 12.3 questions in the piece-rate, and the performance is not significantly different between tournament and piece-rate (t-test, $p > 0.618$). For the tournament task, 30% of subjects guess their performance as ranked 1st, while 36% of the subjects guess their performance as ranked 2nd. Subjects are on average over-confident in their performance for tournament. For the piece-rate task, 22% of subjects guess their performance as ranked 1st, while 38% of the subjects guess their performance as ranked 2nd. There is no significant difference in confidence level in tournament and in piece-rate (t-test, $p > 0.115$). In the risk attitude task, 18.0% of subjects are risk seeking. Consistent with the observation of Niederle and Vesterlund (2007), the observed behaviors are generally correlated with each other using Spearman correlation tests (Table 2A). This led us to control the related behavioral factors, when we examine the relationship between competitiveness and stress in subsequent analyses.

3.2. Observations of cortisol response

We summarize the observations regarding cortisol response in Table 2A and Figure 2. Figure 2A plots baseline cortisol level, cortisol level induced by the piece-rate task and by the tournament task. In both piece-rate and tournament tasks, the measured cortisol levels at 15 minutes post-task is significantly higher than the baseline cortisol level at 0-minute (piece-rate, $p < 0.032$; tournament, $p < 0.001$), and also higher than 40-minute post-task cortisol level (piece-rate, $p < 0.001$; tournament, $p < 0.001$). Between tournament and piece-rate, the cortisol level at 15 minutes post tournament is significantly higher than that at 15 minutes post piece-rate ($p < 0.014$). The differential cortisol response between piece-rate and tournament is also significantly bigger than zero ($p < 0.066$). These results suggest that subjects experience stress indexed by cortisol response in both tasks, and more stress is experienced during tournament than piece-rate.

Figure 2B displays cortisol awakening response**.** As anticipated, the mean cortisol level 30 minutes post-awakening is significantly higher than the cortisol level immediately

[4] Moreover, we drop 10 subjects as outliers from the data analysis, 5 subjects whose performance falls more than 3 standard deviations from the norm and 5 subjects who have zero performance in some of the tasks. We have 187 subjects for the data analysis.

after awakening (0 minute) ($p < 0.001$), and 60 minutes post-awakening ($p < 0.001$). The cortisol response in piece-rate, tournament, cortisol awakening response, and baseline cortisol levels are positively correlated (Table 2B).

3.3. Cortisol response and competitiveness

3.3.1. Cortisol response induced by the tasks and competitiveness

Figure 3A plots for baseline cortisol level, cortisol level induced by the piece-rate task and induced by the tournament task for those choosing piece-rate and for those choosing tournament. Figure 3A reveals a clear pattern that, having similar baseline cortisol level, more competitive subjects have higher cortisol response in the tournament, as well as in the piece-rate. We test the relationship between cortisol and competitiveness using Probit regression with robustness standard error (Table 3). The dependent variable is competitiveness, and the independent variable is cortisol response in the tournament and the control variables including gender and order effect. Column (1) in Table 3 shows that the cortisol response in the tournament is significantly and positively correlated with competitiveness. The marginal effect of the Probit regression is 0.0008, which implies that one standard deviation change in cortisol response changes the probability of choosing tournament by 7.7%.

The observed relationship between cortisol response in the tournament choice with performance is consistent with the meta-analysis in Campbell and Ehlert (2012), which suggests that people with higher social desirability or stronger task engagement, such as trying to preserve a positive social image, have higher cortisol response. Nevertheless, there are other possible behavioral mechanisms. In particular, a heightened cortisol response may reflect a sense of engagement, which increases the performance in the tournament and subsequently increases the probability of choosing the tournament. We examine alternative mechanisms under which cortisol response may primarily affect performance, confidence, risk attitude or tournament choice for past performance leading to the observed correlation between cortisol response and competitiveness.

We examine these alternative mechanisms in two ways. Firstly, we control for a number of behavioral factors including performance in the tournament, performance difference between tournament and piece-rate, confidence in the tournament, confidence difference between tournament and piece-rate, risk attitude and tournament choice for past performance (Table 3, Columns 2 to 8). When we control for all these additional variables in the regression analysis, the relationship remains significant with the marginal effect dropped to 0.0006. Secondly, we test whether cortisol response in tournament significantly affects these behavioral factors (Table 4A). We find that none of these behavioral factors is significantly correlated with cortisol response in the tournament, except for confidence in the tournament (Column 3 of Table 4A). Cortisol response is marginally significantly correlated with confidence ($p < 0.067$), while this effect is not significant after controlling for competitiveness ($p > 0.334$).

Two of these robustness checks are of particular interest. First, when either performance or performance difference between tournament and piece-rate is included as additional independent variables, cortisol response remains significant and has the same effect size (Table 3, Column 2 and 3). This suggests that the effect of cortisol response on competitiveness is unlikely to be driven by performance. Moreover, cortisol response in the tournament task does not correlate with either performance or performance difference between tournament and piece-rate (Table 4A, Column 1 and 2). This suggests that performance is unlikely to be a channel for the correlation between cortisol response and competitiveness.

Second, when tournament choice with past performance is included as a control variable, our results remain significant (Table 3, Column 8). Moreover, cortisol response in the tournament task does not correlate with tournament choice for past performance (Table 4A, Column 6). This suggests that cortisol response is specific for competitiveness rather than other competitiveness-related factors measured in tournament choice with past performance. A similar pattern is observed in Niederle and Vesterlund (2007), where there is significant gender difference for competitiveness, but not for tournament choice with past performance. Moreover, gender difference in competitiveness remains significant after controlling for tournament choice with past performance. The overall evidence suggests that competitiveness and tournament choice for past performance represent distinct behaviors.

The results of our analyses support a robust link between cortisol response in the tournament and competitiveness. There remains a question whether this relationship is specific to cortisol response in the tournament. To examine this question further, we test whether cortisol response in the piece-rate task is significantly associated with competitiveness (Table 4B, Table 5A). Using similar regression analyses, Table 5A shows that the effect is also significant for cortisol response in the piece-rate before controlling for tournament choice with past performance. After we control for tournament choice with past performance together with other variables (see Column 8 in Table 5A), the significance level is dropped to $p > 0.151$. This suggests a weaker association for cortisol response in the piece-rate task. Moreover, cortisol response in the piece-rate task is not significantly associated with the other behavioral factors (see Table 4B). In examining whether the differential cortisol response between tournament and piece-rate may be correlated with tournament choice with performance (Table 5B) and other behavioral measures (Table 4C), we do not observe any significant relationship except for risk attitude.

Given the temporal profile of cortisol response, we examine the individual cortisol level at different time points by including the cortisol level for the 7 time points in a single regression analysis. We find that competitiveness is significantly correlated with cortisol level at 15 minutes after the tournament ($p < 0.019$), which represent the peak of the cortisol response induced by the tournament task, but not significantly correlated with baseline cortisol level along with other time points. Notably, the lack of association between baseline cortisol level and competitiveness replicates the earlier finding of Apicella et al (2011). This provides further support of the link between tournament-induced cortisol response and competitiveness.

3.3.2. Cortisol Awakening Response and Competitiveness

Figure 3B plots cortisol awakening response for those choosing piece-rate and for those choosing tournament. From the figure, more competitive subjects tend to have higher cortisol awakening response on the morning of the experiment. Adopting similar analyses, we test whether there is significant link between cortisol awakening response and competitiveness (Table 5C). Column (1) in Table 5C shows that the cortisol awakening response is significantly and positively correlated with competitiveness. The marginal effect of the Probit regression is 0.0003, which implies that one standard deviation in cortisol response increases the probability of choosing tournament by 8.2%. We further observe that the results are robust after controlling for other behavioral factors in Columns (2) to (8). Moreover, we do not observe significant association between cortisol awakening response and other competitiveness-related behavior (Table 4D). This observation is consistent with the notion that cortisol awakening response reflects the anticipation of demands of the upcoming day. More specifically, more competitive subjects may anticipate higher demands in response to stressful situations.

Lastly, if we include cortisol levels for the 3 time points in a single regression analysis, significance is observed only for peak level, 30 minutes after awakening ($p < 0.017$). Moreover, as the cortisol response in the tournament, piece-rate and cortisol awakening response are positively correlated (Table 2B), we include all three variables as independent variables in the regression analysis. We find that cortisol awakening response remains marginally significant at $p < 0.061$. While cortisol responses in tournament and in piece-rate are non-significant (tournament, $p > 0.166$; piece-rate, $p > 0.551$), an F-test shows that both variables are jointly significant at $p < 0.041$. In sum, our results suggest that cortisol responses during both tasks, and after awakening, can serve as biomarkers of the stress response to predict competitiveness.

3.4. Alpha-amylase and competitiveness

We observe that more competitive subjects have higher cortisol response, a biomarker of stress. In order to examine the robustness of the results, we include an additional biomarker of stress, namely, salivary alpha-amylase. Figure 2C plots alpha-amylase response in the piece-rate and tournament tasks. In Figure 2C, the first 0-minute refers to levels immediately after the piece-rate task and the first 15-minute refers to 15 minutes after the piece-rate task. The second 0-minute refers to levels immediately after the tournament task and the second 15-minute refers to 15 minutes after the tournament task. In both piece-rate and tournament tasks, the alpha-amylase response 15 minutes post-task is significantly higher than alpha-amylase levels at 0 minute ($p < 0.001$ for piece-rate; $p < 0.067$ for tournament). The alpha-amylase response at 0 minute post-tournament is marginally significantly higher than that post-piece-rate ($p < 0.071$), while the alpha-amylase response at 15 minutes post-tournament is not significant different from that post-piece-rate ($p > 0.198$). We suspect that this could be due to the fast response of the SAM axis for which the timing of our design is not able to capture precisely. Alternatively, this might suggest a potentially different adaptive response in the form of attenuation of the SAM axis in relation to the stress experienced by the subjects.

Figure 3C plots of alpha-amylase response for those choosing piece-rate and for those choosing tournament. From the figure, more competitive subjects have higher alpha-amylase response in tournament as well as in piece-rate. Adopting similar regression analyses, we test for the relationship between alpha-amylase in tournament and competitiveness (Table 6A). Column (1) in Table 6A shows that alpha-amylase response in the tournament is significantly and positively correlated with competitiveness. The marginal effect of Probit regression is 0.00008, which implies that one standard deviation in alpha-amylase increases the probability of choosing tournament by 6.5%. We further observe that the results are robust after controlling for other behavioral factors in Columns (2) to (8). For the relationship between alpha-amylase response and other behavioral measures, we conduct a similar analysis (Table 7A). We observe significant positive correlation between alpha-amylase response and performance in the tournament, confidence in the tournament, and confidence difference between tournament and piece-rate. However, all effects are not significant after we further control for competitiveness, which suggests that the primary correlation is between alpha-amylase response and competitiveness. Similarly, we observe significant association for alpha-amylase in the piece-rate (Table 6B and 7B), but not for differential response between tournament and piece-rate (Table 6C and 7C).

Notably, from the correlations in table 2B, alpha-amylase responses in the tournament and in the piece-rate are not significantly correlated with cortisol responses in the tournament and in the piece-rate. This suggests that alpha-amylase response and cortisol response capture the different stress systems of the SAM and HPA axes, respectively. Moreover we observe significant negative correlation between cortisol awakening response and alpha-amylase responses in the tournament as well as in the piece-rate. Finally, we include cortisol awakening response, cortisol response in the tournament and in the piece-rate, alpha-amylase response in the tournament and in the piece-rate as independent variables in the regression analysis, and find that cortisol awakening response remains significant at $p < 0.014$. The individual response during the tasks is not significant except for alpha-amylase response in the piece-rate ($p < 0.012$). Additional F-test reveals that the joint effect of cortisol response in the tournament and in the piece-rate is marginally significant at $p < 0.058$, and the joint effect of alpha-amylase response in the tournament and in the piece-rate is significant at $p < 0.009$. Moreover, the result of a joint F-test for all three variables is highly significant at $p < 0.001$. Alternatively, when we include all 10 measures of cortisol levels, and 4 measures of alpha-amylase levels in the regression, we observe significance for cortisol awakening response 30 minutes after awakening ($p < 0.006$), cortisol levels 15 minutes after the tournament task ($p < 0.096$) and cortisol levels 15 minutes after the piece-rate task ($p < 0.002$). Overall, our results suggest a robust relationship between the stress response, as measured by cortisol and alpha-amylase, and competitiveness.

3.5. Robustness Checks

3.5.1. Testosterone and competitiveness

Our observation between competitiveness and stress could be subject to omitted variable bias. In particular, cortisol response may be correlated with other hormones, especially testosterone. Testosterone has been suggested to be an important part of the neuroendocrine patterns in response to aggression and competition (Archer, 2006). Although our primary interest is cortisol response, we also include a baseline measure of testosterone at the beginning of the experiment.

From Table 2B, we can see that testosterone is positively correlated with baseline cortisol levels and cortisol response in the tournament. Firstly, we test whether baseline testosterone predicts competitiveness using similar analysis (Table A1 in Appendix A). We find that testosterone is significantly and positively correlated with competitiveness. That is, subjects who have higher baseline testosterone level are more likely to choose tournament. However, after we further include risk attitude in the independent variable, the results are no longer significant ($p > 0.284$). This suggests that baseline testosterone level is correlated with competitiveness through the effect of risk attitude. Moreover, our observed results on cortisol response and alpha-amylase remain significant after we further control for baseline testosterone (Table A2 in Appendix A, Panel A).

3.5.2. Self-reported psychological stress and competitiveness

Although we observe a positive relation between the stress response and competitiveness, our results do not demonstrate the direction of the causality. On the one hand, it is possible that more competitive subjects care more about the outcomes of the tasks leading to higher stress response. This first possibility is consistent with observations from a meta-analysis of 358 studies in Campbell and Ehlert (2012), in which they observe that social desirability, motivation engagement and aggression lead to higher cortisol response.

On the other hand, it is also possible that subjects experience higher stress response which results in more competitive behavior. This second possibility is less likely, as the cortisol response is commonly shown to be uncorrelated with psychological stress, and subjects usually cannot perceive their own cortisol response (Campbell and Ehlert, 2012). To further test this possibility, at the end of the experiment before the payment is revealed, we include 20 self-report questions from a psychological inventory called State-Trait Anxiety Inventory (Spielberger et al 1983), which measures anxiety levels at the moment. For example, subjects are asked to report on a scale from 1 to 4 to a question “I am tense”. Higher scores reflect higher levels of psychological anxiety. We find that the state anxiety scores are not correlated with any of the stress response measures of cortisol and alpha-amylase (Spearman correlation < 0.055, $p > 0.464$). This is consistent with existing studies which does not show a relationship between self-reported psychological stress and physiological response of cortisol (Dickerson and Kemeny, 2004). One possible reason is that psychological and physiological stress taps on different brain networks, and another possible reason is that the self-reported psychological stress questionnaire cannot capture transient changes of physiological reactivity over time.

We further test whether the state anxiety score predicts competitiveness (Table A3 in Appendix A). We find that state anxiety score is significantly negatively correlated with competitiveness. That is, subjects reporting higher levels of anxiety score at the moment are more likely to choose piece-rate but this is no longer significant after we include the additional behavioral factors related to competitiveness ($p > 0.219$). This suggests that the association of state anxiety score with competitiveness may come through the behavioral factors related to competitiveness including performance and confidence. Moreover, our observed results on cortisol response and alpha-amylase remain significant after controlling for anxiety score (Table A2, Panel B).

3.5.3. Possible role of gender

This subsubsection explores the possible role of gender. Gender could be a concern in our study for two reasons. Firstly, as gender difference in competitiveness is the key finding in Niederle and Vesterlund (2007), it would be of interest to see whether we could replicate the observation in our sample. Secondly, it has been hypothesized that men and women may react differently to stressors, especially social stressors (Taylor et al., 2000). For example, men have significantly higher cortisol levels than women in response to public speaking tasks (Shalev et al., 2009). Moreover, anticipatory cortisol responses in judo competition were observed among young men, while studies report mixed findings on competition and cortisol among women (Salvador, 2005).

Separating the analysis by gender in Table 1A, we find that men tend to be more confident than women about their performance in the tournament ($p < 0.073$), consistent with previous studies that men are more over-confident (Niederle and Vesterlund, 2007). Moreover, men perform significantly better than women in the tournament task ($p < 0.017$), but not in piece-rate ($p > 0.429$), while the gender difference is not significant after controlling for confidence ($p > 0.322$). We do not find significant gender difference in risk attitude ($p > 0.824$). We observe an 8.4% gender difference in competitiveness (40.0% of men and 31.6% of women choose tournament over piece-rate in Task 3), which is not statistically significant ($p > 0.201$). This contrasts with Niederle and Vesterlund (2007) who find that 73% of their male subjects select tournament over 35% of female subjects making the same choice in a sample of 80 subjects from the University of Pittsburgh. We do not find significant gender difference in competitiveness after further controlling for performance, confidence, risk attitude, age and order of the first two tasks (Table A4 in Appendix A). The lack of replication of Niederle and Vesterlund (2007) could be attributed to culture or subtle differences in experimental design, which we leave it for future studies.

For the hormones, there is no significant gender difference in cortisol response in baseline cortisol ($p > 0.598$), piece-rate ($p > 0.585$), tournament ($p > 0.301$), and differential response ($p > 0.435$). Consistent with previous findings (Nater and Rohleder, 2009), women have significantly higher cortisol awakening response than men ($p < 0.001$). Men have marginally significantly higher overall alpha-amylase response than women in piece-rate task ($p < 0.085$), significantly higher alpha-amylase response in the tournament task ($p < 0.016$), and marginally significant differential response between the two conditions ($p < 0.062$).

To test for the possible role of gender in the observed relationship between competitive and stress, we include the interaction term between gender and stress response including cortisol response in tournament and piece rate, cortisol awakening response, and alpha-amylase response in tournament and piece rate. We do not find significance for any of these interaction terms (Table A2, Panel C). This suggests that among undergraduate Chinese participants the stress response correlates with competitiveness for men and women similarly.

4. Concluding Remarks

Stress has received little attention in economics. In the laboratory setting, we adopt the simple addition tasks in Niederle and Vesterlund (2007) to induce stress, proxied by cortisol response, and study its relationship with competitiveness. Our observation of substantial stress response of cortisol in both piece-rate and tournament tasks points to the efficacy of observing stress levels in economic experiments. Moreover, subjects tend to have higher cortisol response during tournament than during piece-rate, suggesting higher level of stress during tournament task. We uncover the role of task-induced cortisol response as well as cortisol awakening response, rather than baseline cortisol level, in predicting competiveness. We further provide a robust check using a second biomarker for a distinct physiological stress system (SAM) – salivary alpha-amylase, and observe a similar pattern. Finally, we examine the possible role of baseline testosterone levels and self-reported anxiety levels, and find that these do not contribute to the observed relationship between competitiveness and stress. Overall, our results suggest that more competitive individuals tend to have higher stress response across the body's principal stress systems. Our study represents the first demonstration of a direct role of within-tasks stress response in relation to a laboratory-observed disposition to compete, and contribute to extending the scope of research in economics to encompass stress.

One weakness of our study is the lack of direct evidence examining the casual effect. To demonstrate causality, given that the observed relationship is between competitiveness and stress response, one might need to have intervention treatments either to change the competitiveness preference, or to change the stress response instead of baseline cortisol. For instance, one may have subjects employ emotion regulation to be less competitive, and then test whether emotion regulation affects cortisol response. In this regard, Sokol-Hessner et al (2009) instruct subjects to think like a trader, and find that emotion regulation affects both loss aversion and skin conductance response to losses. However, it remains unclear whether emotion regulation primarily affects behavior followed by physiological response or the other way around. Alternatively, one may adopt a pharmacological approach to manipulate the cortisol system and see how it may affect competitiveness. For example, Kandasamy et al (2014) raise cortisol levels using individually tailored hydrocortisone regimens, and examine their effect on financial risk taking behavior. This could be powerful in demonstrating the casual role of cortisol in competitiveness. While hydrocortisone increases cortisol level, it is not clear how it would affect cortisol response during task performance. Moreover, Mehta and Josephs (2006) manipulate testosterone levels using a competition game, and find that losers with increased testosterone levels are more likely to choose competition than losers with decreased testosterone levels. More recently, Apicella, Dreber and Mollerstrom (2014) find that testosterone changes after monetary wins and losses in a chance game predict subsequent risk-taking behavior. While some behavioral tasks could be used to induce changes in cortisol level, it is not clear how it would affect cortisol response subsequently and whether it would change other hormones as well. While we believe that it is highly valuable to demonstrate a causal relationship between competitiveness and stress, running experiments testing for directional casualty could be a challenge which we leave for future studies.

Our study investigates the response to acute stress and competitiveness in the laboratory. It would be of interest to examine stress in the field or natural settings. Evans and Kim (2007) find that the number of years spent living in poverty during childhood is associated with elevated overnight cortisol and a more dysregulated cardiovascular response, while concurrent poverty, i.e., during adolescence, does not affect these physiological stress outcomes. More recently, Chemin et al (2013) observe that low levels of rain in the preceding year increased cortisol levels among farmers in Kenya. Thus, it would be of great interest to investigate whether and how these different contracts such as piece-rate and tournament change the cortisol response in the long run, and whether and how the cortisol response induced by chronic job stress would in turn predict career choice in the workplace.

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Figures and Tables

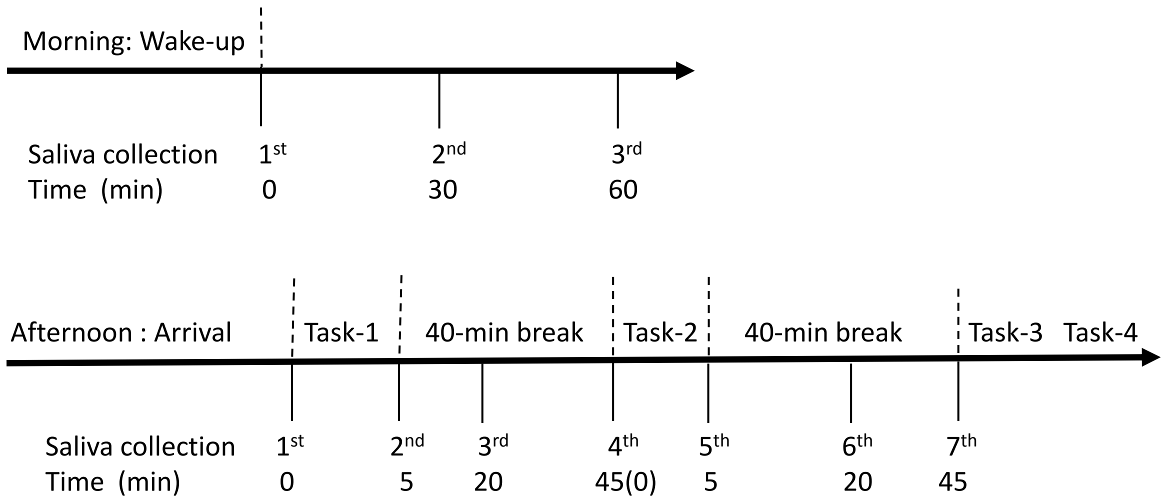

Figure 1. Experimental Design and Timeline. Three saliva samples were collected in the morning to assess the cortisol awakening response at 0, 30, and 60 minutes post awakening. Seven saliva samples were collected in the afternoon session: before Task 1; at 0, 15, and 40 minutes post-Task 1; and at 0, 15, and 40 minutes post-Task 2.

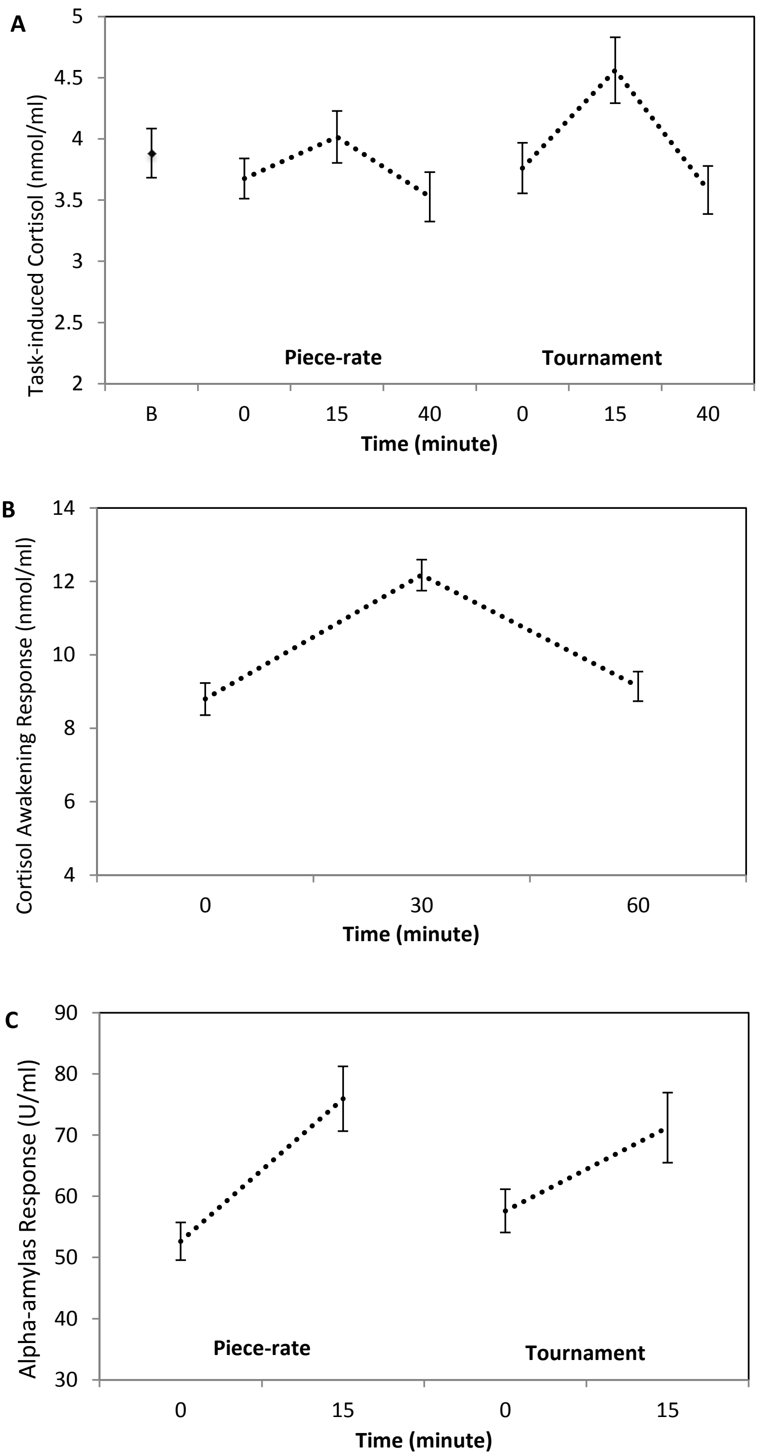

Figure 2. **Stress Response**. A. Task-induced cortisol response. X-axis is the timeline and Y-axis is the response. B. Cortisol awakening response. X-axis is the timeline and Y-axis is the response. C. Task-induced alpha-amylase response. X-axis is the timeline and Y-axis is the response. As we counter-balanced the order of piece-rate and tournament tasks, we reorder the timeline to show the stress response induced by the piece-rate task and tournament task.

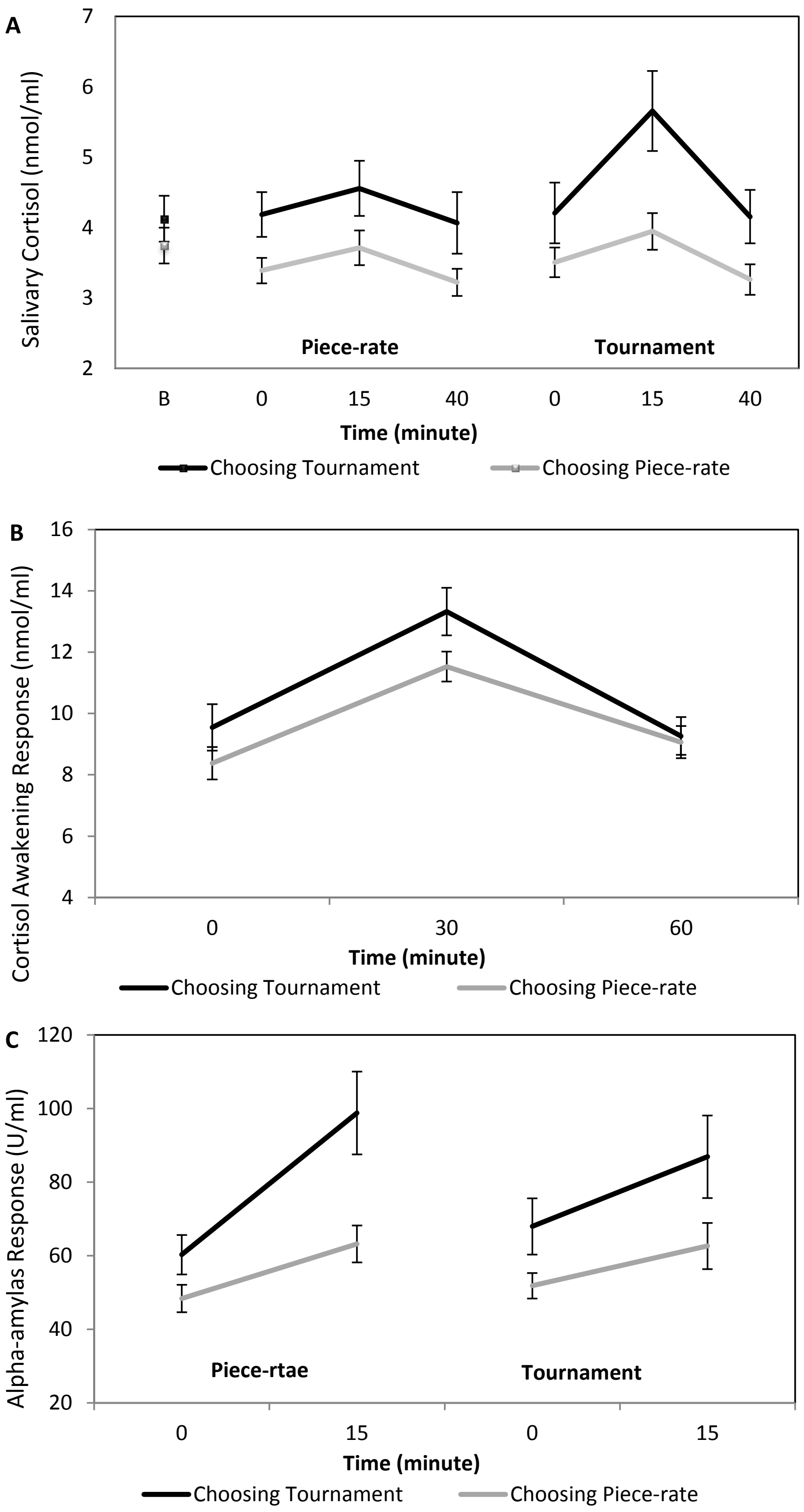

Figure 3. Stress response and competitiveness. A. Task-induced cortisol response by subjects choosing tournament and choosing piece-rate. X-axis is the timeline and Y-axis is the response. B. Cortisol awakening response by subjects choosing tournament and choosing piece-rate. X-axis is the timeline and Y-axis is the response. C. Task-induced alpha-amylase response by subjects choosing tournament and choosing piece-rate. X-axis is the timeline and Y-axis is the response. As we counter-balanced the order of piece-rate and tournament tasks, we reorder the timeline to show the stress response induced by the piece-rate task and tournament task.

Table 1. Summary Statistics

Panel A: Behavior

Behavior	Pool			Men			Women			Difference
	N	Mean	SD	N	Mean	SD	N	Mean	SD	p-value
Tournament choice w performance	187	0.358	0.48	96	0.396	0.49	91	0.319	0.47	0.270
Tournament choice w/o performance	187	0.289	0.45	96	0.323	0.47	91	0.253	0.44	0.254
Performance: P	187	12.310	3.93	96	12.531	4.09	91	12.077	3.75	0.309
Performance: T	187	12.460	3.81	96	12.948	4.32	91	11.945	3.11	0.073
Performance: T-P	187	0.150	4.10	96	0.417	3.85	91	-0.132	4.35	0.367
Confidence: P	187	2.316	0.98	96	2.177	0.95	91	2.462	1.00	0.039
Confidence: T	187	2.171	1.00	96	2.042	1.00	91	2.308	0.99	0.054
Confidence: T-P	187	-0.144	1.25	96	-0.135	1.05	91	-0.154	1.43	0.796
Risk attitude	178	4.326	2.18	92	4.326	2.18	86	4.267	1.89	0.962

Note. The table presents the summary statistics for behavioral variables and hormonal variables for pool as well as for men and women separately. The first column displays the name of the variable. Columns 2 to 10 display the sample size (N), mean and standard deviation (SD) for pool, men and women, respectively. The last column reports p-value testing whether there is significant gender difference. Panel A summarizes the percentages of choosing tournament over piece-rate in Task 3 and Task 4, performance in piece-rate and in tournament, difference in performance between piece-rate and tournament, confidence in piece-rate and in tournament (rank between 1 and 4), difference in confidence between piece-rate and tournament, and risk attitude (between 0 and 10 with 5 indicating risk neutrality). For risk attitude, we excluded 5 men and 5 women who exhibited multiple switch points in the price-list task.

Panel B: Stress Hormone

Stress Hormone	Pool			Men			Women			Difference
	N	Mean	SD	N	Mean	SD	N	Mean	SD	p-value
Awakening 1	185	8.79	5.93	95	8.34	5.26	90	9.27	6.55	0.295
Awakening 2	185	12.17	5.75	95	10.85	5.44	90	13.56	5.76	0.001
Awakening 3	184	9.14	5.47	94	7.66	4.70	90	10.68	5.81	0.001
Cortisol: A	184	633.59	272.44	94	564.34	256.47	90	705.93	271.16	0.001
Baseline Cortisol	186	3.88	2.74	96	3.98	3.21	90	3.77	2.14	0.598
Piece-rate C1	187	3.68	2.25	96	3.54	2.00	91	3.82	2.49	0.410
Piece-rate C2	187	4.02	2.90	96	4.39	3.47	91	3.62	2.10	0.064
Piece-rate C3	186	3.53	2.75	95	3.28	2.27	91	3.78	3.16	0.215
Cortisol: P	185	164.84	119.13	95	156.02	104.57	91	148.28	87.70	0.585
Tournament C4	185	3.76	2.81	95	3.96	3.12	90	3.56	2.43	0.332
Tournament C5	187	4.56	3.68	96	4.94	3.98	91	4.15	3.31	0.141
Tournament C6	187	3.58	2.68	96	3.56	2.39	91	3.61	2.97	0.891
Cortisol: T	186	152.23	96.51	95	173.66	123.30	90	155.53	114.52	0.301
Cortisol: T-P	184	12.40	91.03	94	17.49	108.96	90	7.08	67.63	0.435
Piece-rate A1	186	52.64	42.08	95	56.11	40.55	91	49.03	43.55	0.275
Piece-rate A2	187	75.92	72.31	96	85.68	79.27	91	65.63	62.97	0.058
Amylase: P	186	964.44	813.39	95	1064.56	863.75	91	859.93	747.75	0.092
Tournament A4	187	57.61	48.55	96	65.33	53.44	91	49.46	41.53	0.025
Tournament A5	186	71.21	78.12	95	84.20	87.44	91	57.66	64.77	0.021
Amylase: T	186	965.52	909.20	95	1120.80	1010.72	91	803.42	761.72	0.017
Amylase: T-P	185	8.54	468.69	94	71.52	544.87	91	-56.50	365.93	0.060
Testosterone	186	108.00	57.63	95	147.70	52.04	91	66.56	24.47	0.001

Note. Panel B summarizes three cortisol measures in the morning (Awakening 1 to 3), overall awakening response (Cortisol: A), baseline cortisol before the task, three cortisol measure induced by piece-rate (C1-C3), overall piece-rate induced cortisol response (Cortisol: P), three cortisol measures induced by tournament (C4-C6), overall tournament induced cortisol response (Cortisol: T) and differential cortisol response between tournament and piece-rate (Cortisol: T-P). For alpha-amylase, we have two measures induced by piece-rate (A1, A2), overall piece-rate induced response (Amylase: P), two measures included by tournament (A4, A5), overall tournament induced response (Amylase: T), and differential response between tournament and piece-rate (Amylase: T-P), and baseline testosterone. In addition, there are a few missing values in some of the hormone measures.

Table 2. Correlational Analysis

Panel A: Behavior

	Tournament choice w performance	Tournament choice w performance	Performance: P	Performance: T	Confidence: P	Confidence: T
Tournament choice w/o performance	0.394***					
Performance: P	0.252***	0.310***				
Performance: T	0.180**	-0.038	0.388***			
Confidence: P	-0.291***	-0.632***	-0.532***	-0.172**		
Confidence: T	-0.335***	-0.248***	-0.225**	-0.589***	0.233**	
Risk attitude	0.278***	0.251***	0.176**	0.050	-0.230**	-0.207**

Note. Panel A presents the spearman correlations for behavioral variables including choosing tournament in Task 3 and Task 4, performance in piece-rate and in tournament, confidence in piece-rate and in tournament, and risk attitude. ***significant at 1% level, **5% level, *10% level.

Panel B: Stress Hormone

	Cortisol: B	Cortisol: A	Cortisol: P	Cortisol: T	Amylase: P	Amylase: T
Cortisol: A	0.232***					
Cortisol: P	0.524***	0.173**				
Cortisol: T	0.459***	0.132*	0.694***			
Amylase: P	-0.074	-0.139**	-0.005	0.016		
Amylase: T	-0.054	-0.173**	0.080	0.042	0.805***	
Testosterone	0.179**	-0.076	0.102	0.149**	0.015	0.036

Note. Panel B presents the spearman correlations for stress hormone variables including baseline cortisol (Cortisol: B), overall cortisol awakening response (Cortisol: A), overall piece-rate induced cortisol response (Cortisol: P), overall tournament induced cortisol response (Cortisol: T), overall piece-rate induced alpha-amylase response (Amylase: P), overall tournament induced alpha-amylase response (Amylase: T) and baseline testosterone. ***significant at 1% level, **5% level, *10% level.

Table 3. Competitiveness and Cortisol Response in Tournament

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cortisol: T	0.0008***	0.0008**	0.0008***	0.0007**	0.0008***	0.0008**	0.0006**	0.0006*
	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]
Performance: T		0.0244**					0.0117	0.0242*
		[0.0105]					[0.0137]	[0.0138]
Performance: T – P			-0.0106				-0.0249	-0.0201
			[0.0129]				[0.0163]	[0.0159]
Confidence: T				-0.1640***			-0.2072***	-0.0668
				[0.0434]			[0.0660]	[0.0783]
Confidence: T – P					-0.0213		0.0722	-0.0230
					[0.0305]		[0.0492]	[0.0600]
Risk attitude						0.0719***	0.0545**	0.0537**
						[0.0198]	[0.0217]	[0.0223]
Tournament choice w/o performance								0.3505***
								[0.1135]
Gender	-0.0639	-0.0432	-0.0691	-0.0214	-0.0644	-0.0748	-0.0194	-0.0288
	[0.0717]	[0.0735]	[0.0724]	[0.0748]	[0.0718]	[0.0746]	[0.0828]	[0.0847]
Order effect	-0.0392	0.0162	-0.0960	0.0087	-0.0233	-0.0650	-0.1552	-0.1234
	[0.0738]	[0.0798]	[0.1004]	[0.0769]	[0.0777]	[0.0765]	[0.1039]	[0.1047]
Observations	185	185	185	185	185	176	176	176
Pseudo R-squared	0.0351	0.0575	0.0386	0.111	0.0372	0.0948	0.184	0.222

Note. Probit regression on the relationship between competitiveness and cortisol response in tournament. The dependent variable is competitiveness, and the independent variables include cortisol response in tournament, performance in tournament, performance difference between tournament and piece-rate, confidence in tournament, confidence difference between tournament and piece-rate, risk attitude, tournament choice without performance, gender, and order effect. The table reports the marginal effects with robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Cortisol Response and Other Behavior Measurements

(1) Performance: T	(2) Performance: T-P	(3) Confidence: T	(4) Confidence: T-P	(5) Risk attitude	(6) Tournament choice w/o performance
Panel A: Cortisol: T					
0.0052	-0.0014	-0.0010*	-0.0005	0.0017	0.0003
[0.0035]	[0.0021]	[0.0006]	[0.0006]	[0.0012]	[0.0003]
Panel B: Cortisol: P					
0.0049	-0.0013	-0.0009	0.0002	0.0002	0.0004
[0.0033]	[0.0031]	[0.0007]	[0.0008]	[0.0016]	[0.0004]
Panel C: Cortisol: T-P					
0.0034	-0.0005	-0.0008	-0.0013	0.0028*	-0.00004
[0.0059]	[0.0033]	[0.0008]	[0.0009]	[0.0017]	[0.0004]
Panel D: Cortisol: A					
0.0002	-0.0004	-0.00005	0.0001	0.0009	0.00004
[0.0010]	[0.0008]	[0.0003]	[0.0003]	[0.0006]	[0.0001]

Note. Regression on the relationship between competitiveness related factors and cortisol response. The dependent variable includes performance in tournament (Column 1), performance difference between tournament and piece-rate (Column 2), confidence in tournament (Column 3), confidence difference between tournament and piece-rate (Column 4), risk attitude (Column 5), tournament choice without performance (Column 6). The independent variables are cortisol response in tournament (Panel A), cortisol response in piece-rate (Panel B), cortisol response difference between tournament and piece-rate (Panel C), cortisol awakening response (Panel D). The table reports regression coefficients with robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Competitiveness and Cortisol Response in Piece-rate, Difference Between Piece-rate and Tournament, and after Awakening

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Panel A: Cortisol: P				
Cortisol: P	0.0008**	0.0007*	0.0008**	0.0007*	0.0008**	0.0009**	0.0007*	0.0006
	[0.0004]	[0.0004]	[0.0004]	[0.0004]	[0.0004]	[0.0004]	[0.0004]	[0.0004]
				Panel B: Cortisol: T-P				
Cortisol: T-P	0.0005	0.0004	0.0005	0.0003	0.0004	0.0002	0.0001	0.0002
	[0.0004]	[0.0004]	[0.0004]	[0.0004]	[0.0004]	[0.0005]	[0.0004]	[0.0005]
				Panel C: Cortisol: A				
Cortisol: M	0.0003**	0.0003**	0.0003**	0.0003**	0.0003**	0.0002*	0.0002	0.0003*
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]
Performance: T		Y					Y	Y
Performance: T - P			Y				Y	Y
Confidence: T				Y			Y	Y
Confidence: T - P					Y		Y	Y
Risk attitude						Y	Y	Y
Tournament choice w/o performance								Y
Gender	Y	Y	Y	Y	Y	Y	Y	Y
Order effect	Y	Y	Y	Y	Y	Y	Y	Y

Note. Probit regression on the relationship between competitiveness and cortisol response in piece-rate, difference between piece-rate and tournament, and after awakening. The dependent variable is competitiveness, and the independent variables include cortisol response in piece-rate (Panel A), difference between piece-rate and tournament (Panel B), and after awakening (Panel C). We have a number of control variables including performance in tournament, performance difference between tournament and piece-rate, confidence in tournament, confidence difference between tournament and piece-rate, risk attitude, tournament choice without performance, gender, and order effect. The table reports the marginal effects with robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6. Competitiveness and Alpha-amylase Response

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Panel A: Amylase: T				
Amylase: T	0.00008*	0.00006	0.00008**	0.00005	0.00007*	0.00009**	0.00008*	0.00006
	[0.00004]	[0.00004]	[0.00004]	[0.00004]	[0.00004]	[0.00004]	[0.00004]	[0.00005]
				Panel B: Amylase: P				
Amylase: P	0.00012**	0.00011**	0.00012***	0.00009*	0.00012**	0.00014***	0.00014**	0.00013**
	[0.00005]	[0.00005]	[0.00005]	[0.00005]	[0.00005]	[0.00005]	[0.00006]	[0.00006]
				Panel C: Amylase: T-P				
Amylase: T-P	-0.00005	-0.00007	-0.00005	-0.00007	-0.00005	-0.00007	-0.00011	-0.00012
	[0.00008]	[0.00008]	[0.00008]	[0.00007]	[0.00008]	[0.00009]	[0.00009]	[0.00008]
Performance: T		Y					Y	Y
Performance: T - P			Y				Y	Y
Confidence: T				Y			Y	Y
Confidence: T - P					Y		Y	Y
Risk attitude						Y	Y	Y
Tournament choice w/o performance								Y
Gender	Y	Y	Y	Y	Y	Y	Y	Y
Order effect	Y	Y	Y	Y	Y	Y	Y	Y

Note. Probit regression on the relationship between competitiveness and alpha-amylase response. The dependent variable is competitiveness, and the independent variables include alpha-amylase response in tournament (Panel A), alpha-amylase response in piece-rate (Panel B), and difference between tournament and piece-rate (Panel C). We include a number of control variables including performance in tournament, performance difference between tournament and piece-rate, confidence in tournament, confidence difference between tournament and piece-rate, risk attitude, tournament choice without performance, gender, and order effect. The table reports the marginal effects with robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 7. Alpha-amylase Response and Other Behavior Measurements

(1) Performance: T	(2) Performance: T-P	(3) Confidence: T	(4) Confidence: T-P	(5) Risk attitude	(6) Tournament choice w/o performance
Panel A: Amylase: T					
0.0007*	0.0002	-0.0002***	-0.0002**	-0.0001	0.00004
[0.0003]	[0.0003]	[0.0001]	[0.0001]	[0.0002]	[0.00004]
Panel B: Amylase: P					
0.0006*	0.0002	-0.0002***	-0.0002**	-0.00003	0.00006
[0.0003]	[0.0003]	[0.0001]	[0.0001]	[0.0002]	[0.00004]
Panel C: Amylase: T-P					
0.0007	0.0003	-0.00006	-9.55e-06	-0.00008	-8.48e-06
[0.0007]	[0.0006]	[0.0001]	[0.0002]	[0.0003]	[0.00006]

Note. Regression on the relationship between competitiveness related factors and alpha-amylase response. The dependent variable includes performance in tournament (Column 1), performance difference between tournament and piece-rate (Column 2), confidence in tournament (Column 3), confidence difference between tournament and piece-rate (Column 4), risk attitude (Column 5), and tournament choice without performance (Column 6). The independent variables are alpha-amylase response in tournament (Panel A), alpha-amylase response in piece-rate (Panel B), alpha-amylase response difference between tournament and piece-rate (Panel C). The table reports the regression coefficients with robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Appendix A: Appended Tables

Table A1. Competitiveness and Baseline Testosterone

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Testosterone	0.0015*	0.0016*	0.0015*	0.0016*	0.0015	0.0010	0.0013	0.0009
	[0.0009]	[0.0009]	[0.0009]	[0.0009]	[0.0009]	[0.0009]	[0.0009]	[0.0009]
Performance: T		0.0254**					0.0127	0.0248*
		[0.0101]					[0.0130]	[0.0131]
Performance: T - P			-0.0109				-0.0259	-0.0207
			[0.0125]				[0.0159]	[0.0153]
Confidence: T				-0.1676***			-0.2021***	-0.0646
				[0.0413]			[0.0621]	[0.0740]
Confidence: T - P					-0.0228		0.0699	-0.0237
					[0.0300]		[0.0479]	[0.0582]
Risk attitude						0.0716***	0.0500**	0.0497**
						[0.0195]	[0.0204]	[0.0207]
Tournament choice w/o performance								0.3458***
								[0.1125]
Gender	0.0524	0.0787	0.0487	0.0951	0.0481	-0.0047	0.0710	0.0332
	[0.1022]	[0.1042]	[0.1017]	[0.1015]	[0.1027]	[0.1042]	[0.1098]	[0.1135]
Order effect	-0.0016	0.0561	-0.0612	0.0441	0.0147	-0.0256	-0.1171	-0.0841
	[0.0712]	[0.0760]	[0.0953]	[0.0742]	[0.0749]	[0.0733]	[0.1024]	[0.1035]
Observations	186	186	186	186	186	177	177	177
Pseudo R-squared	0.0173	0.0441	0.0211	0.100	0.0197	0.0755	0.169	0.207

Note. Probit regression on the relationship between competitiveness and testosterone. The dependent variable is competitiveness, and the independent variables include baseline testosterone, performance in tournament, performance difference between tournament and piece-rate, confidence in tournament, confidence difference between tournament and piece-rate, risk attitude, tournament choice without performance, gender, and order effect. The table reports the marginal effects with robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2: Testosterone, Anxiety, and Interaction with Gender

	(1) Cortisol: T	(2) Cortisol: P	(3) Cortisol: A	(4) Alpha-amylase: T	(5) Alpha-amylase: P
Panel A: Control for Baseline Testosterone					
Hormone	0.0009***	0.0008**	0.0003*	0.00008**	0.0001***
	[0.0003]	[0.0004]	[0.0001]	[0.00004]	[0.00005]
Panel B: Control for State-trait Anxiety					
Hormone	0.0008***	0.0008**	0.0003**	0.00008*	0.0001**
	[0.0003]	[0.0004]	[0.0001]	[0.00004]	[0.00005]
Panel C: Interaction Effect with Gender					
Hormone	0.0010**	0.0004	0.0004*	0.0001	0.0002**
	[0.0004]	[0.0005]	[0.0002]	[0.00005]	[0.0001]
Gender	-0.0227	-0.2207*	-0.0276	-0.0718	0.0239
	[0.1232]	[0.1305]	[0.1933]	[0.1070]	[0.1175]
Interaction	-0.0002	0.0010	-0.0001	0.00002	-0.00008
	[0.0006]	[0.0008]	[0.0003]	[0.0001]	[0.00009]

Note. Robustness checks for the observed relationship between competitiveness and cortisol response in tournament (Column 1), cortisol response in piece-rate (Column 3), alpha-amylase response in tournament (Column 4), alpha-amylase response in piece-rate (Column 5). Panel A controls the role of baseline testosterone, Panel B controls the role of State-trait Anxiety, and Panel C examines the interaction effect with gender. The table reports the marginal effects with robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A3. State-trait Anxiety and Tournament Choice with Performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
State-trait Anxiety	-0.0080**	-0.0074**	-0.0078**	-0.0060*	-0.0078**	-0.0067*	-0.0046	-0.0050
	[0.0036]	[0.0037]	[0.0036]	[0.0037]	[0.0036]	[0.0038]	[0.0040]	[0.0040]
Performance: T		0.0247**					0.0121	0.0252*
		[0.0099]					[0.0128]	[0.0130]
Performance: T - P			-0.0090				-0.0238	-0.0180
			[0.0127]				[0.0157]	[0.0151]
Confidence: T				-0.1619***			-0.1971***	-0.0482
				[0.0422]			[0.0633]	[0.0755]
Confidence: T - P					-0.0213		0.0712	-0.0292
					[0.0307]		[0.0486]	[0.0585]
Risk attitude						0.0733***	0.0544***	0.0540***
						[0.0191]	[0.0203]	[0.0209]
Tournament choice w/o performance								0.3719***
								[0.1104]
Gender	-0.0623	-0.0438	-0.0656	-0.0279	-0.0636	-0.0825	-0.0334	-0.0392
	[0.0712]	[0.0725]	[0.0716]	[0.0736]	[0.0713]	[0.0733]	[0.0804]	[0.0827]
Order effect	0.0036	0.0596	-0.0449	0.0475	0.0185	-0.0251	-0.1086	-0.0758
	[0.0708]	[0.0754]	[0.0968]	[0.0736]	[0.0746]	[0.0738]	[0.1027]	[0.1037]
Observations	187	187	187	187	187	178	178	178
Pseudo R-squared	0.0252	0.0503	0.0277	0.101	0.0273	0.0859	0.171	0.215

Note. Probit regression on the relationship between competitiveness and self-reported State-trait Anxiety. The dependent variable is competitiveness, and the independent variables include self-reported State-trait Anxiety, performance in tournament, performance difference between tournament and piece-rate, confidence in tournament, confidence difference between tournament and piece-rate, risk attitude, tournament choice without performance, gender, and order effect. The table reports the marginal effects with robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A4. Gender and Competitiveness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Gender	-0.0777	-0.0560	-0.0816	-0.0383	-0.0788	-0.0916	-0.0400	-0.0466
	[0.0700]	[0.0716]	[0.0705]	[0.0726]	[0.0702]	[0.0726]	[0.0794]	[0.0813]
Performance: T		0.0260***					0.0132	0.0262**
		[0.0099]					[0.0130]	[0.0132]
Performance: T - P			-0.0102				-0.0262*	-0.0206
			[0.0125]				[0.0159]	[0.0154]
Confidence: T				-0.1699***			-0.2013***	-0.0550
				[0.0418]			[0.0631]	[0.0751]
Confidence: T - P					-0.0264		0.0678	-0.0310
					[0.0303]		[0.0483]	[0.0583]
Risk attitude						0.0741***	0.0538***	0.0527**
						[0.0193]	[0.0206]	[0.0212]
Tournament choice w/o performance								0.3656***
								[0.1111]
Order effect	0.0184	0.0765	-0.0375	0.0615	0.0369	-0.0141	-0.1086	-0.0756
	[0.0705]	[0.0752]	[0.0957]	[0.0733]	[0.0742]	[0.0733]	[0.1028]	[0.1042]
Observations	187	187	187	187	187	178	178	178
Pseudo R-squared	0.00525	0.0335	0.00858	0.0908	0.00853	0.0717	0.166	0.208

Note. Probit regression on gender and competitiveness. The dependent variable is competitiveness, and the independent variables include gender, performance in tournament, performance difference between tournament and piece-rate, confidence in tournament, confidence difference between tournament and piece-rate, risk attitude, tournament choice without performance, and order effect. The table reports the marginal effects with robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix B: Experimental Instructions

Welcome to our study on decision making. The descriptions of the study contained in this experimental instrument will be implemented fully and faithfully.

Each participant will receive on average $60 for the study. The overall compensation includes a $30 show up fee in addition to earnings based on how you make decisions.

All information provided will be kept CONFIDENTIAL. Information in the study will be used for research purposes only. You are not to discuss with anyone any aspect of the specific tasks during or after the study.

1. The set of decision making tasks and the instructions for each task are the same for all participants.
2. It is important to read the instructions CAREFULLY so that you understand the tasks and make better decisions.
3. If you have any questions, please raise your hand to ask our experimenters at ANY TIME.
4. PLEASE DO NOT communicate with others during the experiment.
5. Please take the time to go through the instructions carefully and make your decisions.
6. Cell phones and other electronic devices are not allowed.

In the experiment today you will be asked to complete four different tasks involving calculation. None of these will take more than 5 minutes. At the end of the 4 tasks, there is a decision making task involving 10 choices.

The method we use to determine your earnings varies across tasks. Before each task we will describe in detail how your payment is determined. Your total earnings from the experiment are the sum of your payment for the randomly selected task from task 1 to task 4, a randomly selected choice from the 10 choices, and a $30 for show-up fee. At the end of the experiment you will be asked to come to the side where you will be paid in private.

1. P1

For Task 1 you will be asked to calculate the sum of five randomly chosen two-digit numbers. You will be given 5 minutes to calculate the correct sum of a series of these problems. You cannot use a calculator to determine this sum, however you are welcome to write the numbers down and make use of the provided scratch paper. You submit an answer by clicking the submit button with your mouse. When you enter an answer the computer will immediately tell you whether your answer is correct or not. Your answers to the problems are anonymous.

If Task 1 is the one randomly selected for payment, then you get $1.5 per problem you solve correctly in the 5 minutes. Your payment does not decrease if you provide an incorrect answer to a problem. We refer to this payment as the piece rate payment. Please do not talk with one another for the duration of the experiment. If you have any questions, please raise your hand.

ARE THERE ANY QUESTIONS BEFORE WE BEGIN?

2. P2

As in Task 1 you will be given 5 minutes to calculate the correct sum of a series of five 2-digit numbers.

However for this task your payment depends on your performance relative to that of a group of other participants. Each group consists of four people randomly chosen in the room. If Task 2 is the one randomly selected for payment, then your earnings depend on the number of problems you solve compared to the three other people in your group. The individual who correctly solves the largest number of problems will receive $6 per correct problem, while the other participants receive no payment. We refer to this as the tournament payment. You will not be informed of how you did in the tournament until all four tasks have been completed. If there are ties the winner will be randomly determined. Please do not talk with one another. If you have any questions, please raise your hand.

ARE THERE ANY QUESTIONS BEFORE WE BEGIN?

3. P3

As in the previous two tasks you will be given 5 minutes to calculate the correct sum of a series of five 2-digit numbers. However you will now get to choose which of the two previous payment schemes you prefer to apply to your performance on the third task. If Task 3 is the one randomly selected for payment, then your earnings for this task are determined as follows. If you choose the piece rate you receive $1.5 per problem you solve correctly. If you choose the tournament your performance will be evaluated relative to the performance of the other three participants of your group in the Task 2 -tournament. The Task 2-tournament is the one you just completed. If you correctly solve more problems than they did in Task 2, then you receive four times the payment from the piece rate, which is $6 per correct problem. You will receive no earnings for this task if you choose the tournament and do not solve more problems correctly now, than the others in your group did in the Task 2 tournament. You will not be informed of how you did in the tournament until all four tasks have been completed. If there are ties the winner will be randomly determined.

The next computer screen will ask you to choose whether you want the piece rate or the tournament applied to your performance. You will then be given 5 minutes to calculate the correct sum of a series of five randomly chosen two-digit numbers. Please do not talk with one another. If you have any questions, please raise your hand.

ARE THERE ANY QUESTIONS BEFORE WE BEGIN?

4. P4

You do not have to add any numbers for the fourth and final task of the experiment. Instead you may be paid one more time for the number of problems you solved in the Task 1 – Piece Rate. However, you now have to choose which payment scheme you want applied to the number of problems you solved. You can either choose to be paid according to the piece rate, or according to the tournament.

If the fourth task is the one selected for payment, then your earnings for this task are determined as follows. If you choose the piece rate you receive $1.5 per problem you solved in Task 1. If you choose the tournament your performance will be evaluated relative to the performance of the other three participants of your group in the Task 1-piece rate. If you correctly solved more problems in Task 1 than they did then you receive four times the earnings of the piece rate, which is equivalent to $6 per correct problem. You will receive no earnings for this task if you choose the tournament and did not solve more problems correctly in Task 1 than the other members of your group.

This is the last stage of the calculation tasks. You will now need to choose which payment schemes (piece-rate or tournament) to determine your payoff in this task. You don't have to perform calculation in this task, as we will use the number of correct answers in your Piece-Rate round (the first task) to calculate your payoff.

The next computer screen will tell you how many problems you correctly solved in Task 1, and will ask you to choose whether you want the piece rate or the tournament applied to your performance. Please do not talk with one another. If you have any questions, please raise your hand.

ARE THERE ANY QUESTIONS BEFORE WE BEGIN?

Reminder: In the Piece-Rate task, the number of your correct answers is <ScoreTask1 | 1>

5. Rank Guess

We would like you to guess which was your rank compared to your group members in Tasks 1 and 2. In case of ties in the actual ranks, we counted every answer that could be correct as correct. For example, if the performance in the group was 10, 10, 11, 11, then the correct guess for score 10 is either 3rd or 4th, and the correct guess for score 11 is either 1st or 2nd.

Please enter a number between 1 (meaning that you were the best in your group of four) to 4 (meaning that you were the 4th in your group of four) for each task.

For each right guess <GuessPay | 5> will be added to your payment from this part of the experiment.

Please enter your guess for your rank in Task 1:

Please enter your guess for your rank in Task 2:

6. Risk Task

Option A: 50% chance of receiving $10 and 50% chance of receiving $0. The Option B column lists 10 amounts (*displayed in an ascending manner*) each corresponding to what you will receive for sure if you choose this option.

DECISION: For each of the 10 rows, please indicate your decision in the final column with a tick (√).

	Option A	Option B	Decision
1	50% of $ 10, 50% of $ 0	$ 2.5	A □ B □
2	50% of $ 10, 50% of $ 0	$ 3	A □ B □
3	50% of $ 10, 50% of $ 0	$ 3.5	A □ B □
4	50% of $ 10, 50% of $ 0	$ 4	A □ B □
5	50% of $ 10, 50% of $ 0	$ 4.5	A □ B □
6	50% of $ 10, 50% of $ 0	$ 5	A □ B □
7	50% of $ 10, 50% of $ 0	$ 5.5	A □ B □
8	50% of $ 10, 50% of $ 0	$ 6	A □ B □
9	50% of $ 10, 50% of $ 0	$ 6.5	A □ B □
10	50% of $ 10, 50% of $ 0	$ 7	A □ B □