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Imitation under stress

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Abstract

Imitation under stress*

Imitating the best strategy from the previous period has been shown to be an important heuristic, in particular in relatively complex environments. In this experiment we test whether subjects are more likely to use imitation if they are under stress. Subjects play a repeated Cournot oligopoly. Treatments are time pressure within the task and distractions through a second task (a Stroop-task) that has to be performed as well and influences payment. We measure stress levels through salivary cortisol and heart rate. Our main findings are that time pressure and distraction can indeed raise physiological stress levels of subjects within our task. More importantly from an economic perspective, we can also observe a corresponding behavioral change that is indicative of imitation.

Keywords: stress, cortisol, heart rate, imitation, experiment.

JEL classification: C91, C72, D74.

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1 Introduction

Economic decisions are often made under stress. Obvious examples are traders on financial markets who are subject to extreme time pressure, cognitive load through multitasking, and steep financial incentives. To a lesser degree, this is true for most professions. Decisions often have to be taken under time pressure and with many distracting factors present.

There is a growing psychological literature on the effects of stress on specific aspects of decision making. Some of the key findings are that acute stress seems to impair strategic thinking (see e.g. Leder et al., 2013). Stress also seems to inhibit learning from feedback (Petzold et al., 2010; Starcke et al., 2008) and to shift learning processes from goal-directed to habitual (Schwabe et al., 2012). Taken together, stress seems to impair deliberate reasoning so that decisions are made in a more automated manner. Thus, under stress, behavioral deviations from homo oeconomicus may be even more pronounced than usual.

One way of coping with stress may be for decision makers to employ simple heuristics, such as imitation, rather than cognitively more demanding optimization. The simple heuristic of imitating the best strategy from the previous period has a lot of appeal, in particular in relatively complex environments. It has been shown theoretically to be a robust and successful heuristic in many circumstances because it is difficult to exploit by opponents (see e.g. Duersch et al. 2012). Empirically, imitation turned out to describe fairly well the behavior of many experimental subjects in complex strategic situations (see e.g. Huck et al., 1999; Offerman et al., 2002; Apesteguia et al., 2007, 2010). So the question arises whether there is more imitation under stress.

In this experiment we test whether subjects are indeed more likely to use imitation if they are under acute stress. Subjects play a repeated Cournot oligopoly. Rather than inducing stress through some external task as in most psychological studies (e.g. using the Trier Social Stress Test (TSST), Kirschbaum et al., 1993), in our experiment stress can arise endogenously in the main task. Apart from a base treatment there are two treatments that potentially increase stress levels. In treatment Time pressure subjects are fined if they do not decide within a set time interval. In treatment Distraction a second task (a Stroop-task) has to be performed concurrently inducing cognitive load. Arguably, both of these manipulations are typical of modern workplace conditions with deadlines that have to be met and distractions through email or phone calls that require immediate attention.

To check whether our manipulations work, we measure stress levels through salivary cortisol and heart rate measurements. The release of stress-related hormones supports the adaptation process of the organism to changes and can protect the body in the short run. Under acute stress, cortisol redirects energy utilization among various organs. It simultaneously amplifies energy mobilizing mechanisms and inhibits less relevant organ functions. This helps to overcome the increased metabolic demand presented by a host of challenges. Cortisol also impacts on other important physiological systems and exerts significant effects on brain areas involved in affective and cognitive processes like declarative, episodic, and short-term memory (for a meta-analytic review see Het et al., 2005). The free fraction of cortisol, which can be measured in saliva, has been established as a biomarker of psychological stress (for a recent review see Hellhammer et al., 2009). Stress exposure also usually elicits temporary increases in heart rate and blood pressure (see e.g. Kudielka et al., 2004).

Our main findings are that time pressure and distraction can indeed raise physiological stress levels of subjects within our task. More importantly from an economic perspective, we also observe a corresponding behavioral change that is indicative of imitation. In particular, markets in our experiment become substantially more competitive under stress, a finding that is compatible with more imitation (Vega-Redondo, 1997). When looking at individual behavior, we find further direct evidence that subjects resort more to imitation when under stress. For example, subjects use significantly more often the information about others' actions and profits. Also, individual adjustments are on average more in line with imitation than with best reply behavior.

In the next section we summarize the related literature. In Section 3 we describe the details of our experiment. Section 4 reports the results and Section 5 concludes.

2 Related Literature

In this section we summarize the related literature from psychology and economics on stress and decision making. Acute external stress as induced by psychosocial laboratory stress paradigms like the TSST seems to increase risk taking,[1] although this result is not reported unambiguously.[2] Acute stress also seems to have an effect, depending on gender, on the willingness to accept ambiguity (Preston et al., 2007; Lighthall et al., 2009; Van den Bos et al., 2009; but see Buckert et al., 2014). Furthermore, Leder et al. (2013) find first evidence

[1] See e.g., Starcke et al. (2008); Pabst et al. (2013a); Buckert et al. (2014); for recent reviews see Starcke and Brand (2012) and Mather and Lighthall (2012).

[2] See e.g., Lempert et al. (2012); von Dawans et al. (2012); Pabst et al. (2013b); and Gathmann et al. (2014).

that stress may inhibit strategic thinking. In their study, stressed participants showed lower levels of strategic reasoning, probably due to less deliberate reasoning under stress. Indeed, other studies also suggest a shift from deliberate to more automated thinking styles under stress. Kassam et al. (2009), for example, report less adjustment in an anchoring-and-adjustment task for stressed participants. Porcelli and Delgado (2009) found that the reflection bias, i.e. risk taking for losses but risk avoidance for gains (cf. Kahneman and Tversky, 1979), was more pronounced under stress.

However, from a behavioral economics point of view, the above-reviewed results regarding how stress influences decision making are limited in several ways. Most of the psychological studies of stress and decision making so far used hypothetical situations or situations with very low incentives (with some exceptions, e.g., Lempert et al., 2012; von Dawans et al., 2012; Buckert et al., 2014). This is unfortunate, as it has been shown in several studies that incentives do matter (for a review see Camerer and Hogarth, 1999). Most importantly in this respect, many decision making "anomalies" or "biases" disappear when subjects are strongly motivated by monetary incentives. The finding that stressed subjects take suboptimal decisions and learn slower from feedback in hypothetical situations might simply reflect the fact that under stress, resources are used for the more important task at hand, i.e., for coping with the stressor. It would therefore be desirable to study decision making under stressful conditions in situations where performance in the experimental task is at least as important for subjects as handling the stressor. Two stressors that can be implemented at the same time as the main task are time pressure and cognitive load.

Previous studies investigating economic decision making under time pressure found evidence for altered behavior for example in the realm of risk taking (e.g., Ben Zur and Breznitz, 1981; Ordóñez and Benson, 1997; Maule et al., 2000; Jones et al., 2011; Young et al., 2012; Kocher et al., 2013). Most importantly, depth of reasoning decreases under time pressure (Kocher and Sutter, 2006) and information processing is altered so that less information is searched and integrated (Payne et al., 1996; Rieskamp and Hoffrage, 2008; Ibanez et al., 2009). Time pressure also seems to increase cooperation in public goods games (cf. Rand et al., 2012 but also Tinghög et al., 2013). In the Ultimatum game, an economically sub-optimal higher rate of rejections was observed under time pressure for responders, whereas proposers made higher offers in this condition (Sutter et al., 2003; Cappalletti et al., 2011).

Similarly, decision making seems to be affected by cognitive load. Cognitive load is usually induced by applying a second task that has to be worked on in parallel to the decision task. According to dual process models (e.g., Stanovich and West, 2000; Kahneman, 2003), this should lead to impaired deliberative processing as the deliberative system relies on scarce processing resources. Therefore, decision making should become more automatic. Indeed, several studies report less strategic behavior under high cognitive load compared to low cognitive load in different games (Duffy and Smith, 2011; Allred et al., 2013; Carpenter et al., 2013). Other studies manipulating cognitive load also report altered behavior in delay discounting tasks (Hinson et al., 2003; Franco-Watkins et al., 2010; Deck and Jahedi, 2013) as well as risk tasks (Hinson et al., 2002; Whitney et al., 2008; Benjamin et al., 2013; Deck and Jahedi, 2013) and social games like the dictator game and common resource pools (Roch et al., 2000; Hauge et al., 2009; Cornelissen et al., 2011; Schulz et al., 2012). Yet, Cappelletti et al. (2011) only found evidence for altered behavior in an ultimatum game under time pressure, not under cognitive load.

Both, cognitive load and time pressure are often used as stressors that can be applied at the same time as the task on which stress effects are investigated, in contrast to external stress induction protocols that have to be performed before the task of interest. Cognitive load and time pressure might be seen as more realistic stressors in an economic decision making context. Demanding cognitive tasks like the Stroop task (1935) or mental arithmetic tasks have been shown to be able to elicit a hormonal stress response (Dickerson and Kemeny, 2004). Yet, it is not known if time pressure also elicits physiological stress reactions. Therefore, we monitored heart rate and changes of the stress hormone cortisol throughout our study.

3 Experimental design

In a series of computerised experiments we studied a homogenous multi–period Cournot market with linear demand and cost. There were three symmetric firms in each market. Quantities could be chosen as integers between 0 and 100. The demand side of the market was modelled with the computer buying all supplied units according to the inverse demand function

$$p^t = \max\{100 - Q^t, 0\}, \tag{1}$$

with $Q^t = \sum_{i=1}^{3} q_i^t$ denoting total quantity in period t. The cost function for each seller was simply $C(q_i^t) = q_i^t$. Hence, profits were $\pi_i^t = (p^t - 1)q_i^t$.

In the stage game, the symmetric Cournot Nash equilibrium is given by $q_i^N = 25$,

Table 1: **Theoretical benchmarks**

Outcomes	Individual quantities	Prices	Profits
Collusion	16/17	52/49	816
Cournot–Nash	25	25	600
Walrasian / Imitation	33	1	0

$i \in I$, yielding a price of $p^N = 25$ and profit of $\Pi_i^N = 600$.[3] Of interest is also the symmetric Walrasian (or competitive) outcome where price equals marginal cost, $p^W = 1$, $q_i^W = (100 - 1)/3 = 33$, $i \in I$ and the profit is zero. The symmetric collusive or joint profit maximizing outcome would be at $q_i^C = 16, i \in I$, or $q_i^C = 17$, with a corresponding price of $p^C = 52$ or 49, respectively, and a profit of $\Pi_i^C = 816$.

The stage game was played with fixed matching for 15 periods and this was commonly known. After each market period, subjects were informed about their personal profits. Additionally, they were reminded of their own quantity.

In round 1, all subjects had access to a profit calculator, which allowed to input hypothetical quantities for all three firms and would calculate the respective profits. At the end of rounds 1 through 14, subjects had to choose whether in the next round they would like to again use the profit calculator or whether they would receive information about the individual profits and quantities of the other two firms.[4] Obviously, the first choice would be indicative of an interest in best reply behavior while the second would provide the necessary feedback for imitation to work.[5]

Table 2 summarizes the three treatments of our experiment. Treatment *Base* is the standard oligopoly experiment with the feedback choice as explained in the previous paragraph. Subjects were paid according to their total profits from all rounds. Profits where denominated in 'Taler', the exchange rate for euro (€) (600:1 in treatments Base and Time pressure and 1000:1 in treatment Distraction) was known.[6] Additionally, subjects received a show-up fee of 5 €.

[3] Due to the integer nature of the strategy set, there is also an asymmetric equilibrium, in which one firm chooses 24 and the other two choose 25. Profits in this equilibrium are 600 and 625, respectively.

[4] Bigoni (2010) and Bigoni and Fort (2013) also recorded the look-up patterns of subjects with respect to the information they acquired. In their experiments, though, subjects did not have to make an exclusive choice among the information accessed. Rather, subjects could see all information in each round.

[5] Strictly speaking, subjects could only infer the best response from the previous period's price as they were not informed about the individual quantities.

[6] We chose a different exchange rate in Distribution since subjects earned additional money through the Stroop task.

Table 2: **Treatments**

Base	Standard oligopoly experiment
Time pressure	from round 2: shrinking decision time 40, 38, 36, 34,. . . ,14 sec. Penalty of 300 T (~half Nash-eq. profit) if no decision countdown prominently shown on screen
Distraction	In irregular intervals: pop-up Stroop-task, 1-2 sec. payoff: (1+ fraction correct in Stroop) (payoff from main task)

Treatment *Time pressure* was like Base except that subjects had to make their quantity choices within a set decision time. In round 1 there was no time pressure. For round 2, the decision time was 40 seconds, which was calibrated to roughly 2/3 of median response time in Base from rounds 2 through 5. Since the response times in Base were decreasing throughout the experiment, we reduced the decision times by 2 seconds every period so that it was 14 seconds in the last period in order to keep the time pressure up. The screen showed a large clock counting down the seconds. There was a penalty of 300 Taler (about half of the Nash equilibrium profit) for not entering a quantity in time. If subjects failed to enter a new quantity, the quantity from the previous period was used again to calculate profits.

Treatment *Distraction* was like Base except that in irregular intervals subjects had to perform a Stroop-task. The task popped up on the screen and subjects had between 1-2 seconds to answer. The task (Stroop, 1935) was a multiple choice task where subjects had to name the font color of a word like "Green" or "Red" where usually the font color and the meaning of the word differed. The Stroop tasks kept popping up until the last subject of a group had entered a quantity for the oligopoly task. Subjects' overall payoff was calculated as (1+ fraction of correct answers in the Stroop task) times the payoff from the oligopoly task.

The experiments were conducted in the experimental lab of the economics department of the University of Heidelberg. Subjects were recruited via ORSEE (Greiner, 2004) and flyers on campus.

In each session either 6 or 9 subjects participated. All sessions were conducted at the same time of day (2:30 p.m.) since cortisol levels typically follow a daily cycle. The experiment was computerized using z-Tree (Fischbacher, 2007). Subjects were randomly allocated to computer terminals in the lab such that they could not infer with whom they would interact in a fixed group of three. For each treatment we had seven independent groups of subjects, making a total of $3 \times 7 \times 3 = 63$ subjects who participated in the experiments. All subjects were male and healthy students.

The average payoff was about 14 €. Experiments lasted about 60 minutes including instruction time. Instructions (see Appendix A) were written on paper and distributed at the beginning of each session.

3.1 Physiological measures

To check whether our manipulations worked, we collected physiological measures before, during, and after the experiment. As explained above, the free fraction of cortisol, which can be measured in saliva, has been established as a biomarker of psychological stress (Hellhammer et al., 2009). Also, a temporary increase in heart rate is usually seen as a signal of stress exposure (see e.g. Kudielka et al., 2004).

- Cortisol. Saliva samples were collected at three time points throughout the experiment using Salivette collection devices (Sarsted, Nuembrecht, Germany): one at the start of the experiment, one after 8 rounds of the game had been played (during stress, approximately 15 minutes after stressor onset), and one after the last round (post-stress, approximately 30 minutes after the game starts). As the cortisol reaction is relatively slow, the cortisol peak is expected to occur between 15 and 25 minutes after stressor onset (cf. Dickerson and Kemeny, 2004). The number of observations was 21 for treatments Base and Time pressure. For treatment Distraction only 6 observations were available for the 2nd measurement and 20 for the 3rd.[7] Samples were analyzed by the Psychobiological Research Laboratory of the University of Trier, Germany.

- Heart rate. Heart rate was measured continuously using Polar Sport Tester RS800CX (Polar Electro, Finland). Each participant was equipped with a breast belt and a display similar to a wrist watch was placed on the table invisible for the participants. For the analysis, the Polar Pro Trainer software was used. Data were aggregated into three intervals: baseline (first 5 min., before the game started), part 1 of the game

[7] In session 8 and 9 of treatment Distraction subjects were so slow such that round 8 (when we usually conducted the second measurement) occurred at the time at which the third measurement was taking place in the remaining sessions. We therefore take this measure as equivalent to the third measure in the other treatments (and have missing data for the second measure).

(round 1 through 8), and part 2 of the game (rounds 9 through 15). In between part 1 and part 2 of the game, a salivary cortisol measurement took place (see above). For some subjects data were not available due to hardware failures. The number of remaining observations were 18, 17, and 13, for treatments Base, Time pressure, and Distraction, respectively.

4 Results

4.1 Physiological data

Since cortisol levels and heart rates can vary greatly between individuals, we normalize all values by dividing through the first measurement of each subject at the beginning of the experiment, before subjects learned anything about the experiment. That is, all physiological measures are shown as ratios M_t/M_1, where $t = 2, 3$ are the 2nd and 3rd measurements, respectively. Figure 1 compares the averages of these ratios for cortisol and heart rate for the different treatments. Usually, cortisol levels decrease in the afternoon (Engert et al., 2011), the time of the experiments. In treatment Base we have a slight decrease at the third measurement. In contrast, in treatment Time pressure cortisol ratios are higher at the 2nd and 3rd measurements. The differences to treatment Base are significant (Mann-Whitney U-tests (MWU), $p = 0.058$ and $p = 0.013$ for the second and third measurement, respectively).[8] There are no significant differences between treatments Distraction and Base for the second measurement. However, for the third measurement, the cortisol ratio in Distraction is (weakly) significantly higher than in Base (MWU-test, $p = 0.060$).

Figure 1 (bottom panel) shows the average development of heart rates. Although heart rate ratios in treatments Time pressure and Distraction are higher than in Base, the differences are not significant according to MWU-tests.

Result 1 *Time pressure and, to a lesser extent, a Stroop task seem to increase stress levels as measured by cortisol.*

4.2 Behavioral data

In the end, what should matter to economists are the behavioral outcomes. Figure 2 shows the average profits per period aggregated over all subjects in a treatment. Only profits from the oligopoly game are shown (i.e. without payments for the Stroop task and

[8] All test statistics in this paper refer to two-sided tests.

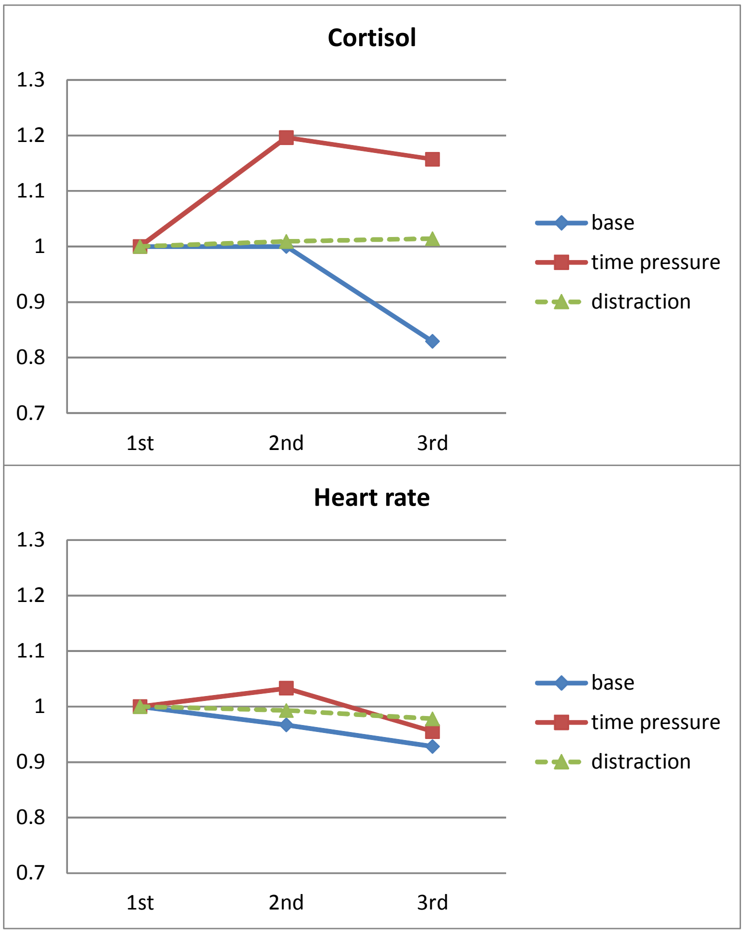

Figure 1: Average cortisol (top panel) and heart rate ratios (bottom panel) of subjects across treatments.

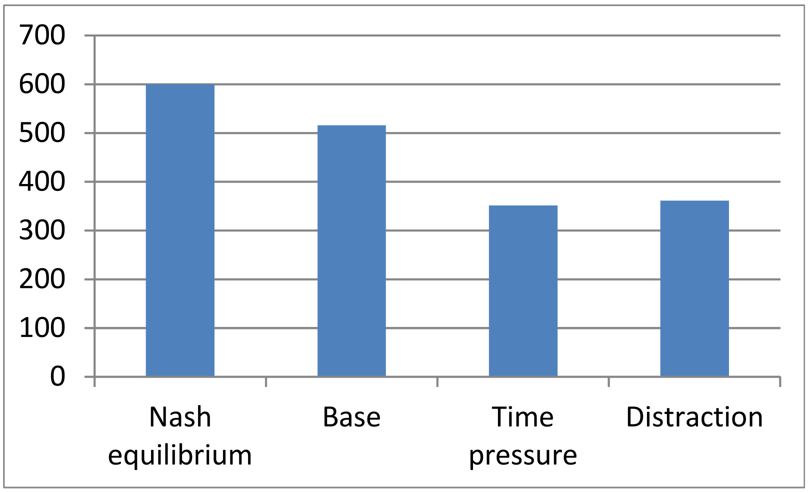

Figure 2: Average profits of subjects in the different treatments compared to the Nash equilibrium profit.

Note: Profits are net of payments for the Stroop taks and penalities for exceeding the time limit.

penalties for exceeding the time limit). Recall that the Nash equilibrium prediction is a profit of 600. As expected from the previous literature (Huck et al., 1999, Offerman et al., 2002, and Apesteguia et al., 2007) we find that even in treatment Base, profits (average profit per round = 516.0) are lower than predicted by the Nash equilibrium (although this difference is not significant: Wilcoxon test ($p = 0.128$) taking the average profit from each group as one independent observation). Yet, Figure 2 shows that the profits in treatment Time pressure (351.6) and Distraction (361.4) are lower still. The differences to Base are significant according to a MWU-test ($p = 0.048$ for Time pressure vs. Base and $p = 0.025$ for Distraction vs. Base).

Result 2 *Profits in the oligopoly game (i.e. profits without punishment in Time pressure and payments for Stroop task) in treatments Time pressure and Distraction are significantly lower than in Base.*

4.3 More imitation under stress?

Just because the aggregate outcomes are more competitive in treatments Time pressure and Distraction one cannot necessarily conclude that there is more imitation under stress. A second indication comes from the feedback choices of subjects. Recall that imitation

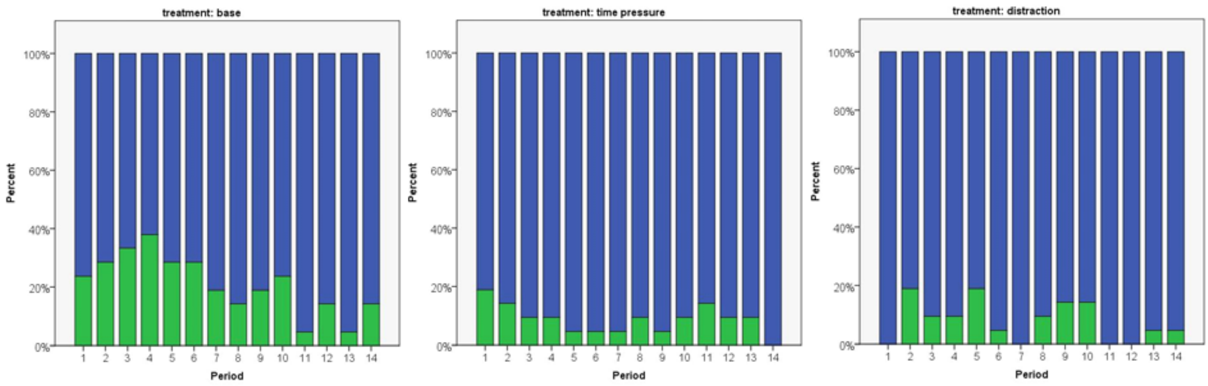

Figure 3: Feedback choice of subjects in %: Green = choice of profit calculator, blue = choice to see quantities and profits of others.

requires knowledge about the quantity and profits of the other firms in the market. But there is a trade-off. When subjects opt to receive information on quantities and profits of others, they have to give up the option of using the profit calculator in this round. Since the profit calculator is (for most people) essential for employing any belief based learning process, we can infer something about the learning process subjects use.

Figure 3 shows the percentage of subjects requesting the two forms of feedback by treatment and period. Overall it is striking how large the percentage of subjects is that request information about others' quantities and profits (blue bars). However, while in treatment Base there are about 20% of subjects using the profit calculator in the first half of the experiment, there are much fewer in the other two treatments. In fact, these differences are significant according to MWU-tests (two-sided $p = 0.017$ and $p = 0.010$ for the difference between Base and Time pressure and between Base and Distraction, respectively, taking the average from each oligopoly as one observation).

Result 3 *Subjects use significantly more often the information about others' actions and profits in treatment Time pressure and Distraction than in treatment Base.*

A possible objection is that under time pressure subjects do not have the time to use the profit calculator. Although this may be true to some extent in treatment Time pressure, subjects have no time pressure in treatment Distraction. They also did not try to speed up their quantity decisions in order to be able to focus solely on the Stroop task. In fact,

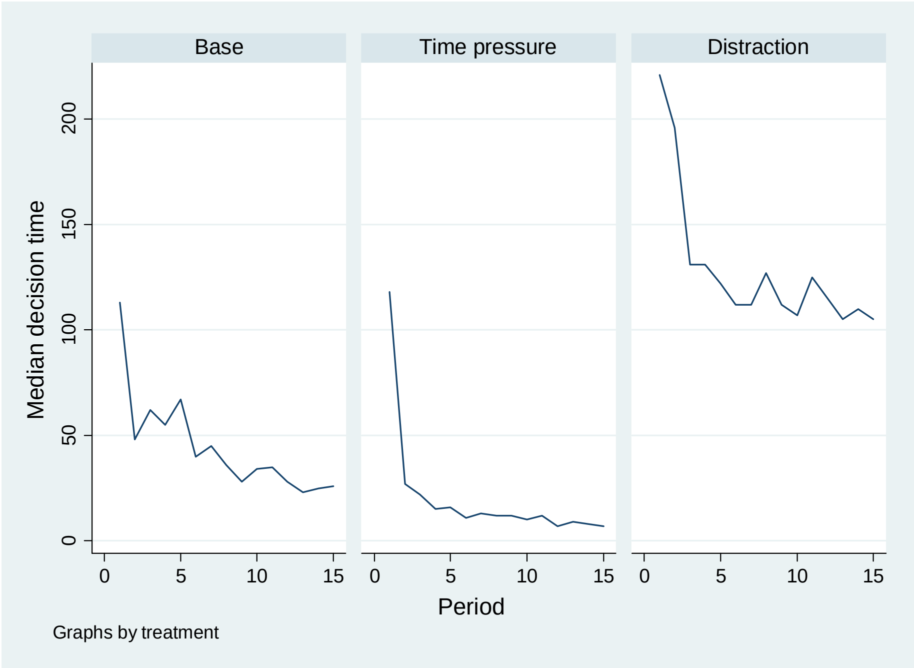

Figure 4: Median decision times (in seconds) of subjects for the quantity decision

they took more time than in the base treatment (see Figure 4, which shows the median decision times for the different treatments).

For the remainder of the section we shall focus on individual behavior since this is the most demanding test for checking whether subjects actually imitate. First, we simply count the number of times in which a subject chose exactly the quantity that yielded the highest profit in the previous round. We call this an "imitation instance". Table 3 lists the percentage of all quantity choices that were imitation instances, separately for each treatment. The second row in Table 3 lists the percentage of choices that were within ± 3 of the quantity that yielded the highest profit in the previous round. A χ^2-test shows for either measure that imitation instances are more frequent in treatment Time pressure than in Base or Distraction ($p < 0.01$ for all tests) whereas there is no significant difference between Base and Distraction.

Result 4 *The frequency of imitation instances in treatment Time pressure is significantly higher than in treatments Base and Distraction.*

Table 3: **Imitation instances**

	Base	Time pressure	Distraction
imitation instances	10.2%	21.7%	13.3%
imitation instances ±3	32.7%	48.4%	36.1%

Note: Periods in which subjects were forced to repeat their action due to exceeding the time limit were not counted.

We suspect that subjects often show a certain kind of inertia and adjust their quantities incompletely from their current status quo (q_i^{t-1}) towards a new goal. To check whether this new goal is more in line with a prediction derived from an imitation rule or derived from a best reply process, we estimate the following equation using a random effects GLS regression:

$$q_i^t - q_i^{t-1} = \beta_0 + \beta_1 \left(br_i^{t-1} - q_i^{t-1}\right) + \beta_2 \left(i^{t-1} - q_i^{t-1}\right) + \varepsilon, \qquad (2)$$

where br_i^{t-1} denotes subject i's best reply (i.e. reaction function) given the other firms' quantities in $t-1$; i^{t-1} stands for "imitate the best" and denotes the quantity of the firm which had the highest profit in period $t-1$. If all subjects strictly played a myopic best reply every period, we would have $\beta_1 = 1$ and $\beta_2 = 0$. Analogously, if all subjects strictly followed the rule "imitate the best", we would find $\beta_1 = 0$ and $\beta_2 = 1$.

Table 4: Quantity adjustments: Random effects regression

dependent variable:	Base		Time pressure		Distraction	
$q_i^t - q_i^{t-1}$	coeff.	std. error	coeff.	std. error	coeff.	std. error
$br_i^{t-1} - q_i^{t-1}$	0.24***	0.04	0.14**	0.06	0.18***	0.03
$i^{t-1} - q_i^{t-1}$	0.39***	0.09	0.48***	0.17	0.41***	0.06
constant	−1.16***	0.39	0.00	1.32	0.47	0.81
R^2	0.45		0.46		0.45	

Note: ***,**,* significant at 1%, 5%, 10% level; $N = 294$ in all regressions. Robust standard errors are clustered at the group level.

As shown in Table 4, the coefficients of both variables are highly significant in all treatments.[9] So it seems that there is a mix of the two learning processes, which is consistent with earlier findings (see e.g. Huck et al., 1999 or Bigoni and Fort, 2013). However, there are noticeable differences across treatments with respect to the size of the coefficients. While the coefficient for the imitation process is larger in all treatments, the difference is

[9] Running the regression jointly for all treatments with treatment dummies and interaction terms shows that there are no significant treatment differences in the learning dynamics.

particularly pronounced in treatment Time pressure and less so in treatment Base. The difference between the imitation coefficient and the best reply coefficient is significant at the 5% level of a χ^2-test in treatment Time pressure but not signiciantly different in Base. As before, treatment Distraction is somewhere in between (the difference between the coeffcients is signifant at the 10% level).[10]

Result 5 *Individual adjustments are on average more in line with imitation than with best reply behavior. This tendency is more pronounced in treatment Time pressure than in Base.*

Finally, we check whether the tendency to imitate may actually be related to the stress levels of individuals. For this, we run a logit regression on the probability of an imitation instance ±3 depending on the normalized cortisol and heart rate measurements.[11]

Table 5: Probability of imitating: Logit regressions

dependent variable:	(1)		(2)	
imitation instance ±3	coeff.	std. error	coeff.	std. error
cortisol 3rd measurement ratio	0.37*	0.19	0.27*	0.14
heart rate 2nd measurement ratio	2.87**	1.38	2.31*	1.28
constant	−3.76***	1.37	−3.23***	1.22
dummy treatment Time pressure	–		0.32	0.28
dummy treatment Distraction	–		0.03	0.32
pseudo R^2	0.02		0.02	

Note: ***,** ,* significant at 1%, 5%, 10% level; $N = 661$. Robust standard errors are clustered at the group level.

Table 5 shows the result of two of those logit regressions, once with treatment dummies and once without. The treatment dummies are not significant. In both specifications higher cortisol and heart rates are associated with a higher probability to imitate, although some of the results are only weakly significant at the 10% level.[12]

Result 6 *Individuals' probabilities to imitate are increasing with their cortisol and heart rate values.*

[10] The results are unchanged if we run a pooled model with treatment interaction terms.

[11] We use 3rd measurements for cortisol and 2nd measurements for heart rates since heart rates react instantly while cortisol reacts with delay (see e.g. Pabst et al., 2013). Using 3rd measurements for heart rates yields results that are also significant at the 5% level.

[12] When we run an equivalent regression trying to explain the probability of best responding, we obtain an insignificant coefficient for cortisol and a significant and negative coefficient for heart rate (see Table 6 in the appendix).

5 Conclusion

In this paper we have studied the question whether subjects tend to imitate others more if they are under stress. To induce stress, we used two stressors that are quite typical of economic decision making, time pressure and distraction through another task. Our experimental data support the hypothesis that stress leads to more imitation. To be precise, what we showed is that time pressure and distraction yielded physiological reactions that are typically associated with stress, namely higher cortisol levels and, to some degree, higher heart rates. We also showed that at the same time, time pressure and distraction yielded behavior that is typical of imitation.

What we are not able to conclude is that there are direct causal links from time pressure or distraction to stress and from stress to imitation. This is for two reasons. First, it is unclear how to define stress precisely. Some researchers *define* stress to be an increase in cortisol or other physiological measures while others define stress according to behavioral features (see e.g. Levine, 1985). Secondly, it may well be possible that time pressure and distraction influence physiological measures and at the same time increase the tendency to imitate without stress being causal for imitation. An interesting test would be to check whether the administration of cortisol by itself would increase the tendency to imitate. With respect to other tasks, for example Putman et al. (2010) find that the administration of cortisol increases risk taking behavior.

From an economist's perspective, however, it may be fully sufficient to conclude that imitation is more frequent under time pressure and distraction. Whether we call this stress or not is secondary. But the behavioral effects are clear. The tendency to imitate increases when subjects are pressed for time or when they are distracted by another task. And this in turn yields more competitive outcomes.

References

[1] Allred, S., Duffy, S. and Smith, J. (2013), "Cognitive load and strategic sophistication", mimeo, Rutgers University.

[2] Apesteguia, J., Huck, S., Oechssler, J., and Weidenholzer, S. (2010), "Imitation and the Evolution of Walrasian Behavior: Theoretically Fragile but Behaviorally Robust", *Journal of Economic Theory*, 145, 1603-1617.

[3] Apesteguia, J., Huck, S., and Oechssler, J. (2007), "Imitation - Theory and Experimental Evidence", *Journal of Economic Theory* 136, 217-235.

[4] Ben Zur, H. and Breznitz, S. J. (1981). "The effect of time pressure on risky choice behavior", *Acta Psychologica*, 47(2), 89-104.

[5] Benjamin, D. J., Brown, S. A., and Shapiro, J. M. (2013), "Who is "Behavioral"? Cognitive Ability and Anomalous Preferences", *Journal of the European Economic Association*, 11(6), 1231–1255.

[6] Bigoni, M. and Fort, M. (2013), "Information and Learning in Oligopoly: An Experiment", *Games and Economic Behavior*, 81, 192-214.

[7] Bigoni, M. (2010), "What do you want to know? Information acquisition and learning in experimental Cournot games", *Research in Economics*, 64(1), 1-17.

[8] Buckert M., Schwieren C., Kudielka B.M., and Fiebach C.J. (2014), "Acute stress affects risk taking but not ambiguity aversion", *Frontiers in Neuroscience*, 8:82. doi:10.3389/fnins.2014.00082.

[9] Camerer, C. F. and Hogarth, R. M. (1999), "The Effects of Financial Incentives in Experiments: A Review and Capital-Labor-Production Framework." *Journal of Risk and Uncertainty*, 19(1-3), 7-42.

[10] Cappelletti, D., Güth, W., and Ploner, M. (2011), "Being of two minds: Ultimatum offers under cognitive constraints." *Journal of Economic Psychology,* 32(6), 940-950.

[11] Carpenter, J., Graham, M. and Wolf, J. (2013), "Cognitive Ability and Strategic Sophistication", *Games and Economic Behavior*, 80(1), 115-130.

[12] Cornelissen, G., Dewitte, S., and Warlop, L. (2011). "Are Social Value Orientations expressed automatically? Decision making in the dictator game", *Personality and Social Psychology Bulletin*, 37(8), 1080-1090.

[13] Deck, C. and Jahedi, S. (2013), "The Effect of Cognitive Load on Economic Decision Making", mimeo, University of Arkansas.

[14] Dickerson, S. S. and Kemeny, M. E. (2004), "Acute stressors and cortisol responses: a theoretical integration and synthesis of laboratory research." *Psychological Bulletin,* 130(3), 355-391.

[15] Duersch, P., Oechssler, J., and Schipper, B.C. (2012). "Unbeatable Imitation", *Games and Economic Behavior,* 76, 88-96.

[16] Duffy, S. and Smith, J. (2011), "Cognitive Load in the Multi-player Prisoner's Dilemma Game: Are There Brains in Games?", *Journal of Behavioral and Experimental Economics*, forthcoming.

[17] Engert V., Vogel S., Efanov S.I., Duchesne A., Corbo V., Ali N., and Pruessner J.C. (2011), "Investigation into the cross-correlation of salivary cortisol and alpha-amylase responses to psychological stress", *Psychoneuroendocrinology*, 36(9), 1294-1302.

[18] Fischbacher, U. (2007), "z–Tree: Zurich Toolbox for Ready–made Economic Experiments", *Experimental Economics* 10, 171-178.

[19] Franco-Watkins, A. M., Rickard, T. C., and Pashler, H. (2010), "Taxing executive processes does not necessarily increase impulsive decision making", *Experimental Psychology*, 57(3), 193-201.

[20] Gathmann, B., Schulte, F. P., Maderwald, S., Pawlikowski, M., Starcke, K., Schafer, L. C., Scholer, T., Wolf, O. T., and Brand, M. (2014). "Stress and decision making: neural correlates of the interaction between stress, executive functions, and decision making under risk". *Experimental Brain Research*, 1-17.

[21] Greiner, B. (2004), "The Online Recruitment System ORSEE 2.0 – A Guide for the Organization of Experiments in Economics", University of Cologne, Working Paper Series in Economics 10.

[22] Hauge, K.E., Brekke, K.A., Johansson, L.O., Johansson-Stenman, O., and Svedsäter, H. (2009), "Are Social Preferences Skin Deep? Dictators under Cognitive Load", No 371, Working Papers in Economics, University of Gothenburg.

[23] Hellhammer, D. H., Wüst, S. and Kudielka, B. M. (2009), "Salivary Cortisol as a Biomarker in Stress Research", *Psychoneuroendocrinology*, 34(2), 163-171.

[24] Het, S., Ramlow, G. and Wolf, O. T. (2005), "A MetaAnalytic Review of the Effects of Acute Cortisol Administration on Human Memory". *Psychoneuroendocrinology*, 30(8), 771-784.

[25] Hinson, J. M., Jameson, T. L., and Whitney, P. (2003), "Impulsive decision making and working memory." *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 29(2), 298-306.

[26] Hinson, J. M., Jameson, T. L., and Whitney, P. (2002), "Somatic markers, working memory, and decision making," *Cognitive, Affective, & Behavioral Neuroscience,* 2(4), 341-353.

[27] Huck, S., Normann, H.-T., and Oechssler, J. (1999). "Learning in Cournot oligopoly - An experiment", *Economic Journal* 109, C80–C95.

[28] Ibanez Diaz, M., Czermak, S., and Sutter, M. (2009), "Searching for a better deal: On the influence of team decision making, time pressure and gender", *Journal of Economic Psychology*, 30, 1-10.

[29] Jones, C. L., Minati, L., Harrison, N. A., Ward, J., and Critchley, H. D. (2011). "Under pressure: response urgency modulates striatal and insula activity during decision-making under risk", *PLoS ONE*, 6(6), e20942.

[30] Kahneman, D. (2003). "A perspective on judgment and choice: Mapping bounded rationality", *American Psychologist*, 58(9), 697-720.

[31] Kahneman, D. and Tversky, A. (1979), "Prospect Theory: An Analysis of Decision under Risk", *Econometrica,* 47 (2), 263-292.

[32] Kassam, K. S., Koslov, K., and Mendes, W.B. (2009), "Decisions under distress stress profiles influence anchoring and adjustment." *Psychological Science* 20(11), 1394-1399.

[33] Kirschbaum, C., Pirke, K. M. and Hellhammer, D. H. (1993), "The 'Trier Social Stress Test' a Tool for Investigating Psychobiology Stress Responses in a Laboratory Setting". *Neuropsychobiology*, 28, 76-81.

[34] Kocher, M. G., and Sutter, M. (2006), "Time is money—Time pressure, incentives, and the quality of decision-making", *Journal of Economic Behavior & Organization* 61(3), 375-392.

[35] Kocher, M. G., Pahlke, J., and Trautmann, S.T. (2013), "Tempus Fugit: Time Pressure in Risky Decisions", *Management Science* 59(10), 2380-2391.

[36] Kudielka, B. M., Buske-Kirschbaum, A., Hellhammer, D. H. and Kirschbaum, C. (2004), "Differential Heart Rate Reactivity and Recovery after Psychosocial Stress (TSST) in Healthy Children, Younger Adults, and Elderly Adults: The Impact of Age and Gender", *International Journal of Behavioral Medicine*, 11(2), 116-121.

[37] Leder, J., Häusser, J.A., and Mojzisch, A. (2013), "Stress and strategic decision-making in the beauty contest game", *Psychoneuroendocrinology,* 38(9), 1503–1511.

[38] Lempert, K. M., Porcelli, A. J., Delgado, M. R., and Tricomi, E. (2012). "Individual differences in delay discounting under acute stress: the role of trait perceived stress", *Frontiers in Psychology*, 3 (251), 1-10.

[39] Levine, S. (1985). "A definition of stress?" in *Animal Stress* (Gary P. Moberg ed.), Springer Verlag, New York, 51-69.

[40] Lighthall, N. R., Mather, M., and Gorlick, M.A. (2009), "Acute stress increases sex differences in risk seeking in the balloon analogue risk task." *PLoS One* 4.7, DOI: 10.1371/journal.pone.0006002.

[41] Mather, M. and Lighthall, N. R. (2012). "Risk and Reward Are Processed Differently in Decisions Made Under Stress", *Current Directions in Psychological Science*, 21(1), 36-41.

[42] Maule, A. J., Hockey, G. R. J., and Bdzola L. (2000), "Effects of time pressure on decision making under uncertainty: changes in affective state and information processing strategy", *Acta Psychologica*, 104, 283-301.

[43] Offerman, T., Potters, J., and Sonnemans, J. (2002). "Imitation and belief learning in an oligopoly experiment", *Review of Economic Studies,* 69, 973–997.

[44] Ordóñez, L. and Benson, I. L. (1997). "Decisions under Time Pressure: How Time Constraint Affects Risky Decision Making", *Organizational Behavior and Human Decision Processes*, 71(2), 121-140.

[45] Pabst, S., Brand, M., Wolf, O. (2013), "Stress and decision making: A few minutes make all the difference", *Behavioral Brain Research,* 250, 39-45.

[46] Pabst, S., Brand, M., Wolf, O. T. (2013a), "Stress effects on framed decisions: there are differences for gains and losses", *Frontiers in Behavioral Neuroscience*, 7 (142), 1-10.

[47] Pabst, S., Schoofs, D., Pawlikowski, M., Brand, M., Wolf, O. T. (2013b), "Paradoxical Effects of Stress and an Executive Task on Decisions Under Risk", *Behavioral Neuroscience*, 127(3), 369-79

[48] Payne, J. W., Bettman, J. R., Luce, M. F. (1996), "When time is money: Decision behavior under opportunity-cost time pressure", *Organizational Behavior and Human Decision Processes*, 66(2), 131-152.

[49] Petzold, A., Plessow, F., Goschke, T., and Kirschbaum, C. (2010), "Stress reduces use of negative feedback in a feedback-based learning task", *Behavioral Neuroscience*, 124(2), 248-255.

[50] Porcelli, A. J. and Delgado, M. R. (2009), "Acute Stress Modulates Risk Taking in Financial Decision Making." *Psychological Science*, 3(2), 1-6.

[51] Preston, S. D., Buchanan, T. W., Stansfield, R. B. and Bechara, A. (2007), "Effects of Anticipatory Stress on Decision Making in a Gambling Task", *Behavioral Neuroscience*, 121(2), 257-263.

[52] Putman, P., Antypa, N., Crysovergi, P., and van der Does, W. A., (2010), "Exogenous cortisol acutely influences motivated decision making in healthy young men", *Psychopharmacology*, 208(2), 257-263.

[53] Rand D. G.,Greene, J.D., and Nowak, M.A. (2012), "Spontaneous giving and calculated greed," *Nature*, 489, 427–430.

[54] Reutskaja, E., Nagel, R., Camerer, C. F., and Rangel, A. (2011), "Search dynamics in consumer choice under time pressure: An eye-tracking study", *American Economic Review*, 101(2), 900-926.

[55] Rieskamp, J., and Hoffrage, U. (2008), "Inferences under time pressure: How opportunity costs affect strategy selection", *Acta Psychologica*, 127, 258-276.

[56] Roch, S. G., Lane, J. A., Samuelson, C. D., Allison, S. T., Dent, J. L. (2000). "Cognitive load and the equality heuristic: A two-stage model of resource overconsumption

in small groups", *Organizational Behavior and Human Decision Processes*, 83(2), 185-212.

[57] Schwabe, L., Dalm, S., Schächinger, H., and Oitzl, M. S. (2008), "Chronic Stress Modulates the Use of Spatial and Stimulus Response Learning Strategies in Mice and Man", *Neurobiology of Learning & Memory*, 90, 495-503.

[58] Schulz, J. F., Fischbacher, U., Thöni, C., Utikal, V. (2012). "Affect and fairness: Dictator games under cognitive load", *Journal of Economic Psychology*, in press.

[59] Stanovich, K. E. and West, R. F. (2000). "Individual differences in reasoning: Implications for the rationality debate?", *Behavioral and Brain Sciences*, 23, 645–726.

[60] Starcke, K. and Brand, M. (2012). "Decision making under stress: A selective review", *Neuroscience and Biobehavioral Reviews*, 36, 1228-1248.

[61] Starcke, K., Wolf, O. T., Markowitsch, H. J., and Brand, M. (2008), "Anticipatory Stress Influences Decision Making under Explicit Risk Conditions", *Behavioral Neuroscience*, 122(6), 1352-1360.

[62] Stroop, J.R. (1935), "Studies of interference in serial verbal reactions". *Journal of Experimental Psychology* 18 (6), 643–662.

[63] Sutter, M., Kocher, M. and Strauß, S. (2003), "Bargaining under time pressure in an experimental ultimatum game", *Economics Letters,* 81(3), 341-347.

[64] Tinghög, G., Andersson, D., Bonn, C., Böttiger, H., Josephson, C., Lundgren, G., Västfjäll, D., Kirchler, M. and Johannesson, M. (2013), "Intuition and cooperation reconsidered", *Nature*, 498(7452), E1-E2.

[65] van den Bos, R., M. Harteveld, and Stoop, H. (2009), "Stress and decision-making in humans: performance is related to cortisol reactivity, albeit differently in men and women", *Psychoneuroendocrinology,* 34(10), 1449-1458.

[66] von Dawans, B., Fischbacher, U., Kirschbaum, C., Fehr, E., and Heinrichs, M. (2012), "The Social Dimension of Stress Reactivity Acute Stress Increases Prosocial Behavior in Humans", *Psychological Science*, 23(6), 651-660.

[67] Vega-Redondo, F. (1997). "The evolution of Walrasian behavior", *Econometrica* 65, 375–384.

[68] Whitney, P., Rinehart, C. A., Hinson, J. M. (2008). “Framing effects under cognitive load: The role of working memory in risky decisions”, *Psychonomic Bulletin & Review*, 15(6), 1179-1184.

[69] Young, D. L., Goodie, A. S., Hall, D. B., Wu, E. (2012). “Decision making under time pressure, modeled in a prospect theory framework”, *Organizational Behavior and Human Decision Processes*, 118(2), 179-188.

Appendix

A Instructions

[English translation of the German instructions, differences between treatments are indicated]

Welcome to our experiment. Please read these instructions carefully.

In this experiment we want to gather a number of biological parameters in a situation of economic decision making. Before being assigned an economic task, you will receive a heart rate monitor consisting of a breast strap and a wrist watch that you will wear for the duration of the experiment. To determine certain hormone levels, we will take saliva samples several times during the experiment. The experimenter will explain in detail the procedure when collecting a saliva sample using a salivette (i.e., a small cotton roll which you will have to chew for a short time). The experiment will take approx. 90 minutes.

Rules of the economic experiment: You will have to make several decisions on the computer. In the process, you can earn real money. But first of all, please note:

Be absolutely quiet for the whole duration of the experiment. Participants ignoring this rule cannot be paid. If you have any question, raise your hand, and someone will come over.

You will receive your payoff individually and discreetly right at the end of the experiment.

The experiment's payoffs will be calculated in Taler (T). At the end of the experiment your payoffs will be converted into euros, with 600 T = 1 €.

The experiment comprises 15 rounds.

During the whole experiment you will be interacting with two participants in this room. These two participants will stay here over the 15 rounds. No one will learn as to who interacted with whom.

Each of you represents a firm that produces and sells a product. So there are, in addition to you, two competitors who produce and sell the same product. The production costs are 1 T per unit (for all firms). Your task is to make a decision on how many units you want to sell of your product.

The following important rule applies: The higher the total quantity produced by all three firms, the lower the market price. Above a certain quantity the price becomes zero.

The profit per unit is the difference between the price and the unit cost (1 T). Note that you will suffer a loss if the price falls below the unit cost. Your profit in this round is calculated as profit per unit multiplied with the number of units sold by you.

At the end all profits realized during the rounds will be added and paid.

Starting from the second round you will receive the following information in each round:

Your own quantity and the resulting profit of the previous round.

Moreover, you can choose between two options to receive additional information:

a) Display the quantities and profits that the two other firms realized in the previous round.

b) Use the profit calculator. There you can enter hypothetical quantities for all three firms and obtain the resulting profits of the firms.

In each round you can choose only one of the two options. But you can make your choice in each individual round.

[This paragraph for treatment Time pressure only] In the first round there is no time limit for your decision. But starting from the second round on you must make your decisions concerning the quantity and the choice of feedback option within a certain time interval. This time interval is 40 seconds in the 2nd round. It will be reduced by 2 seconds for each subsequent round, so that you will have 14 seconds in the 15th (final) round. The time interval available for each round will be displayed as a big „countdown“ on the screen. If you fail to make a decision within this interval, you must pay a 300 T fine for this round. Also, the quantity you selected in the previous round will be selected automatically for this round.

[This paragraph for treatment Distraction only] In addition to this task you must execute, starting from round 2, a color recognition task at irregular times. For this task you will be shown words whose font colors are either green, blue, black, red, or yellow.

Your task is to recognize the font color and then to click the associated color field. Ignore the meaning of the word and only concentrate on the font color! You must proceed quickly because you have only 1-2 seconds per task. If you select no color at all or a wrong color, the result of the color recognition task will be marked as wrong. Assume that the proportion of correct questions of the color recognition task is x. Then, at the end, you will get the total profits over all rounds of the first task, multiplied with $(1 + x)$. This will be your payoff for the entire experiment. For example, if you have answered 80% of the questions in the color recognition task correctly, your payoff for the experiment is:

$$(1 + 0.8) \times \text{ (total profit over all rounds of the first task).}$$

To achieve an overall high payoff, you have to perform well in both tasks.

[all treatments] Everything described above applies not only to you but also to the two other firms. All three of you are reading exactly the same instructions.

Have fun!

B Additional tables

Table 6: Probability of best responding: Logit regressions

dependent variable:	(1)		(2)	
best response ±3	coeff.	std. error	coeff.	std. error
cortisol 3rd measurement ratio	−0.12	0.47	−0.27	0.43
heart rate 2nd measurement ratio	−3.35***	1.09	−4.03***	1.22
constant	2.24*	1.34	2.97**	1.35
dummy treatment Time pressure	–		0.49	0.51
dummy treatment Distraction	–		−0.35	0.36
pseudo R^2	0.02		0.03	

Note: ***,**,* significant at 1%, 5%, 10% level; $N = 672$. Robust standard errors are clustered at the group level.

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