Can tournaments induce persistent workaholism?

Kun Zhang[*], Hebei University of Economics and Business
kunzhang_uk@163.com

Nick Feltovich, Monash University
nicholas.feltovich@monash.edu

Yanren Zhang, Fudan University
zhangyanren@gmail.com

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Abstract

Work is ordinary and necessary for most people, but some people work excessively ("workaholism") seemingly driven by internal forces. We theoretically and experimentally investigate the role of tournaments in causing or exacerbating workaholism. In our setting, agents perform a task over two stages. In the first stage, they can earn prizes, which are allocated either randomly or according to performance. Afterwards, they can continue working in a second stage, with payment by piece rate and no competition against others. Our model of motivated belief updating predicts that agents adjust their beliefs asymmetrically: they attribute the tournament outcome more to their productivity if they win a prize, and more to luck if they lose. This bias leads both winners and losers of the first-stage prize to overwork in the subsequent piece-rate stage. Results from a real-effort experiment confirm these predictions: effort in the piece-rate stage is roughly 20 percent higher when earlier bonus prizes had been allocated by performance, compared to when those prizes had been allocated randomly. The effect is seen in both winners and losers.

Keywords: workaholic; workaholism; tournament; motivated beliefs; asymmetric belief updating; experiment

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1 Introduction

Excessive involvement with work – driven by internal motivations rather than job requirements – is referred to as *workaholism* (Fassel, 1990; Spence and Robbins, 1992; Porter, 1996; Schaufeli et al., 2008).[1] Since the phenomenon of workaholism was first identified (to our knowledge, by Oates, 1971), it has attracted much attention in the popular press, and the term itself has become a colloquialism.

Although workaholism has been found to be closely related to overabundant labour supply and to adversely affect social welfare (e.g., Nishiyama and Johnson, 1997; Robinson et al., 2001; Andreassen et al., 2013), the attention given to it in economics is relatively scant. Adopting a model of self-signalling, Bénabou and Tirole (2004) argue that individuals may adhere to an exceedingly rigid rule that results in workaholism, because the fear of appearing weak to themselves leads workers to choose a degree of self-restraint to put their willpower to the test. Müller and Schotter (2010) observe workaholic behaviours in an experimental study, and attribute this finding to the possibility that subjects behave in a loss-averse manner.

In this study, we develop a simple theoretical model of workaholic behaviour. Workers' self-image is related to their productivity. As they receive relevant information, they may interpret it in a biased manner. Specifically, workers who receive positive performance information will *overestimate* its value as a signal of their productivity, while those receiving negative information workers will *underestimate* its signalling value. This motivated updating of beliefs implies that both groups of agents will work excessively in subsequent tasks, in order to preserve their self-image. Results from a lab experiment support this conjecture.

In our setting, the performance information received by workers is the outcome of a rank-order tournament: they either earn a bonus prize or they do not. Economists (e.g., Lazear and Rosen, 1981; Malcomson, 1984; Waldman, 2012) have long observed that many labour markets are organised as tournaments, particularly with regard to internal competition for prizes such as bonuses or promotions. The existing tournament literature has focussed on agents' *extrinsic*

[1] According to Sussman et al. (2012), approximately 10 percent of the general US population may be workaholics. Estimates in other studies are even higher (Andreassen et al., 2012). A prevalence of workaholism has been observed especially among management-level workers and in specific sectors (Andreassen et al., 2012; Taris et al., 2012).

motivation, before prizes are paid out and when effort can influence the chance of receiving a prize (e.g., Rosen, 1986; Moldovanu and Sela, 2001; Hvide, 2003; Müller and Schotter, 2010). By contrast, our study explores whether and how competition for prizes may shape agents' *intrinsic* motivation, which then drives them to continue working excessively – even after all prizes are paid out.

Our model has one firm and two workers. Workers care about their own income and about their self-image, with the latter influenced by their relative productivity. A more positive self-image is associated with a higher intrinsic motivation, and therefore a lower cost of subsequent effort.

The firm offers each worker a two-stage incentive scheme. Prior to the first stage, each worker is uninformed about their productivity, either in an absolute sense or relative to the other worker. In the first stage, workers compete for a fixed prize, and then the results are announced. In the second stage, each worker (who now has gained some information about their productivity) works under a piece-rate incentive system, with no competitive incentives at all.

The main result of the model is that self-image concerns, combined with biased belief updating, lead workers to distort their second-stage effort provision. Winners (those receiving the tournament prize based on their first-stage outcome) will raise their effort, in order to maintain their current perception of themselves. The bias also prevents losers (those not receiving the prize) from lowering their efforts in the second stage; rather they reassert their self-image by *also increasing* their efforts. This drives the tournament participants in aggregate – winners and losers combined – to work excessively, relative to the monetary incentives they face.

Despite its intuitive appeal, such a bias is difficult to test in the field, as establishing a tournament wherein everything else remains equal is nearly impossible in real workplaces. In particular, as Gibbons and Roberts (2013) stress, "incentive pay may cause selection, and the productivity effects of this selection can be as important as the productivity effects of the incentives themselves" (p. 95). For example, an extensive literature on asymmetric learning in labour markets (e.g., Waldman, 1984; Bernhardt, 1995; DeVaro and Waldman, 2012) view promotion tournaments as a signalling device since the promoted worker will have come from the high end of the ability distribution. To sidestep this problem, we design a tightly controlled experiment in which we vary how subjects are rewarded – based either on performance rank or on luck – but we do so in a way that largely eliminates selection effects (as detailed below).

The experiment, like the theoretical model, comprises two stages. In the first stage, subjects undertake a simple but tedious "real effort" task.[2] They must complete a fixed, known number of units of the task in order to go on to the next stage.

After the first stage ended, bonus prizes are allocated. In our *Random* treatment, a die roll determines whether a subject receives the prize for the first-stage task; thus earning the prize is due entirely to luck, and subjects are aware of this. In our *Tournament* treatment, subjects are told (truthfully) that they are paired with another, anonymous, subject, and that they receive the prize if they had completed the first-stage task faster than their matched rival. Unbeknownst to the subjects, half are randomly chosen to be matched to an extremely slow rival from a previous session, and the other half to an extremely fast rival. This minimises selection effects, since earning the bonus from the first-stage task is nearly unrelated to productivity, even in the Tournament treatment. (See Section 2.3 for a further discussion of this feature of our experimental design.)

In the second stage, subjects undertake the same real-effort task as in the first stage. Unlike in the first stage, the second-stage payment is based on a known piece rate. Subjects choose how long they wish to continue working, and can stop when they wish, at which time they are paid and can leave the session. There are no differences between the treatments in how the second stage is conducted. This allows us to identify the effect of self-image, by comparing second-stage effort provision between our Random and Tournament treatments with income effects and selection effects arguably controlled.[3]

[2]We use the zero-counting task of Abeler et al. (2011). This task is well suited for our experiment for three reasons, all previously noted by Abeler et al. First, the output and effort of a subject can be easily measured (tables completed and time spent, respectively). Second, a subject's individual productivity θ barely changes across time because the task is straightforward. That is, little learning is involved. Third, we can minimise the possibility of voluntary effort, altruism or reciprocity towards the experimenters because the completed tables per se are obviously worthless for us.

[3]Nonetheless, our analysis includes instrumental-variable models that account for the minor extent of selection in our Tournament treatment. As demonstrated in Section 3, our results are unaffected by whether or not these methods are used.

We observe strong evidence of workaholism in the experimental data. Overall, subjects provide approximately 20 percent more effort in the *second stage* when success in the *first stage* is seen as attributable to performance (in our Tournament treatment) than when it is seen as attributable to luck (in our Random treatment). "Winners" – subjects who were successful in the *first stage* – work significantly longer during the second stage in our Tournament treatment than winners in our Random treatment. If beliefs were updated in a symmetric way, we would then expect the opposite result for the remaining subjects ("losers"): working less in the second stage in the Tournament treatment than in the Random treatment. In fact, our data indicate the opposite: losers in the Tournament treatment actually work *more* in the second stage than their counterparts in the Random treatment, though this last difference is sometimes only marginally significant. These results suggest not only that self-image concerns are important in guiding choices of work effort, but also that self-image is updated in a motivated way in response to new information.

1.1 Related literature

Our study makes at least three contributions. First, it complements the economics literature about workaholism. Bénabou and Tirole (2004) view workaholism as a compulsive behaviour. They propose a model of self-control wherein people see their own choices as signals of their desire. They claim that workaholism represents a costly form of self-signalling in which "the individual is so afraid of appearing weak to himself that every decision becomes a test of his willpower" (Bénabou and Tirole, 2004, p. 851). Müller and Schotter (2010) are the first (to our knowledge) to associate workaholism with tournaments. In their experiment, they find that high-ability subjects in a tournament appear unable to stop themselves from working. This result is attributed to the possibility that winning subjects behave in a loss-averse manner in a tournament; high-ability subjects work excessively for fear of not winning the prize. We also examine the connection between workaholism and tournaments, but we examine *ex post* workaholic behaviours: distinct from behaviour in the tournament itself.

Second, our study connects to the literature on rank-order tournaments. Following the seminal work of Lazear and Rosen (1981), a large volume of literature has investigated settings where every agent chooses an *ex ante* (i.e., before all prizes are paid out) effort level (e.g., Lazear, 1999; Hvide, 2003; Goltsman and Mukherjee, 2011; Zabojnik, 2012; Imhoff and Krakel, 2016; Boudreau et al., 2016). Santos-Pinto (2010) considers positive self-image in a tournament model, and the effect of biased beliefs, but again focuses on *ex ante* effort provision. Huffman et al. (2022) observe positive correlations between managers' (positively) biased recollections about their past tournament results and overconfident beliefs about their future performance in similar tournaments. In contrast to these studies, we highlight the role of tournaments in shaping the intrinsic incentives of agents even after all prizes are paid out. Our experimental evidence shows that the rank-order tournament boosts agents' *ex post* effort provision.

Third, this study is related to the literature about asymmetric belief updating. A growing body of evidence from behavioural economics suggests that people have difficulty in forming unbiased opinions about their own abilities (e.g., Svenson, 1981; Malmendier and Tate, 2005; Englmaier, 2006; Burks et al., 2013). One underlying reason for this phenomenon is that people systematically under-update when they perceive negative signals but apply Bayesian rules when they recognise positive ones. Behavioural-theory models of such asymmetric updating have been proposed by Bénabou and Tirole (2002) and others. Empirically, Eil and Rao (2011) and Möbius et al. (2022) report evidence suggesting that subjects defend their beliefs about their IQ by judging positive signals as more informative than negative ones. Möbius et al. (2022) further find that such biases are mitigated when subjects update about an event not related to their ability, indicating that they are motivated (preference-based) rather than cognitive biases. Zimmerman (2020) observes that positive signals about IQ are persistently incorporated into beliefs, while negative signals have only a transitory effect. Chew, Huang and Zhao (2020) go further, arguing that individuals may forget bad signals or reinterpret them as good ones, or fabricate good signals from nothing. Our experiment adds to this stream of research by finding significant asymmetry between good news and bad news in their impact on effort choices.

2 Theory and experiment

For both the theoretical model and the experiment, we consider a two-stage setting with one (non-strategic) firm and two workers, called i and j, who perform the same task for the firm.

2.1 Model

Workers' initial wealth is normalised to zero. A worker's output y in a given stage is a function of absolute productivity $\theta > 0$ and effort level $l \geq 0$:

$$y = \theta l.$$

Both workers' absolute productivities θ_i and θ_j are exogenous and initially unknown. They are independently drawn from the same continuous distribution, and remain unchanged for all stages. The effort level l can be thought of as time spent working; there is no analogous choice of work intensity.

Each worker's stage utility is a function of individual wealth (up to but not including the current stage) $\omega \geq 0$, individual income (from the current stage) $m \geq 0$, relative standing s, and effort level l. Specifically, each worker has the stage-utility function

$$U(\omega + m, s, l) = \frac{(\omega + m)^{\gamma}}{\gamma} - \frac{l^{\beta}}{\beta(1+s)}. \tag{1}$$

The first term of the right-hand side of (1) represents the worker's utility from material gains $(\omega + m)$, and the second term represents the cost of effort. Here, $\gamma \in (0, 1]$ and $\beta > 1$ are parameters. Because $\gamma \leq 1$, marginal utility of material gains is non-increasing (and strictly decreasing if $\gamma < 1$), and because $\beta > 1$, the cost of effort is convex. Workers are myopic: they ignore any impacts on later stages when making decisions about their behaviour in earlier stages.

The relative standing parameter s in (1) captures the worker's "ego utility" (Bénabou and Tirole, 2002; Kőszegi, 2006), which is influenced by their relative productivity $\widetilde{\theta}$. Specifically,

$s = k\widetilde{\theta}$, where $k \in [k_{min}, k_{max}]$, with $-1 < k_{min} < 0 < k_{max} < 1$. We have

$$\widetilde{\theta}_i = \begin{cases} 1 & if \quad \theta_i > \theta_j \\ 0 & if \quad \theta_i = \theta_j \\ -1 & if \quad \theta_i < \theta_j \end{cases} \tag{2}$$

for worker i.

The parameter k characterises the connection between s and $\widetilde{\theta}$: the worker's interpretation of the revealed output rank. When $k = 0$, meaning that the worker believes s is unaffected by $\widetilde{\theta}$, we have $s = 0$ regardless of $\widetilde{\theta}$. When $k > 0$, a high $\widetilde{\theta}$ entails that s is high, while a low $\widetilde{\theta}$ entails that s is low. We also allow for the possibility that $k < 0$, for cases where the worker views the signal as negatively correlated with productivity.[4]

The marginal cost of effort is decreasing in s, meaning that workers with higher relative standing are intrinsically more motivated to exert effort. In the case that information about θ_j is unavailable, $\widetilde{\theta}_i = 0$. At the beginning of the first stage, workers do not know their own absolute productivity θ, nor that of the other worker. We therefore assume $\widetilde{\theta}_i = 0$ and $s_i = 0$ initially for all i.

2.2 Two-stage incentive scheme

At the first stage, the firm establishes a tournament, where the worker with the higher first-stage productivity receives a prize of π money units (in the event of a tie, which occurs with probability zero in equilibrium, one of the workers is randomly chosen to receive the prize). There is also a (possibly zero) non-tournament component to earnings, $v \geq 0$. So, first-stage earnings are $m = \pi + v$ if the worker receives the prize, and $m = v$ if not. Including both a tournament and a non-tournament component to earnings makes our model correspond more closely to the experimental setting – which contains both of these components – and also reflects the ubiquity of non-tournament remuneration in real workplaces, even highly competitive ones.

Note that, since θ_i and θ_j are drawn from the same distribution, each worker is identical

[4] We require $-1 < k_{min} < k_{max} < 1$ to ensure $s > -1$, so that the last term in (1) is always defined.

before θ is realized. Also, as noted above, $s = 0$ in the first stage. As a result, in equilibrium each worker exerts the same (in expectation) first-stage effort l_1 and wins the tournament with probability one-half. At the end of the tournament stage, each worker observes their first-stage output y_1 and infers their own θ. They also can infer their relative productivity $\widetilde{\theta}$ from the revealed output rank. Specifically, from (2) above, $\widetilde{\theta}_i$ is equal to 1 if worker i is the winner, and -1 if i is the loser.

In the second stage, a piece-rate formula ties a worker's income to their output. The worker exerts effort l_2, which yields the (observable and verifiable) second-stage output y_2, and the worker earns $m = \alpha y_2$, where $\alpha > 0$ is the known piece rate. If a worker receives the tournament prize as a winner in the first stage, then when the second stage begins, they possess wealth $\omega = \pi + \upsilon_{winner}$. By contrast, $\omega = \upsilon_{loser}$ if the worker lost in the first stage. We assume that for a given worker, υ is weakly larger if the worker is a tournament winner:

Assumption 1 $\upsilon_{winner} \geq \upsilon_{loser}$

This would follow from the non-tournament component of payment being unrelated to productivity (e.g., salary), but would also follow from the amount being strictly increasing in productivity, such as a piece rate, performance reviews by supervisors, and so on.

To illustrate the potential impacts of the tournament on the workers' effort provision at the piece-rate stage, we consider three cases.

Case 1: Workers without self-image concern. For this benchmark case, we suppose that there are no self-image concerns that would influence workers' behaviour, i.e., $s = 0$. Then, substituting $\omega = \pi + \upsilon_{winner}$, $m = \alpha y_2 = \alpha\theta l_2$ and $s = 0$ into the utility function (1), we have the winner's problem:

$$\max_{l_2} \left\{ \frac{(\pi + \upsilon_{winner} + \alpha\theta l_2)^\gamma}{\gamma} - \frac{l_2^\beta}{\beta} \right\}. \tag{3}$$

The winner's first-order condition can be expressed as

$$\alpha\theta(\pi + \upsilon_{winner} + \alpha\theta l_2)^{\gamma-1} = l_2^{\beta-1}, \tag{4}$$

which solution implicitly yields the winner's optimal effort provision $l^*_{2,winner}$.

Likewise, substituting $\omega = \upsilon_{loser}$, $m = \alpha y_2$ and $s = 0$ into (1) yields the loser's problem:

$$\max_{l_2} \left\{ \frac{(\upsilon_{loser} + \alpha\theta l_2)^\gamma}{\gamma} - \frac{l_2^\beta}{\beta} \right\}. \tag{5}$$

The loser's first-order condition is

$$\alpha\theta(\upsilon_{loser} + \alpha\theta l_2)^{\gamma-1} = l_2^{\beta-1}, \tag{6}$$

which solution implicitly yields the loser's optimal effort provision $l^*_{2,loser}$.

It is straightforward to show that winners exert weakly less effort in the second stage than losers, other things equal:

Proposition 1 *If Assumption 1 holds,* $l^*_{2,winner} \leq l^*_{2,loser}$

The intuition behind this result is simple.[5] The prize awarded at the end of the tournament stage (weakly) reduces the winner's marginal utility of additional income in the subsequent piece-rate stage when $\gamma < 1$.

Case 2: Workers with unbiased self-image concern. Now, suppose that workers have self-image concerns, and that they update their self-image in an unbiased way as they receive new information. In this situation, k (the variable relating relative productivity and self-image) can be viewed as a fixed positive parameter; we assume $k = \hat{k} \in (0, k_{max})$. For a worker who won the prize, the utility maximisation problem becomes

$$\max_{l_2} \left\{ \frac{(\pi + \upsilon_{winner} + \alpha\theta l_2)^\gamma}{\gamma} - \frac{l_2^\beta}{\beta(1+\hat{k})} \right\}. \tag{7}$$

For a worker who did not win the prize, the utility maximisation problem becomes

$$\max_{l_2} \left\{ \frac{(\upsilon_{loser} + \alpha\theta l_2)^\gamma}{\gamma} - \frac{l_2^\beta}{\beta(1-\hat{k})} \right\}. \tag{8}$$

[5]The proofs of all theoretical results in this paper are in Appendix A. Note that Assumption 1 is used in the proof of Proposition 1, but not for any other theoretical results. Also, we acknowledge that in a more general version of our model, with heterogeneous cost-of-effort functions, Proposition 1 would continue to hold for within-person comparisons (a given worker would work less hard after winning than after losing the prize) but not necessarily for between-person comparisons (a worker who won may not work less hard than a different worker who lost).

Following the procedures similar to those in Case 1, we find the first-order condition for the winner

$$\alpha\theta(\pi + \upsilon_{winner} + \alpha\theta l_2)^{\gamma-1} = \frac{l_2^{\beta-1}}{1+\hat{k}}, \tag{9}$$

and for the loser

$$\alpha\theta(\upsilon_{loser} + \alpha\theta l_2)^{\gamma-1} = \frac{l_2^{\beta-1}}{1-\hat{k}}, \tag{10}$$

which as before yield the winner's optimal effort provision $l_{2,winner}^{UB}$ and the loser's $l_{2,loser}^{UB}$ implicitly.

It is straightforward to show that these unbiased image concerns lead to *higher* second-stage efforts by winners and *lower* efforts by losers, compared to when there are no image concerns (that is, Case 2 as compared to Case 1):

Proposition 2 $l_{2,winner}^{UB} \geq l_{2,winner}^{*}$ *and* $l_{2,loser}^{UB} \leq l_{2,loser}^{*}$

Intuitively, positive feedback about s decreases the marginal cost of effort and hence reinforces the intrinsic motivation in the ego-driven worker, while negative feedback about s does the opposite.

Case 3: Workers with biased self-image concern. We continue to suppose that workers have self-image concerns, but now they are *biased* in how they update their beliefs in response to new information. By this, we mean that the variable k, rather than being an exogenous parameter as above, acts as a choice variable. We will see below that a worker who is successful in the tournament will assign a high value to k (overestimating the prize as a signal of productivity), while an unsuccessful worker will assign a low value to k (under-estimating its signal).

In this situation, the winner's problem is

$$\max_{k,\ l_2} \left\{ \frac{(\pi + \upsilon_{winner} + \alpha\theta l_2)^{\gamma}}{\gamma} - \frac{l_2^{\beta}}{\beta(1+k)} \right\}, \tag{11}$$

while the loser's problem is

$$\max_{k,\ l_2} \left\{ \frac{(\upsilon_{loser} + \alpha\theta l_2)^\gamma}{\gamma} - \frac{l_2^\beta}{\beta(1-k)} \right\}. \tag{12}$$

Observing (11) and (12), we notice that given the effort level l_2, the winner can increase utility by adjusting their beliefs about k upward while the loser can increase utility by adjusting their beliefs about k downward. Intuitively, if a worker outperforms in the tournament, they have an incentive to make a stronger positive connection between output rank and relative standing in their mind, in order to improve their self-image. If the worker underperforms, they will underestimate the connection in order to protect their self-image. So, in equilibrium, the winner is inclined to believe $k = k_{max}$ (performance was maximally attributable to ability) while the loser is inclined to believe $k = k_{min}$ (performance was maximally negatively related to ability).

This argument allows us to simplify (11) and (12) to

$$\max_{l_2} \left\{ \frac{(\pi + \upsilon_{winner} + \alpha\theta l_2)^\gamma}{\gamma} - \frac{l_2^\beta}{\beta(1+k_{max})} \right\} \tag{13}$$

and

$$\max_{l_2} \left\{ \frac{(\upsilon_{loser} + \alpha\theta l_2)^\gamma}{\gamma} - \frac{l_2^\beta}{\beta(1-k_{min})} \right\}. \tag{14}$$

The corresponding first-order conditions are

$$\alpha\theta(\pi + \upsilon_{winner} + \alpha\theta l_2)^{\gamma-1} = \frac{l_2^{\beta-1}}{1+k_{max}} \tag{15}$$

for winners and

$$\alpha\theta(\upsilon_{loser} + \alpha\theta l_2)^{\gamma-1} = \frac{l_2^{\beta-1}}{1-k_{min}} \tag{16}$$

for losers, which implicitly yield the winner's and loser's optimal effort provisions $l_{2,winner}^{BI}$ and $l_{2,loser}^{BI}$ respectively.

By arguments similar to those underlying Proposition 2, it is easy to show that winners' second-stage effort is higher than in Case 2, and losers' is higher than in Case 1.

Proposition 3 $l^{BI}_{2,winner} \geq l^{UB}_{2,winner}$ *and* $l^{BI}_{2,loser} \geq l^{*}_{2,loser}$

Thus we have

$$l^{BI}_{2,winner} \geq l^{UB}_{2,winner} \geq l^{*}_{2,winner}$$

and

$$l^{BI}_{2,loser} \geq l^{*}_{2,loser} \geq l^{UB}_{2,loser}.$$

This means that both winners' and losers' second-stage efforts (and therefore the average effort across both types) are highest in Case 3.[6]

2.3 Experimental design and procedures

We test the model and its implications with a lab experiment, in which we vary the basis for rewarding subjects in the tournament (output rank or luck). The experiment took place at Hebei University of Economics and Business (Shijiazhuang, China); it was computerised using the z-Tree platform and conducted in Chinese. A total of 164 subjects participated in this experiment, from a variety of majors. There were no exclusion criteria, but most students were undergraduates (82.3 percent) and majoring in economics or business (79.9 percent). The average age of subjects was 20.45 years, and 64.0 percent were female.

Before the experiment started, subjects were told that they were not allowed to communicate with each other during the experiment, and that their payoffs were denominated in lab money ("talers"). Then, subjects answered a set of control questions (see Appendix C.1), including a series of small-stakes lottery choices with to assess attitudes toward risk (Holt and Laury, 2002) and losses versus gains (Gächter et al., 2007) and a brief questionnaire on the subjects' age, gender, and college major.

The main part of the experiment had two stages. First, the subjects read the instructions for the first stage (see Appendix C.2). They were informed that there would be a second stage, but the details were not announced until after the first stage ended. During the first stage,

[6] It is worth pointing out that Proposition 3 follows from setting $k = k_{max}$ for winners and $k = k_{min}$ for losers, as we have done, but weaker conditions on k would still yield the result. It suffices that winners' k is larger than $\hat{k}$ from Case 2, and that losers' k is negative.

each subject worked on a simple but tedious "zero-counting" task (Abeler et al., 2011). They were given 30 tables, each with 150 randomly ordered zeros and ones. For each table, they were asked to count the number of zeros and enter it; if correct, they went on to the next table. For each subject, the elapsed time is displayed on the screen throughout the task, so each is informed about their own time spent in counting the 30 tables. Our measure of individual (absolute) productivity is this counting speed: the number of correctly completed tables per minute during this stage, or equivalently, 30 divided by the time spent working. Subjects' payoffs for the first stage had two components. First, a bonus prize was received by half of the subjects; this is described later in this section. Second, subjects incurred a cost of 1 taler for each minute required (rounded down to the nearest taler) to complete the 30 units of the task; this was subtracted from a lump-sum participation payment of 100 talers.[7]

At the end of the first stage, subjects received instructions for the second stage (see Appendix C.3). The second stage began with subjects being informed of the first-stage result: whether or not they had earned the bonus of 90 talers. In the Random treatment, they were told, "we give you a chance to earn the first-stage bonus by playing dice. Please roll the virtual die under the supervision of one experimenter. If the die shows 1, 3, or 5, you will earn zero. If the die shows 2, 4, or 6, you will earn 90 talers". Clearly, which subjects earned the first-stage prize would be attributable to luck in this treatment.

In the Tournament treatment, the instruction was "we give you a chance to earn the first-stage bonus by performance comparison. Specifically, we paired you with another participant (your rival) prior to the first stage. If you spent more time in completing the first-stage task than your rival did, you will earn zero; otherwise, you will earn 90 talers". The instructions did not specify how the pairings were determined. In fact, we purposely selected the "rivals" from a previous pilot session: one rival was quick, whereas the other was slow. A given subject was very likely to win if paired with the slow rival, and to lose if paired with the fast rival; indeed, it turns out that only 3 out of 82 (3.7 percent) of subjects in this treatment either beat the fast

[7]In principle, it was possible for subjects to have negative real-money earnings at the end of the first stage, by taking longer than 100 minutes to complete the task. However, the task was calibrated to make this was very unlikely. In fact, subjects on average took only 27 minutes to complete the first-stage task, and the slowest subject finished in 58 minutes.

rival or lost to the slow rival. As one of these two rivals was randomly assigned to each subject, the underlying reason some subjects earned the first-stage prize in the tournament treatment was therefore nearly the same as that in the random treatment, minimising the selection issues normally present in tournaments.

We are aware that this aspect of the design may be regarded as deception by some readers, even though it falls into the category of limited disclosure (not providing information that may be relevant to subjects) rather than lying to subjects (stating information that is false). Many experimenters tend to support limited disclosure to subjects, especially if it is essential to the design and does not involve outright lying, as is the case here (Hertwig and Ortmann, 2008; Charness et al., 2022).[8]

All subjects in all groups then undertook the second-stage task. The task was the same as before, but with two changes to the surrounding setting. First, the incentive scheme was changed: subjects received a known and certain piece rate (3 talers per correct answer), with no competition against other subjects. Second, subjects could decide how much and for how long they wanted to work, up to a maximum of 90 minutes. When they wanted to leave, they could click a button on the screen to signal that the experiment was over.[9]

When a subject chose to finish the experiment, the subject was paid and left. Talers were converted to Chinese yuan (CNY) following the exchange rate of 1 CNY per 10 talers (rounded to the nearest 0.1 CNY).[10] There was a show-up fee of 10 CNY; as noted above, this was used to offset any losses in the first stage. Subjects' earnings averaged 38.2 CNY, and ranged from 7.8 to 80.4 CNY. Sessions took approximately two hours on average, including the time for instructions.

[8]During the experimental sessions, subjects were told that they could ask questions about the details of the experiment, which would be answered privately. No subject asked for clarification of how they were paired in the tournament treatment, though we would have answered such a question truthfully.

[9]We led the subjects inside a classroom in different batches (the time interval between two successive batches is 10 minutes) and randomly assigned a cubicle to each. As subjects might start the experiment at different times, those working on the second-stage task were not peer pressured when deciding whether to leave.

[10]In 2019, the minimum hourly wage in Shijiazhuang was around 16 CNY (2.27 US dollars).

2.4 Hypotheses

We use the time spent in the second-stage real-effort task as a measure of effort provision in that stage. Therefore, we can test whether subjects process information about their own productivity in a biased manner by comparing the average second-stage effort provision across treatments and groups. Specifically, according to the model, each subject in the Random treatment has $s = 0$ in the second stage. Thus, winners should exert the second-stage effort $l^*_{2,winner}$ and losers should exert $l^*_{2,loser}$, as described in Section 2.2. In the Tournament treatment, subjects should exert the second-stage efforts $l^{UB}_{2,winner}$ and $l^{UB}_{2,loser}$ if they are unbiased, and $l^{BI}_{2,winner}$ and $l^{BI}_{2,loser}$ if they are biased.

Both of our experimental treatments satisfy Assumption 1 in Section 2.2. So, our Propositions 1 - 3 can be used to formulate hypotheses. The hypotheses below are expressed as directional alternative hypotheses; corresponding null hypotheses are only specified if not clear from context. All of these hypotheses involve subjects' effort in the second stage, after the first-stage results become known.[11]

Hypothesis 1 *In stage 2, time spent working in the Random treatment is higher for losers than winners.*

Hypothesis 1 is a test for an income effect. In the Random treatment, winners and losers are drawn randomly, and thus should have similar productivity on average, and because subjects understand that winners are randomly chosen, self-image concerns should not come into play. Hence, and as demonstrated in Proposition 1, winners in that treatment should work weakly less than losers, due to the prize's effect on marginal utility of money (i.e., because $\gamma \leq 1$).

The next hypothesis is a test for self-image concerns:

Hypothesis 2 *In stage 2, winners in the Tournament treatment spend more time working than their counterparts in the Random treatment.*

The reasoning behind Cases 2 and 3 in Section 2.2 implies that compared to the Random treatment, winners in the Tournament treatment exert more effort in the second stage. The

[11] We state these hypotheses in terms of strict inequalities. However, it should be noted that in the (unlikely but possible) case that the maximum or minimum second-stage effort level (90 minutes and 0 minutes, resp.) turns out to be binding for a large number of subjects, the inequalities would be weak instead of strict.

difference between Cases 2 and 3 is that when self-image concern is unbiased (Case 2), losers in the Tournament treatment will exert *less* effort in the second stage compared to their counterparts in the Random treatment, while biased self-image concerns (Case 3) mean that losers would intensify their efforts in the Tournament treatment. Thus, our final hypothesis is a test of *biased* self-image concerns:

Hypothesis 3 *In stage 2, losers in the Tournament treatment spend more time working than their counterparts in the Random treatment.*

3 Experimental results

Table 1 presents descriptive statistics from the experiment, including the average time spent working in stage 2 (effort) and the corresponding number of completed tables: for each treatment overall, and separately according to the first-stage outcome. (Figure 1 below provides more disaggregated information.)

Table 1: Descriptive statistics, by treatment and first-stage outcome

Treatment:	**Random**		**Tournament**	
Stage 1 productivity (units completed/minutes worked)	1.17 (0.33)		1.19 (0.33)	
Stage 2 effort (minutes worked)	58.62 (28.81)		71.55 (21.99)	
Stage 2 output (units completed)	72.52 (42.71)		93.23 (42.84)	
Stage 1 outcome:	**Winner**	**Loser**	**Winner**	**Loser**
Stage 1 productivity	1.17 (0.35)	1.16 (0.31)	1.25 (0.38)	1.14 (0.28)
Stage 2 effort	56.03 (26.63)	61.34 (31.04)	75.10 (18.74)	68.33 (24.35)
Percent with maximum stage 2 effort (90 minutes)	19.0	30.0	43.6	20.9
Stage 2 output	68.33 (41.41)	76.93 (44.12)	100.95 (42.52)	86.23 (42.39)
Observations	42	40	39	43

Notes: Standard errors are in parentheses.

As before, we use the terms "winners" and "losers" to mean those who won, or failed to win, the prize at the end of the first stage. Recall from Section 2.3 that in the Random treatment, winners and losers were determined by random draws, making assignment of this role exogenous.

In the Tournament treatment, subjects were randomly matched to either a very slow or a very fast subject from a pilot session, and were winners or losers as they outperformed or did not outperform their assigned rival. It was therefore possible that some subjects selected to be "winners" did not actually win (due to being even slower than the slow rival), and similarly for those selected as "losers". This happened for 1 of 38 subjects (2.6 percent) selected to be "winners" and 2 of 44 (4.5 percent) selected to be "losers". Therefore, while our design did not completely eliminate selection effects, it did reduce them dramatically. Our regression analysis will include robustness checks using instrumental variables (see below for details), but it turns out that our results are not materially affected by whether or not these are used.

Before examining our main research questions, we briefly discuss some of the other results shown in Table 1. First, there is no significant difference between treatments in first-stage productivity ($p > 0.20$ for pooled first-stage winners and losers, two-tailed robust rank-order test), consistent with our random assignment of subjects to treatments. There are also no significant first-stage productivity differences between first-stage winners and losers in the Random treatment ($p > 0.20$), nor in the Tournament treatment ($p > 0.20$); this last finding supports our assertion that our implementation of the tournament minimises the issues of selection common in experimental studies. Next, while all subjects chose to work a positive number of minutes in the second stage, some appear to have been constrained by the second-stage maximum of 90 minutes. However, most of them (more than two-thirds overall) chose to work less than the maximum, suggesting that the experiment should have sufficient power to detect treatment effects. In our regressions below, we will include Tobit specifications to account for the right-censoring.

We move to our main interest: the analysis of subjects' effort choices, that is, time spent working on the second-stage task.[12] Table 1 indicates clearly higher efforts in the Tournament treatment than in the Random treatment, both overall and for winners and losers separately. The differences are substantial in magnitude: efforts in the Tournament treatment are nearly 20 percent higher overall than in the Random treatment, and the difference is roughly 30 percent

[12]Results involving second-stage output (tables completed) are broadly similar to those discussed here involving effort; details are available from the corresponding author.

for first-stage winners and 10 percent for first-stage losers.[13] Nonparametric tests confirm these treatment effects, with differences between the treatments in aggregate significant ($p < 0.01$ for pooled winners and losers, two-tailed robust rank-order test). The differences are also significant for winners alone (Tournament winners versus Random winners, $p < 0.01$). The differences for losers are not significant ($p > 0.20$), but here it is equally important that there is no difference *in the other direction* (let alone a significant difference), as would be implied by unbiased self-image concerns (recall Section 2.4). This means that the lack of support for unbiased self-image concerns in our data is not due to a lack of power to detect a difference, but rather suggests that there actually is no difference in the direction predicted by unbiased self-image concerns. To the extent that differences do exist, they (and the corresponding differences for winners) are instead consistent with biased self-image concerns, i.e., with Hypothesis 3.

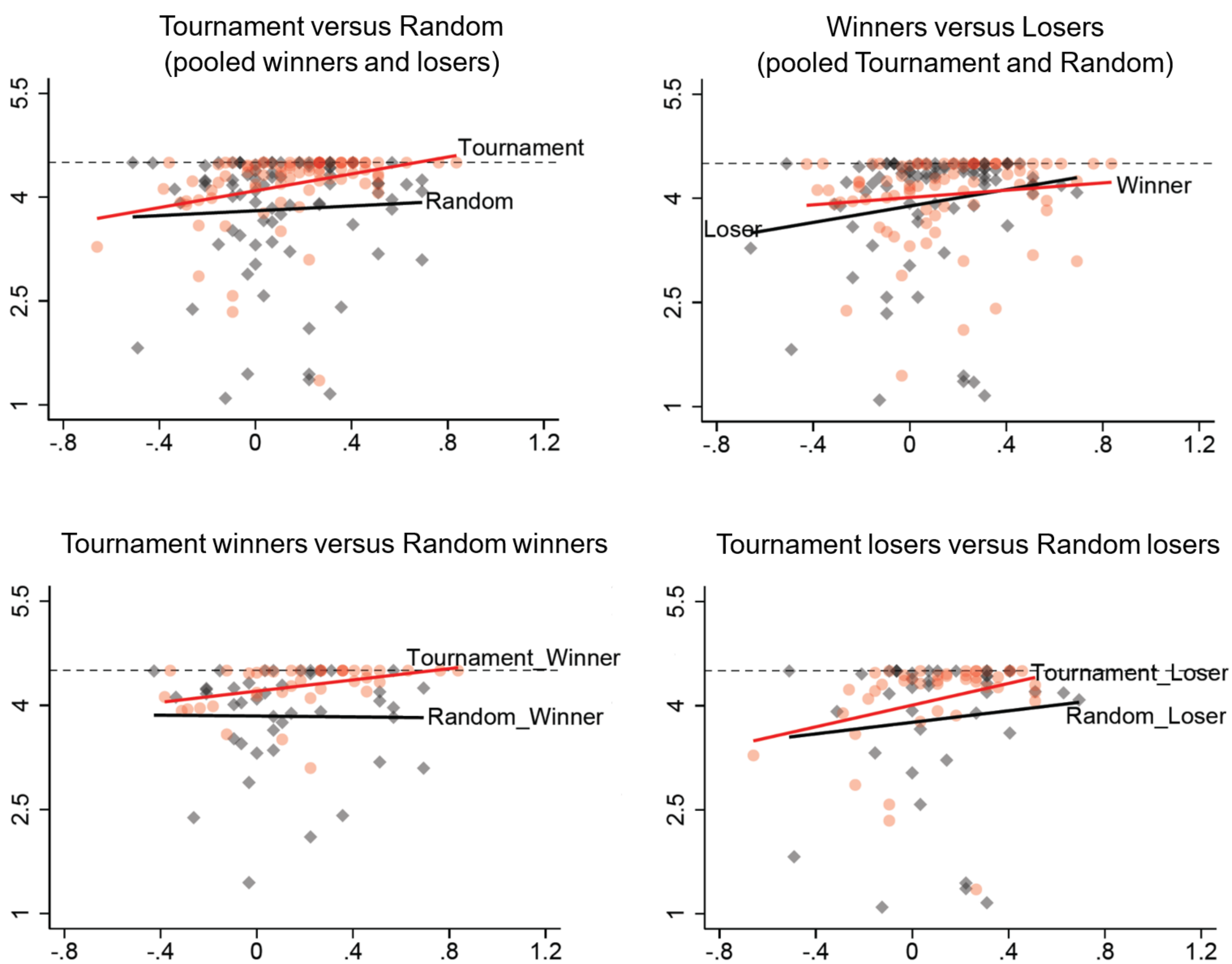
Figure 1 displays four scatterplots of log productivity (horizontal axis) and log effort (vertical axis), along with fitted OLS trend lines. In the top-left panel, these correspond to the Random and Tournament treatments (black and red lines, respectively). On average, the red scattered points lie above the black ones, indicating higher effort in the Tournament treatment. The treatment effect appears to be larger at higher levels of productivity, though we will see in Table 2 below that the interaction between treatment and productivity is not significant. The bottom-left and bottom-right panels indicate similar effects for first-stage winners and losers separately.

Examination of the bottom-left and bottom-right panels of Figure 1 suggests that income effects in the Random treatment are negligible, as there do not appear to be any meaningful differences in second-stage effort between winners and losers of the first-stage prize. (Below, we examine this result further using regressions.)

As discussed in Case 2 in Section 2.2, unbiased self-image concerns imply that if being informed of their output rank after the first stage makes winners in the Tournament treatment increase their subsequent effort provision (i.e., $l^{UB}_{winner} > l^{*}_{winner}$), then losers should correspondingly reduce theirs (i.e., $l^{UB}_{loser} < l^{*}_{loser}$). Since our data do indeed show that winners in the

[13] Midpoint formulas (difference between A and B, divided by average of A and B) used for computing percent differences.

Figure 1: Scatterplots of first-stage productivity and second-stage effort. Vertical (horizontal) axis: natural logarithm of time spent working (productivity). Red (black) points represent individual subjects in the Tournament (Random) treatment [top-left panel], winners (losers) [top-right panel], Tournament winners (Random winners) [bottom-left panel], and Tournament losers (Random losers) [bottom-right panel]. Solid lines represent associated OLS trend lines. Dashed lines mark the natural logarithm of time limit (ln(90)).



Tournament treatment work more in the second stage than winners in the Random treatment, losers in the Tournament treatment ought to work *less* in the second stage than winners in the Random treatment. However, as noted already, the observed difference is actually in the opposite direction. Our data therefore do not support unbiased self-image concerns; rather they are consistent with subjects' updating their beliefs about k in a biased manner, as discussed in Case 3 of Section 2.2, and consistent with Hypothesis 3.

Table 2 continues the examination of these treatment effects. In columns I-III and V, we

Table 2: Second-stage effort (time working), estimated coefficients and marginal effects

	(I) Tobit	(II) Tobit	(III) Tobit	(IV) inst. vars.	(V) Tobit	(VI) inst. vars.
Coefficient estimates						
Tournament	0.433***	0.422***			0.329*	0.347**
	(0.149)	(0.155)			(0.197)	(0.151)
Win			0.103	0.024	–0.073	–0.032
			(0.149)	(0.119)	(0.196)	(0.154)
Tournament x Win					0.415	0.143
					(0.283)	(0.215)
log(Prod)	0.692**	0.261	0.669**	0.333	0.635**	0.319**
	(0.274)	(0.359)	(0.275)	(0.227)	(0.262)	(0.219)
Tournament x log(Prod)		0.847				
		(0.520)				
Female		0.550***	0.462***	0.372***	0.564***	0.454***
		(0.150)	(0.155)	(0.117)	(0.150)	(0.114)
Loss Aversion		0.030	0.044	0.053	0.039	0.042
		(0.056)	(0.059)	(0.044)	(0.056)	(0.042)
Risk Aversion		–0.019	–0.001	–0.023	–0.017	–0.035
		(0.047)	(0.049)	(0.037)	(0.047)	(0.035)
Adj/Pseudo-R^2	0.037	0.080	0.043	0.097	0.080	0.174
Marginal effects of Tournament variable						
Average effect	0.433***	0.530***			0.534***	0.418***
	(0.149)	(0.144)			(0.144)	(0.109)
Winners					0.744***	0.490***
					(0.207)	(0.155)
Losers					0.329*	0.347**
					(0.197)	(0.151)

*Notes: $N = 164$. Standard errors in parentheses. * (**, ***) Significant at 10% (5%, 1%) level.*

report results of Tobit regressions, where the dependent variable is the natural logarithm of second-stage effort (time spent working).[14] The main explanatory variables are a dummy for the

[14]OLS regressions, presented in Appendix B, yield similar conclusions, aside from somewhat smaller estimated

Tournament treatment, a dummy for winning the prize (in either the Random or Tournament treatment) and the natural logarithm of productivity (log(Prod)). (Recall that productivity is defined as the subject's number of correctly completed tables per minute in the first stage.) Column I shows that the effect of the Tournament dummy is positive and significant, and Column II indicates that this effect is robust to whether we include gender, measures of risk and loss aversion (with higher values of these variables corresponding to more aversion to risk and loss), and interaction with productivity in the regression.

In columns IV and VI, we account for the endogeneity of our Win variable in the Tournament treatment, using instrumental-variables (linear) regressions. The instrument we use is whether the subject was paired with the slow or fast rival; this is exogenous, highly correlated with our Win variable, and has no effect on our dependent variable except via the Win variable. The similarity of columns IV and VI to (respectively) columns III and V confirms our main results.

Result 1 *Subjects in the Tournament treatment spend significantly more time working in the second stage than their counterparts in the Random treatment.*

The insignificant coefficient of Win in columns III and IV confirms that winners' effort provision does not differ from losers'; that is, there is no significant income effect (the data do not support Hypothesis 1).

Result 2 *There are no significant differences between winners' and losers' second-stage efforts.*

Models V and VI allow us to find the marginal effects of the Tournament treatment separately for winners and losers. The positive and significant marginal effect on winners indicates that first-stage winners in the Tournament treatment increase their second-stage effort significantly more than their counterparts in the Random treatment, and statistically confirms the graphical evidence from the bottom-left panel of Figure 1. Moreover, the corresponding marginal effect on losers, though not always significant at the usual 5-percent level, suggests

effect sizes, due to Tobit models' accounting for the downward-censoring of subjects who worked for the upper bound of 90 minutes (about 28 percent of subjects did so).

that first-stage losers in the Tournament treatment also increase their second-stage effort provision (relative to their counterparts in the Random treatment). This last result, which confirms the graphical evidence from the bottom-right panel of Figure 1, is consistent with the prediction derived from the assumption of biased beliefs about k (biased self-image).

Result 3 *Winners in the Tournament treatment exert significantly more second-stage effort than their counterparts in the Random treatment.*

Result 4 *Losers also exert more second-stage effort than their counterparts in the Random treatment, though the difference is sometimes only weakly significant.*

With these experimental results in mind, we can re-assess the theoretical model from Section 2. Our Result 1 (differences in aggregate behaviour between Tournament and Random treatments) highlights that self-image matters; that is, the relative standing parameter s is positive in our Tournament treatment, which in turn implies that the parameter k (relationship between s and the signal of relative productivity) is nonzero for a substantial portion of our subjects. Our Result 2 (lack of a significant income effect) suggests that the parameter γ (exponent of income in the utility function) is close to 1. Our Result 3 (more second-stage effort for winners in the Tournament treatment, compared to the Random treatment) suggests that for winners, $k > 0$. This positive value is consistent with winners' viewing the tournament outcome as a positive signal of productivity, with a corresponding effect on their self-image.

Our Result 4 (weakly more second-stage effort in the Tournament treatment) indicates that k is non-positive for losers, though the borderline significance implies that we cannot rule out that its value is zero. This in turn suggests that our assumption that k can be freely chosen over its entire range (between k_{min} and k_{max}) may be an oversimplification. Instead, and consistent with previous results in the literature (e.g., Bénabou and Tirole, 2016), the selection of k likely reflects a trade-off between desirability and accuracy. In our setting, a negative value of k (that is, a negative correlation between one's productivity and one's first-stage performance) may be viewed by some agents as implausible. For these agents, the actual lower bound on k would instead be zero (no correlation between productivity and performance), leading to levels of effort in the Tournament treatment comparable to how they would have behaved in the Random treatment.

4 Discussion

We theoretically and experimentally examine *workaholism*. Workers make effort decisions under a two-stage incentive scheme; they compete for a fixed prize in the first stage, and face a piece-rate system in the second stage. Our theoretical model allows for motivated belief updating: workers interpret information from their first-stage tournament outcome asymmetrically as a signal of their underlying productivity. Workers who "won" (received the tournament prize) in the first stage *overestimate* the usefulness of this positive signal, and thus overestimate their productivity. Those who "lost" (did not receive the prize) *underestimate* the usefulness of this negative signal, and thus also overestimate their productivity. As a result, tournament participants in aggregate (winners and losers combined) tend to work excessively afterwards, under the subsequent piece-rate system.

We test for workaholism with an experiment that implements the theoretical setting. In the first stage, subjects are assigned a task with a fixed workload and a fixed potential prize, which half of them will earn. In the second stage, they perform the same task but choose how many units of the task they undertake under a piece-rate system, with no competition against others.

Our treatments differ only in the feedback subjects receive between stages. In our Random treatment, subjects are informed that a die roll determines who wins the prize. In the Tournament treatment, subjects are informed that they were assigned to a rival at the beginning of the experimental session, and only those who outperformed their rivals are rewarded. However, these rivals were chosen from previous sessions: one rival was very quick and the other was very slow (so respectively, the subject was almost certain to lose or almost certain to win). The rival was assigned randomly, making this treatment nearly identical to the Random treatment except for the tournament framing, and minimising issues of selection and endogeneity.

The data provide support for our "workaholism" hypotheses. Overall, subjects in the Tournament treatment work significantly harder in the second stage than those in the Random treatment. This result is seen both in winners (those in the Tournament treatment work significantly harder than their counterparts in the Random treatment) and in losers (who also work harder in the Tournament treatment, though the difference is not always significant). Our results are robust to controlling for the (minor) selection issues in the Tournament treatment.

Our results complement the existing literature about workaholism (e.g., Bénabou and Tirole, 2004; Müller and Schotter, 2010). Like Müller and Schotter (2010), we associate workaholism with tournament incentives, but our emphasis is on how self-serving attribution bias induces ex-post workaholic behaviours (i.e., after the tournament has ended), in contrast to the earlier focus on behaviour during the tournament. Our study is also germane to the general literature on tournaments (e.g., Lazear and Rosen, 1981; Lazear, 1999) and highlights how tournaments shape agents' need to work, even after all prizes have been awarded. Finally, our study contributes to the literature about motivated beliefs (e.g., Eil and Rao, 2011; Möbius et al., 2022) by finding significant asymmetry between good news and bad news in the domain of real-effort choices.

We close by mentioning some of the limitations of this study. Firstly, we believe our theoretical model incorporates self-image into effort choice in a natural way. However, other model structures may yield different theoretical implications. In particular, our model assumes that the benefit of money and the disutility of labour are additively separable, and that the disutility of labour is reduced as self-image improves. Neither of these assumptions is completely innocuous. Secondly, we have implemented motivated belief updating as overestimating the value of positive signals and underestimating that of negative signals. Other authors have argued for different explanations: e.g., as noted in Section 1.1, Zimmerman (2020) proposes that positive signals are more persistently incorporated into beliefs than negative signals, while Chew, Huang and Zhao (2020) suggest that negative signals may be ignored or reinterpreted as good signals. Our experiment was not designed to distinguish between these alternative explanations for motivated beliefs, but future research (perhaps eliciting beliefs about the signals directly, rather than indirectly via behaviour) may do so. Thirdly, our model and experiment are one-shot; it is possible that workaholism would be attenuated if workers repeatedly faced tournaments followed by non-tournament incentives. Along the same lines, workers faced the same task in both stages of our setting, which may have highlighted the value of the first-stage outcome as a signal for the second stage. This value might have been reduced, or even reversed, if the second-stage task were different in nature from the first-stage task. We encourage future research along these lines.

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A Proofs

Proof of Proposition 1: Consider the equation

$$l_2^{\beta-1} = \alpha\theta[x\pi + x\upsilon_{winner} + (1-x)\upsilon_{loser} + \alpha\theta l_2]^{\gamma-1}. \tag{17}$$

Note that when $x = 1$ and $x = 0$, (17) reduces to the first-order conditions for winners and losers respectively (see (4) and (6) in the main text), and recall from Section 2 that $\upsilon_{winner} \geq \upsilon_{loser}$, $\beta > 1 \geq \gamma$, and $\alpha, \theta > 0$.

Differentiating implicitly (with respect to l_2 and x), we have

$$(\beta-1)l_2^{\beta-2}dl_2 = \alpha\theta(\gamma-1)[x\pi+x\upsilon_{winner}+(1-x)\upsilon_{loser}+\alpha\theta l_2]^{\gamma-2}[(\pi+\upsilon_{winner}-\upsilon_{loser})dx+\alpha\theta dl_2]$$

which simplifies to

$$\frac{dl_2}{dx} = \frac{\alpha\theta(\gamma-1)(\pi+\upsilon_{winner}-\upsilon_{loser})[x\pi+x\upsilon_{winner}+(1-x)\upsilon_{loser}+\alpha\theta l_2]^{\gamma-2}}{(\beta-1)l_2^{\beta-2} - \alpha\theta(\gamma-1)[x\pi+x\upsilon_{winner}+(1-x)\upsilon_{loser}+\alpha\theta l_2]^{\gamma-2}} \tag{18}$$

On the right-hand side of (18), the numerator is non-positive (since $\gamma \leq 1$). The first term of the denominator is positive (since $\beta > 1$), and the second term is non-positive, so the entire denominator is strictly positive, making the entire right-hand-side non-positive. So l_2 is weakly decreasing in x, meaning that $l^*_{2,winner} \geq l^*_{2,loser}$. (Note that this inequality is strict if $\gamma < 1$.)

Proof of Proposition 2: For winners, consider the equation

$$\alpha\theta(\pi + \upsilon_{winner} + \alpha\theta l_2)^{\gamma-1} = \frac{l_2^{\beta-1}}{1+k}. \tag{19}$$

This equation yields the first-order conditions for winners in Case 1 (when $k = 0$) and in Case 2 (when $k = \hat{k}$), and as noted above, we have $\beta > 1 \geq \gamma$ and $\alpha, \theta > 0$.

Differentiating implicitly (with respect to l_2 and k), we have

$$(\alpha\theta)^2(\gamma-1)(\pi+\upsilon_{winner}+\alpha\theta l_2)^{\gamma-2}dl_2 = (\beta-1)l_2^{\beta-2}[1+k]^{-1}dl_2 + l_2^{\beta-1}[1+k]^{-2}dk,$$

which can be written as

$$\frac{dl_{2,winner}}{dk} = \frac{l_2^{\beta-1}}{(\beta-1)[1+k]l_2^{\beta-1} - (\alpha\theta)^2(\gamma-1)[1+k]^2(\pi+\upsilon_{winner}+\alpha\theta l_2)^{\gamma-2}}.$$

The numerator of the right-hand side is positive, as is the first term of the denominator. The second term of the denominator is non-positive (since $\gamma \leq 1$), making the entire denominator, and thus the entire right-hand side, positive.

Hence we have

$$\frac{dl_{2,winner}}{dk} > 0.$$

Since $k = 0$ gives us Case 1 and $k = \hat{k} > 0$ gives us Case 2, we can conclude that l_2 is higher for winners in Case 2 compared to Case 1: $l^{UB}_{2,winner} > l^*_{2,winner}$.

The corresponding proof for losers is similar. Consider the equation

$$\alpha\theta(\pi+\upsilon_{winner}+\alpha\theta l_2)^{\gamma-1} = \frac{l_2^{\beta-1}}{1-k}, \tag{20}$$

which yields the first-order conditions for losers in Case 1 (when $k = 0$) and in Case 2 (when $k = \hat{k}$).

Differentiating implicitly,

$$(\alpha\theta)^2(\gamma-1)(\upsilon_{loser}+\alpha\theta l_2)^{\gamma-2}dl_2 = (\beta-1)l_2^{\beta-2}[1-k]^{-1}dl_2 + l_2^{\beta-1}[1-k]^{-2}dk,$$

which can be written as

$$\frac{dl_{2,loser}}{dk} = \frac{l_2^{\beta-1}}{(\alpha\theta)^2(\gamma-1)[1-k]^2(\upsilon_{loser}+\alpha\theta l_2)^{\gamma-2} - (\beta-1)[1-k]l_2^{\beta-1}}.$$

The numerator of the right-hand side is positive, as is the second term of the denominator. The first term of the denominator is non-positive (since $\gamma \leq 1$), making the entire denominator, and thus the entire right-hand side, negative.

Hence we have

$$\frac{dl_{2,loser}}{dk} < 0.$$

Since $k = 0$ gives us Case 1 and $k = \hat{k} > 0$ gives us Case 2, we can conclude that l_2 is lower for losers in Case 2 compared to Case 1: $l^{UB}_{2,loser} < l^*_{2,loser}$.

Proof of Proposition 3: For winners, the first-order condition in Case 3 is

$$\alpha\theta(\pi + \upsilon_{winner} + \alpha\theta l_2)^{\gamma-1} = \frac{l_2^{\beta-1}}{1 + k_{max}},$$

which is just (19) above with $k = k_{max}$. From the proof of Proposition 2, $dl_{2,winner}/dk > 0$. Since $l^{UB}_{2,winner}$ is based on $k = \hat{k} < k_{max}$ and $l^{BI}_{2,winner}$ is based on $k = k_{max}$, we have $l^{BI}_{2,winner} > l^{UB}_{2,winner}$.

For losers, the first-order condition in Case 3 is

$$\alpha\theta(\upsilon_{loser} + \alpha\theta l_2)^{\gamma-1} = \frac{l_2^{\beta-1}}{1 - k_{min}},$$

which is (20) above with $k = k_{min}$. From the proof of Proposition 2, $dl_{2,loser}/dk < 0$. Since $l^*_{2,loser}$ is based on $k = 0 > k_{min}$ and $l^{BI}_{2,loser}$ is based on $k = k_{min}$, we have $l^{BI}_{2,loser} > l^*_{2,loser}$.

B OLS results corresponding to Table 2

Table 3: Estimated treatment effects, corresponding to Table 2 (OLS)

	(VII)	(VIII)	(IX)	(X)
Coefficient estimates				
Tournament	0.345***	0.370***		0.336**
	(0.114)	(0.122)		(0.155)
Win			0.066	–0.011
			(0.114)	(0.155)
Tournament x Win				0.172
				(0.219)
log(Prod)	0.395**	0.231	0.431**	0.402*
	(0.207)	(0.285)	(0.211)	(0.171)
Tournament x log(Prod)		0.377		
		(0.399)		
Female		0.445***	0.364***	0.457***
		(0.117)	(0.120)	(0.118)
Loss Aversion		0.036	0.050	0.036
		(0.043)	(0.045)	(0.043)
Risk Aversion		–0.033	–0.019	–0.031
		(0.036)	(0.038)	(0.036)
Marginal effects of Tournament variable				
Average effect	0.345***	0.418***		0.421***
	(0.114)	(0.111)		(0.112)
Winners				0.507***
				(0.159)
Losers				0.336**
				(0.155)
Adj/Pseudo R^2	0.065	0.138	0.064	0.134

*Notes: $N = 164$. Standard errors in parentheses. * (**, ***) Significant at 10% (5%, 1%) level.*

C Experimental instructions

Below are the instructions of the experiment translated into English.

Thank you for participating! Please switch off your mobile phone and do not talk to other participants during the experiment. If you have any questions, raise your hand, and one of the instructors will answer your question. For your arrival on time, you receive 10 yuans that will be paid to you at the end of the experiment. In this classroom, different participants start and complete their tasks at different times.[15] So, some participants will come in and go out now and then. Please focus on your own tasks, and ensure that your decisions are NOT influenced by the others. Your answers in the experiment stay completely anonymous. The computer stores all the information you have given for analysis only.

In this experiment you will be asked to carry out several tasks for which you can earn a number of talers. These talers will be translated into your payment at the end of the experiment at the exchange rate of:

10 talers = 1 yuan.

C.1 Questionnaire and lottery decision tasks

Before the experiment starts, you are asked to fill in a short questionnaire and two lottery decision sheets.

Questionnaire. There are several questions about your gender, date of birth and college major. Please take your time and fill the questionnaire in truthfully. The answers you give have no impact on your payments, but they are important for our scientific analysis.

The first lottery. Your screen will show you 6 rows. Each row shows you one lottery. You have to decide on either rejecting or accepting a lottery.[16] In each lottery, the losing price is varied between 10 and 35 Talers, and the winning price is fixed at 30 talers. After the

[15] Here, we try to eliminate the effect of peer pressure. For example, if we let all participants start at the same time, in the second stage, some of them may not stop working until someone else leaves the classroom.

[16] According to Gächter et al. (2007), the number of rejected lotteries measures the degree of loss aversion—a subject with higher loss aversion should reject more lotteries.

experiment, the computer will choose one of these six lotteries for pay. If you have accepted the lottery, a virtual coin will be tossed to determine your payoff. If you have rejected a lottery, both winning and losing prices are zero.

Example 1 *Suppose the computer picks Lottery No.3. If you have rejected Lottery No.3, you earn zero; if you have accepted Lottery No.3, the computer will randomly select a number N between $[0, 1]$. When $N \leq 0.5$, you will lose 20 talers; otherwise, you will earn 30 talers.*

The following is the decision sheet you need to fill in.

Lottery	Accept	Reject
1. You lose 10 talers with probability 50%; you win 30 talers with probability 50%.	☐	☐
2. You lose 15 talers with probability 50%; you win 30 talers with probability 50%.	☐	☐
3. You lose 20 talers with probability 50%; you win 30 talers with probability 50%.	☐	☐
4. You lose 25 talers with probability 50%; you win 30 talers with probability 50%.	☐	☐
5. You lose 30 talers with probability 50%; you win 30 talers with probability 50%.	☐	☐
6. You lose 35 talers with probability 50%; you win 30 talers with probability 50%.	☐	☐

The second lottery. Your screen will show you 10 rows. In each row, two options are displayed: Option A and B. You need to decide which of the two options you prefer. After the experiment, the computer will randomly pick one of the 10 rows. For that row, the computer then randomly determines your earnings for the Option (A or B) you chose.

Example 2 *Suppose the computer picks Row No.3 and you prefer Option A. Then, the computer will randomly select a number N between $[0, 1]$. When $N \leq 0.3$, you will earn 20 talers; otherwise, you will earn 16 talers.*

Example 3 *Suppose the computer picks Row No.7 and you prefer Option B. Then, the computer will randomly select a number N between $[0, 1]$. When $N \leq 0.7$, you will earn 38.5 talers; otherwise, you will earn 1 taler.*

The following is the decision sheet you need to fill in.

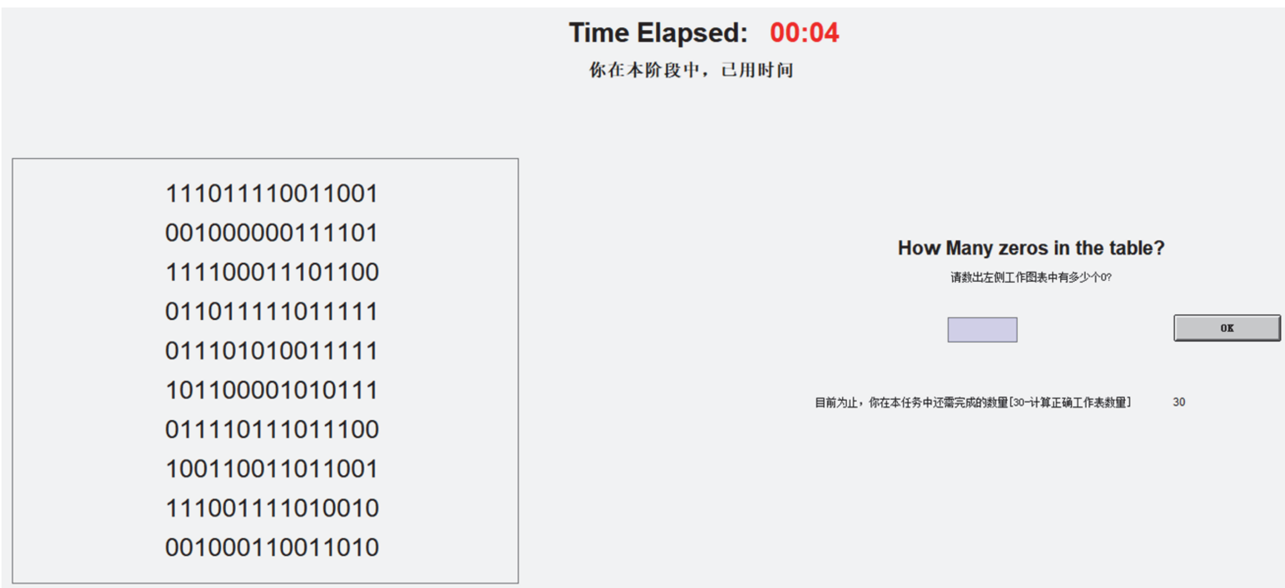
Lottery	
1. A. You earn 20 talers with probability 1/10 and earn 16 talers with probability 9/10;	☐
B. You earn 38.5 talers with probability 1/10 and earn 1 taler with probability 9/10.	☐
2. A. You earn 20 talers with probability 2/10 and earn 16 talers with probability 8/10;	☐
B. You earn 38.5 talers with probability 2/10 and earn 1 taler with probability 8/10.	☐
3. A. You earn 20 talers with probability 3/10 and earn 16 talers with probability 7/10;	☐
B. You earn 38.5 talers with probability 3/10 and earn 1 taler with probability 7/10.	☐
4. A. You earn 20 talers with probability 4/10 and earn 16 talers with probability 6/10;	☐
B. You earn 38.5 talers with probability 4/10 and earn 1 taler with probability 6/10.	☐
5. A. You earn 20 talers with probability 5/10 and earn 16 talers with probability 5/10;	☐
B. You earn 38.5 talers with probability 5/10 and earn 1 taler with probability 5/10.	☐
6. A. You earn 20 talers with probability 6/10 and earn 16 talers with probability 4/10;	☐
B. You earn 38.5 talers with probability 6/10 and earn 1 taler with probability 4/10.	☐
7. A. You earn 20 talers with probability 7/10 and earn 16 talers with probability 3/10;	☐
B. You earn 38.5 talers with probability 7/10 and earn 1 taler with probability 3/10.	☐
8. A. You earn 20 talers with probability 8/10 and earn 16 talers with probability 2/10;	☐
B. You earn 38.5 talers with probability 8/10 and earn 1 taler with probability 2/10.	☐
9. A. You earn 20 talers with probability 9/10 and earn 16 talers with probability 1/10;	☐
B. You earn 38.5 talers with probability 9/10 and earn 1 taler with probability 1/10.	☐
10. A. You earn 20 talers with probability 0 and earn 16 talers with probability 1;	☐
B. You earn 38.5 talers with probability 0 and earn 1 taler with probability 1.	☐

C.2 The instruction for the first stage

The experiment consists of two stages. You can only enter the second stage after completing the tasks specified at the first stage. Now, please read the experimental instruction for the first stage carefully.

Task description At this stage, you need to correctly count the number of zeros in a series of tables. The following figure shows the work screen you will use later. Enter the number of zeros into the box on the right side of the screen. After you have entered the number, click the OK-button. If you enter the correct result, a new table will be generated. If your input was wrong, you have two additional tries to enter the correct number into the table. You therefore have a total of three tries to solve each table. You only have to enter the correct answer once in three chances to be judged as correct. If all three inputs are incorrect on the same table, a new table will then be generated but the number of completed tables won't increase.

Figure 2: Work screen of counting zeros in the first stage



Task requirements At this stage, you must correctly count 30 tables before you can proceed to the second stage of the experiment. We do not have a time restriction for the 30-table task. Nevertheless, once the 30-table task starts, we will deduct 1 taler from your final payment every minute you spend in the task, i.e. the less time consumed, the less talers will be deducted.

Example 4 *If you complete the 30-table task in 9 minutes and 35 seconds, you will be deducted 9 talers.*

Example 5 *If you complete the 30-table task in 25 minutes and 46 seconds, you will be deducted 25 talers.*

Please raise your hand after completing the 30-table task. We will provide you the instruction for the second stage.

C.3 The instruction for the second stage

Now, you are at the second stage. Please read the following instruction for this stage carefully.

- *Subjects in the random treatment read the following sentences:*

As you have completed the 30-table task at the first stage, we give you a chance to earn the first-stage prize by playing dice. Please roll the virtual dice under the supervision of one experimenter. If the dice shows 1, 3, or 5, you will earn zero. If the dice shows 2, 4, or 6, you will earn 90 talers.

Regardless of whether you earn the first-stage prize or not, you are eligible to enter the second stage of the experiment. The second-stage payment depends on how many tables do you solve correctly at this stage. You will receive 3 talers for each table you solved correctly.

- *Subjects in the tournament treatment read the following sentences:*

As you have completed the 30-table task at the first stage, we give you a chance to earn the first-stage prize by performance comparison. Specifically, we paired you with another participant (your rival) prior to the first stage. If you spent more time in completing the first-stage task than your rival did, you will earn zero; otherwise, you will earn 90 talers.

Regardless of whether you earn first-stage prize or not, you are eligible to enter the second stage of the experiment. The second-stage payment depends on how many tables do you solve correctly at this stage. You will receive 3 talers for each table you solved correctly.

Task description At this stage, you need to correctly count the number of zeros in a series of tables which is similar with that at the first stage. The following figure shows the work screen you will use later. However, it should be noted that there are two differences between the first and second-stage tasks.

(1) At this stage, there is an immediate reward for each table solved correctly. Enter the number of zeros into the box on the right side of the screen. After you have entered the number, click the OK-button. If you enter the correct result, you will get 3 talers and a new table will be generated. If your input was wrong, you have two additional tries to enter the correct number into the table. If you enter three times a wrong number for a table, 3 talers will be subtracted from your earnings and a new table will then be generated.

(2) At this stage, there is no requirement for the number of tables should be solved, nor deduction according to the minutes you used. In other words, you are free to choose how many tables you want to solve and how long it will take. However, the maximum working time is 90 minutes. When time is up, the computer will automatically end the task and the experiment is over. If you want to stop working before the 90-minute deadline, please click the red button "stop working and leave". And then the whole experiment is over.

Figure 3: Work screen of counting zeros in the second stage

Example 6 *Suppose you correctly solve 60 tables, but miscounted 2 tables, in the second stage. Your second-stage payment is* $(60 - 2) \times 3 = 174$ *Talers.*

Total payment You will be paid anonymously after the experiment. Your total earnings in *talers* = *Lottery payment* + *first-stage payment* + *second-stage payment* + *showup fee.* Your total earnings in *China yuan* = *Total earnings in talers* × *0.1*.