Effort Provision under Present Bias: Optimal Goal-Setting as a Commitment Device

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Abstract

In economic theory, present-biased preferences can lead to self-control problems, e.g., insufficient effort on a task when costs are immediate but payments are delayed. The paper first develops a model in which a present-biased individual has access to a "psychological commitment device" in the form of self-set goals. These act as reference points, pitting the motive of loss aversion against present bias. In this multiple-selves model, narrow goal setting is defined as setting one goal for each short-run self, whereas broad goal-setting is defined as setting one broad goal for several short-run selves to jointly achieve. In line with the predictions, the results of our online experiment with a real effort task show that: 1) "Nudging" subjects to set narrow goals facilitates self-control when payments are delayed; 2) the assumption that goals work as reference points is supported by empirical evidence; 3) subjects who are more present-biased benefit more from goal-setting; 4) broad goal-setting does not work when payments are delayed and it also causes procrastination; 5) surprisingly, but consistent with the model, narrow goal-setting always outperforms broad goal-setting regardless of the degree of present bias. However, the gap between the two goal-setting methods shrinks as present bias decreases, suggesting that there exists a trade-off between commitment and flexibility.

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1. Introduction

In economic theory, present biased preferences have important implications for behavior and welfare. Due to dynamic inconsistency, short-run selves will want to deviate from the plans of the long-run self. In the case that costs of an activity are immediate, whereas benefits are delayed, short-run selves will underperform in the workplace, save too little for retirement, eat too unhealthily, etc. (Laibson, 1997; O'Donoghue and Rabin, 1999; Gul and Pesendorfer, 2001, 2004; Fudenberg and Levine, 2006). A puzzle raised in the literature, however, is why markets do not sell more commitment contracts or other commitment devices, if people are present biased (Laibson, 2015).

One potential explanation, suggested by a large literature in psychology on self-regulation, and a smaller theoretical literature in economics on "psychological commitment devices", is that individuals have access to internal commitment devices. Goal-setting is a prominent example: it has been proposed that goals can act as reference points as in prospect theory (Kahneman and Tversky, 1979), with the psychological motive of loss aversion causing individuals to want to reach their goals (Heath, Larrick and Wu, 1999).[1] By appropriately setting goals over time, individuals might be able to pit loss aversion against present bias, and achieve optimal behavior of short-run selves.

This paper sets out to test whether goals can offset present bias, and also explore whether certain types of goals work better than others. The paper first develops a model in which present-biased individuals can set goals for themselves. The paper then presents results of a real-effort experiment on Amazon Mechanical Turk (MTurk) that tests whether goals can offset present bias in the way predicted by the model.

The model involves individuals who are present biased, but have access to a technology of psychological commitment devices, in the form of self-set goals. The model has three periods: in period 1 the individual can set goals for the future selves; in periods 2 and 3 she chooses effort levels. Effort costs are immediate in each period. Payment is delayed in period 2 but is instant in period 3. Because the period 2 self has immediate costs but

[1]Other forms of psychological commitment devices include mental accounting (Thaler, 1985), shame (De Hooge, Breugelmans and Zeelenberg, 2008), peer pressure (Kast, Meier and Pomeranz, 2012), etc.

delayed benefits, she will work less hard than desired by the period 1 self. Thus, the period 1 self will want to set goals that address this self-control problem.

The model also explores the effectiveness of different ways of setting goals, taking into account a trade-off that arises in dynamic settings with randomly varying effort costs. In particular, individuals can either set narrowly-bracketed goals, which involve setting a separate goal for each short-run self, or broadly-bracketed goals, which involves setting a goal for several short-run selves to jointly achieve. Narrow goals have stronger commitment value because individuals face a loss aversion cost in each period. With a broad goal, short-run selves can leave it to the future selves to complete the goal, this procrastination possibility means less incentives to exert effort. Broader goals have more flexibility, in terms of allowing future selves to use their private information about whether effort costs are high or low. One surprising prediction of the model is that narrow goals always outperform broad goals regardless of the degree of present bias. The intuition for this result is as follows: first, as goals are self-chosen, flexibility can also be provided with narrow goals by setting low goals that are only (psychologically) binding in some states; second, procrastination under broad goals leads the later short-run self (period 3 self) to work sub-optimally hard, which is costly for both herself and the long-run self.[2] As a result, the long-run self cannot afford a high enough broad goal.

The experiment to test the model was conducted on Mturk. In the experiment, the subjects work on a counting task at the place of their choosing for 2 hours each day over 3 consecutive days. The payment scheme is piece rate. There are two levels of task difficulty that are varied randomly over time. Subjects also have the option to enjoy leisure during the experiment. Under the leisure mode, they have the full freedom to choose their activities and are also paid, but at a rate lower than the task piece rate.

The timing of the payment over the 3 days is as follows. On Day 1, the payment in the first hour is delivered a week later (delayed) but the payment in the second hour is delivered in that hour (immediate). We employ the difference in performance in these

[2] In most of parts of the paper, "binding" means psychologically binding. The goals we discuss in both our model and the experiment is not binding in terms of money. Failing to reach a goal dose not lead to monetary loss. However, they are psychologically binding in the sense that failing to reach a goal leads to a loss in the reference-dependence utility.

two hours to measure the present bias after controlling for learning and fatigue.[3] On Day 2, the payment in the 2 hour session is delivered a week later. On Day 3, the payment is instant.

There are three main treatments: *no goal*, *narrow goal* and *broad goal*. In the narrow and broad conditions, subjects are asked at the end of day 1 to set narrow or broad goals for Days 2 and 3, respectively. The goal(s) are self-chosen and involve no monetary rewards or punishments. In the no goal condition subjects do not receive a suggestion to set goals. A fourth condition involves subjects working only for day 1, with delayed payments for both hours, to control for learning or other time trends.

A first finding is that, on aggregate, individuals exhibit present bias on Day 1. In hour 1 of Day 1, when the payoff was delayed by a week, subjects on average finished 0.78 tasks in a minute. The number increased to 0.87 in the second hour of Day 1 when the payment was immediate. If the pattern is driven by present bias, it should go away if payments for both hours are made delayed. Indeed, the control condition with delayed payments for both hours of day 1 does not show any such increasing effort profile.

The second main finding is that narrow goals help to counteract present bias. Compared to the *No Goal* treatment, setting a narrow goal significantly increases the output of the subjects by 15.6% under delayed payment (Day 2), where the output is measured by the number of tasks completed per minute. The improvement in output is mainly driven by the increase in labor supply as measured by the seconds devoted to working per minute. However, on Day 3 when the payment is immediate, there is not a significant increase in output or labor supply under narrow goals. This is as predicted, if the goal has an impact by counteracting present bias.

A third finding is that broad goal-setting does not significantly improve output relative to no goals when the payment is delayed. Under broad goal-setting, the effort provision on Day 2 is slightly improved compared to the *No Goal* treatment but the effect is not significant. Interestingly, as predicted by the model, broad goal-setting leads to procrastination, in the sense that individuals in *Broad goal* condition work harder on Day 3 than

[3] To better focus the exploration of how goals can counteract present bias, subjects who exhibit no signs of present bias on day 1 are excluded from participating in Days 2 and 3.

individuals in the *no goal* condition.

Investigating the underlying mechanism, the data are consistent with goals influencing behavior through reference dependence with loss aversion. There is a sharp drop in output per minute that occurs after individuals reach their goals, controlling for the time and output level at which this occurs. On average, when individuals reach the goal, there is a drop in output per minute of 9.8 percent.

We also test another prediction of the model, that the impact of goals should be stronger for individuals with stronger present bias, and that the difference in effectiveness of narrow and broad goals should shrink as present bias becomes weaker. Indeed, we find that when the payment is delayed, the size of the goal-setting effect for those with strong present bias is more than three times higher than that for those with weak bias. Meanwhile, even though we observe that narrow goals always motivate more effort than broad goals on Day 2 for any range of present bias, the gap between the two reduces monotonically as present bias decreases. It suggests that the trade-off between flexibility and commitment does exist.

This paper contributes to a literature on goals as soft commitment devices. Following the psychology literature (e.g. Heath, Larrick and Wu (1999)), the seminal work in economics of Koch and Nafziger (2011), Hsiaw (2013) and Koch, Nafziger, Suvorov and van de Ven (2014) developed a model to study the effect of goals, serving as reference points, on addressing self-control problems. We contribute to this literature by empirically testing the effect of goal-setting on counteracting self-control problems in an online experiment. Our results strongly support the idea that goals can counteract present bias. The key assumption that goals work as reference points is also consistent with our empirical findings. Our study also contributes to the literature on optimal bracketing of goals when goals work as reference points. Building on their previous framework, Koch and Nafziger (2016) and Hsiaw (2018) compare narrow goals (incremental goals) with broad goals (aggregate goals) from the long-run self's perspective. Goals are assumed to be the rational expectations in both models. We deviate from them by assuming that the long-run self can endogenously choose goals in the optimal goal bracketing problem. [4] We also

[4] It is important to note here we are not the first to study endogenous/optimal goals. Both Koch and

empirically investigate the optimal bracketing of goals when goals are self-chosen.

It is well established in the psychology literature that goals consistently increase effort in a wide range of experiments covering both physical and cognitive tasks (e.g., Heath, Larrick and Wu, 1999; Locke and Latham, 1990, 2002). A recent literature in economics also reach a similar conclusion (see e.g. Gómez-Miñambres (2012), Dalton et al. (2015), Smithers (2015), Clark, Gill, Prowse and Rush (2017), van Lent and Souverijn (2017), Herranz-Zarzoso and Sabater-Grande (2018), Markle, Wu, White and Sackett (2018)). Closest to ours are Brookins, Goerg and Kube (2017) and Koch and Nafziger (2017). The former observes that the use of self-chosen goals leads to a significant output increase even without goal-contingent monetary incentives in a one day field experiment. The latter compares daily goals with weekly goals in an online, real-effort experiment and find that daily goals outperform weekly goals. We depart from this literature mainly by providing direct evidence that goal-setting can be used to deal with present bias. In particular, we find that narrow goals motivate people to perform better when the payment is delayed and self-control is needed but have no effect when self-control problems do not exist.

The findings also complement a previous empirical literature on present bias and externally binding commitment devices. In a longitudinal experiment, Augenblick, Niederle and Sprenger (2015) identify present bias in the form of dynamic inconsistency in effort choice and show that present bias has predictive power for demand of an externally binding commitment device. Ashraf, Karlan and Yin (2006) consider hypothetical intertemporal choices and link those to take-up of a savings commitment device. Ariely and Wertenbroch (2002) document demand for binding deadlines for homework and work assignments. Our study is most closely related to Kaur, Kremer and Mullainathan (2015) who conduct a field experiment with data entry workers and find that workers' efforts increase significantly as the (randomly assigned) payday gets closer. This is consistent with our finding that effort increases as payments become immediate. They also show that the workers are willing to take a dominated contract that offers hard commitment and that such a contract works. Our approach is complementary by testing whether a

Nafziger (2011) and Hsiaw (2013) studied endogenous goals in their models.

soft commitment (goal-setting) can counteract present bias and studying the optimal way to bracket goals.

The findings also shed new light on the puzzle of why individuals may exhibit present-biased behavior even though commitment devices, hard or soft, may be available.[5] They suggest that individuals are not necessarily naïve about present bias, but rather about the optimal approach to set goals. Indeed, even though individuals are always free to set goals in our study even in the *No goal* treatment, suggesting narrow goals improves performance relative to no suggestion (but suggesting broad goal setting does not). Returning to the puzzle of why markets do not provide commitment devices, it may be that individuals can use goals instead, and even though they use them sub-optimally, they are free.

2. Model

2.1. Basic Setup

Consider a risk neutral Decision Maker (DM) who is facing a task that requires effort to complete. There are 3 periods, $t = 1, 2, 3$. The payoff of effort is denoted by $v_t(e)$, which is strictly increasing and concave in e. The payoff is delayed: it is not received by the DM till the end of period 3 (the last period). The cost of effort is given by $c_t(e, s)$, which is strictly increasing and convex in e. $s \in \{H, L\}$ is the state of the world and $c_t'(e, H) > c_t'(e, L)$ $\forall e \in (0, \bar{e}]$, which means effort is more costly in state H than in state L. We further assume that the state is i.i.d among periods. $P(s_t = H) = p$, $P(s_t = L) = 1 - p$. Effort e is bounded by $\bar{e}$ in every period. Thus there are some physical constraints on effort provision. The cost is immediate in each period.

At the beginning of each period (except for period 1), the state in that period is realized. After the state is revealed, the DM chooses her effort level. Here only effort costs are assumed to be uncertain. However, assuming an uncertain payoff of effort will not

[5]For field evidence of present-biased behaviors, see, for example, Shapiro (2005) on food stamp usage, Laibson (1996) on retirement saving and Kuchler and Pagel (2018) on credit card debt paydown.

change our results.

The DM is a Expected Utility maximizer with present bias. Let U_t be the DM's intertemporal (expected) utility function from the perspective of time t. We adopt a quasi-hyperbolic utility function of the (β, δ) form (Laibson, 1997).

$$U_t = \delta^t u_t + \beta \sum_{\tau=t+1}^{2} \delta^\tau u_\tau. \tag{1}$$

where $\beta \in [0, 1)$ is the hyperbolic discount factor. Note that the regular, i.e., non-hyperbolic, discount rate δ is normalized to 1; likewise, the risk-free interest rate is zero. U_t can be simplified to $U_t = u_t + \beta \sum_{\tau=t+1}^{2} u_\tau$. The agent is sophisticated, in the sense that at each date she correctly anticipates her preferences at future dates.

Following Fudenberg and Levine (2006), we interpret the DM in different periods as different selves. Period 1 self is the long-run self and is analogous to the principal in a Principal-agent model. All other selves are analogous to the agents in a Principal-agent model. The long-run self does not work for the task, instead, she sets goals for the other selves. The stage payoff of this period is 0. U_1 is given by

$$U_1 = \beta(E(v(e_2) - c(e_2, s_2)) + E(v(e_3) - c(e_3, s_3))). \tag{2}$$

Period 2 self does not have the same incentives as period 1: she discounts her payoff by β as it is delayed, but the cost is not discounted. The utility function of period 2 self, for instance, is given by

$$U_2 = -c(e_2, s_2) + \beta(v(e_t) + E(v(e_3) - c(e_3, s_3))). \tag{3}$$

Period 3 self's incentive is perfectly aligned with that of the long-run self because payment is immediate for her. Her utility is given by

$$U_3 = v(e_3) - c(e_3, s_3). \tag{4}$$

In the absence of goals, this present bias causes an intra-personal conflict of interest. The short-run selves discount the future benefits by the present-bias factor $\beta \le 1$, while the long-run self weights equally the future costs and benefits. That is, the individual faces a self-control problem: the long-run self wants a higher effort than period 2 self actually is willing to provide. At the same time, self 2 and self 3 also have private information regarding the cost of effort, which makes it a delegation problem where the principal needs to trade-off commitment and flexibility.

Specifically, the first-best rule that maximizes the long-run self's welfare at period $t = i$ is defined by a stochastic sequence of effort choices that satisfy $e_t^{lr} = e_t^{lr}(s_t)$, where

$$c_e(e_t^{lr}(s_t), s_t) = v'(e_t^{lr}(s_t)). \tag{5}$$

Meanwhile, self t chooses effort $e_t^{sr} = e_t^{sr}(s_t)$ to maximize his welfare with full flexibility, where $e_t^{sr}(s_t)$ is defined by

$$c_e(e_t^{sr}(s_t), s_t) = \beta v'(e_t^{sr}(s_t)). \tag{6}$$

2.2. Goal Setting

Goal-setting is the only commitment device the principal can use in this model. [6] Following Heath, Larrick and Wu (1999), Koch and Nafziger (2011) and Hsiaw (2013), we assume that goals work like reference points as in Kahneman and Tversky (1979)'s reference dependent value function.[7]

As mentioned earlier, self 1 can only set goals. There are two ways to set goals: narrow goals or a broad goal. When setting the narrow goals, self 1 sets goals for self 2 and self 3 separately in period 1. When setting the broad goal, period 1 self sets a total goal for the two future selves and the reference dependence value function will be realized at the end of period 3. Broad goal setting is better than narrow goal setting in terms of flexibility. But narrow goal setting is better from the perspective of commitment.

In the broad goal case, with a monotone transformation, the utility function of period

[6]This approach differs from the commitment device literature (Gul and Pesendorfer, 2001, 2004; Fudenberg and Levine, 2006) in two ways: first, hard commitment devices regulate selves by narrowing the choice set, while goal-setting controls selves by providing incentives though reference dependent utility. Second, commitment devices are assumed to be costly, while goal-setting can be costless in equilibrium because when the action always meets the goal, the reference dependent utility can be 0.

[7]In a later section, we show that this assumption is supported by empirical evidence from our online experiment.

1 is

$$U_1^B = E(v(e_2) - c(e_2, s_2)) + E(v(e_3) - c(e_3, s_3)) - E(\mathbb{1}_{(e_2+e_3<g^B)} \eta f(g^B - e_2 - e_3)). \tag{7}$$

The corresponding utility of self 2 and self 3 are given by

$$U_2^B = -c(e_2, s_2) + \beta v(e_2) + \beta E(v(e_3) - c(e_3, s_3)) - E(\mathbb{1}_{(e_2+e_3<g^B)} \eta \beta f(g^B - e_2 - e_3)). \tag{8}$$

$$U_3^B = v(e_3) - c(e_3, s_3) - \mathbb{1}_{(e_2+e_3<g^B)} \eta f(g^B - e_2 - e_3). \tag{9}$$

where $\eta > 0$ is the weight of reference dependence utility, and e^B is the goal in broad goal-setting and the reference point. $\mathbb{1}$ is the indicator function for failing to reach the goal. $f(g^B - e_1 - e_2)$ is the psychological cost caused by failing to reach the goal. We don't need to assume a functional form of the gain-loss utility to derive the main qualitative results. Assuming that the cost is monotonic with respect to the gap between the goal and the actual effort is enough. However, to get analytical solutions for the optimal goals, we do need to assume that the cost is linear.

By assuming a reference-dependent utility function with this form, we adopt several assumptions from Kőszegi and Rabin (2006). Firstly, consumption utility and reference dependence utility are separable. Secondly, the short-run selves and the long-run self suffer a loss if the short-run selves under-perform compared to the goal, but overshooting generates no gain or loss.[8]

In the narrow goal case, with a monotone transformation, the utility function of period 1 is

[8]We make this assumption for two reasons. First, it is standard in the reference dependence literature to assume that there is no gain from overshooting. If the gain from overshooting is large enough, Period 0 self can always set a 0 goal to maximize this gain. This is inconsistent with the findings in the goal effect literature (Heath et al., 1999; Locke and Latham, 2002; Brookins et al., 2017). Goals people usually set are "challenging yet achievable" instead of being 0. Second, even though gain from outperforming the goal is not a crazy idea in the goal-setting scenario, it limits the generality of this model. For example, we can interpret the model as a principal-agent model in which the agents face present bias and the principal designs contracts with money burning to motivate them. In this case, gain from overshooting is analogous to money printing as both the principal and the agents benefit from it. By getting rid of the gain from overshooting, we are able to apply our model to situations where money printing is unavailable.

$$U_1^N = E(v(e_2) - c(e_2, s_2) - \mathbb{1}_{(e_2 < g_2^N)} \eta f(g_2^N - e_2)) + E(v(e_3) - c(e_3, s_3) - \mathbb{1}_{(e_3 < g_3^N)} \eta f(g_3^N - e_3)). \quad (10)$$

where g_i^N is the narrow goal reference point for self i. The corresponding utility of self 2 and self 3 are

$$U_2^N = \beta v(e_3) - c(e_2, s_2) - \mathbb{1}_{(e_2 < g_2^N)} \eta f(g_2^N - e_2) + \beta E(v(e_3) - c(e_3, s_3) - \mathbb{1}_{(e_3 < g_3^N)} \eta f(g_3^N - e_3)). \quad (11)$$

$$U_3^N = v(e_3) - c(e_3, s_3) - \mathbb{1}_{(e_3 < g_3^N)} \eta f(g_3^N - e_3). \quad (12)$$

2.3. Optimal Goal-Setting Problem

The optimal narrow goal setting problem can be summarized as follows.

$$\begin{aligned}
\max_{g_2^N, g_3^N} \quad & E(v(e_2) - c(e_2, s_2) - \mathbb{1}_{(e_2 < g_2^N)} \eta f(g_2^N - e_2)) + E(v(e_3) - c(e_3, s_3) - \mathbb{1}_{(e_3 < g_3^N)} \eta f(g_3^N - e_3)) \\
\text{s.t.} \quad & e_2 \in \operatorname{argmax}\{\beta v(e_2) - c(e_2, s_2) - \mathbb{1}_{(e_2 < g_2^N)} \eta f(g_2^N - e_2) + \beta U_3^N\} \\
& e_3 \in \operatorname{argmax}\{v(e_3) - c(e_3, s_3) - \mathbb{1}_{(e_3 < g_3^N)} \eta f(g_3^N - e_3)\}
\end{aligned}$$

The optimal broad goal setting problem is presented below.

$$\begin{aligned}
\max_{g^B} \quad & E(v(e_2) - c(e_2, s_2)) + E(v(e_3) - c(e_3, s_3)) - E(\mathbb{1}_{(e_2 + e_3 < g^B)} \eta f(g^B - e_2 - e_3)) \\
\text{s.t.} \quad & e_2 \in \operatorname{argmax}\{\beta v(e_2) - c(e_2, s_2) \\
& + \beta E(v(e_3) - c(e_3, s_3)) - E(\mathbb{1}_{(e_2 + e_3 < g^B)} \eta \beta f(g^B - e_2 - e_3))\} \\
& e_3 \in \operatorname{argmax}\{v(e_3) - c(e_3, s_3) - \mathbb{1}_{(e_2 + e_3 < g^B)} \beta \eta f(g^B - e_2 - e_3)\}
\end{aligned}$$

2.4. Applications

We have described the model in terms of exerting efforts to conduct a task. But the model can also be straightforwardly interpreted as consumption of goods, enabling us to analyze under-saving problems. In this interpretation, the agent must decide how much income to save/consume in a period with an i.i.d shock to spending needs. Present-bias means she wants to over-consume in each period. The long-run self can set saving goals for the short-run selves to deal with this problem.[9]

2.5. Predictions

We present the main predictions of the model in this section. For more details, please see Appendix A.

Hypothesis 1: Narrow goal-setting motivates efforts when the payoff is delayed (self 2). But when the payoff is instant (self 3), it has no effect.

This prediction is straightforward. When the payoff is delayed, the long-run self faces a self-control problem in period 2. She can set a (psychologically) binding goal and the potential loss in the gain-loss utility can motive self 2 to work harder. When the payoff is instant, the present-biased short-run self's optimal effort is the same with the long-run self. When setting narrow goals, the long-run self can set a goal that is low enough so that it never binds in any state. This way the short-run self is not affected.

Hypothesis 2: Broad goal-setting can also motivate effort with delayed payment (self 2). But it leads to procrastination: self 3, the later short-run self, exerts more effort than the no goal case.

The key intuition behind this prediction is that to motivate self 2 to work harder, the long-run self must make self 3 exert above optimal effort. Otherwise, self 2 can keep exerting the same level of effort and count on self 3 to finish the broad goal. Self 3 cares more about the broad goal as the broad goal is realized in period 3 and thus is in the present for her. Self 3 also faces less uncertainty as she exactly knows whether the goal can be achieved or not but for self 2 there is some chance that the broad goal won't be binding. Therefore, self 2 will not be willing to exert extra effort without self 3 doing that.

[9]A second alternative interpretation relates to Amador et al. (2006) and Halac and Yared (2014, 2017)'s analysis of a society that wishes to constrain government's over-spending. In their model, the government is biased towards public spending and privately informed about shocks to the value of the spending. Society chooses a fiscal rule to trade-off the cost of overspending against the benefit of flexibility. Under this interpretation, the society is the time-consistent long-run self. It sets the spending goals for the governments and spending above the goal leads to punishment. A key departure from the previous literature is we consider a case with limited enforcement. There is no deficit limit that defines the choice set of the government. We consider limited punishment for over-spending as a function of the distance between the goal and the actual spending. The question is is it better to set narrow goals (quarterly fiscal target) or broad goals (yearly fiscal target)?

On the other hand, present bias also implies that self 2 cares about utility in period 3. As the initial level of effort provision is optimal, exerting more effort lowers period 3 utility from the perspective of self 2. She is willing to exert some extra effort to reduce the losses in period 3.

Hypothesis 3: a) Narrow goal-setting always outperforms broad goal-setting from the long-run self's perspective regardless of the degree of present bias β. b) Narrow goal-setting can motivate more effort than broad when the payoff is delayed (self 2) regardless of β, but the gap decreases as β goes to 1.

Hypothesis 3a is perhaps the most surprising prediction of the model. It states that even though there exists a trade-off between commitment and flexibility, narrow goal-setting is always optimal from the long-run self's perspective. There are three crucial intuitions to understand this result. First, narrow goal-setting can provide more commitment. The reason is that under narrow goal-setting, the short-run selves are directly incentivized by the gain-loss utility introduced by the goals. While under broad goal-setting, self 2 is only motivated by the loss of self 3, which is the minimum of the gain-loss utility and the cost of exerting above optimal effort. Second, narrow goal-setting can also provide flexibility as the long-run self can freely choose the goals. When present bias is not a big problem, she can set a low goal so that self 3 is only restricted in some states and can make their own decisions in the other states.[10] The third reason is specific to the i.i.d shocks. Under i.i.d shocks, the long-run self faces aggregate uncertainty when setting a broad goal. For example, a goal that is binding when the cost is low in both period 1 and 2 can cause two much loss in the gain-loss utility when the actual state is two *high*s in a row. As the long-run self shares the punishment with the shot-run selves, the aggregate shock limits the ability for her to set a high goal.

We are not able to test 3a as utility is not directly observable. We test 3b instead. The intuition that narrow goals can always lead to more effort provision in period 2 is similar to 3a. The fact that the gap between the two goal-setting methods decreases as β goes to 1 is the result of the trade-off between commitment and flexibility. As β becomes larger,

[10] By contrast, in a *personal equilibrium* model Kőszegi and Rabin (2006), where the goal is *ex ante* fixed as the rational expectation of effort in equilibrium, setting a low goal and then going above it when the cost is low cannot happen in equilibrium.

flexibility becomes more important.

3. Design of the Experiment

This paper focuses on the motivational effect of goal-setting and whether the way goals are set affects individuals' inter-temporal allocations of effort. We adopt an experimental design conducted over three days. On Day 1, we recruit subjects on Mturk and ask them to undertake a real effort task. First there is a practice period lasting one hour for fixed payment, then they can on the task with a piece rate for 2 hours. The first hour's piece rate payment is delivered a week later but the second hour's payment is immediate. At the end of Day 1, subjects are asked to set goals for Day 2 and Day 3 except for those in the *No Goal* group. On Day 2, the payment is delayed by a week and the payment on Day 3 is immediate. Participants who appear to be present-biased on Day 1 are re-recruited and are reminded of their goals on each day. There are two difficulty levels and there is a random draw every 30 minutes that determines which will be the difficulty level for the next 30 minutes. Subjects also have access to paid real leisure, which makes present bias meaningful, since people have a fun alternative to working.

Work Environment

Subjects conduct real-effort counting tasks in the experiment. The task we use is particularly long, laborious and mentally effortful (Abeler, Falk, Goette and Huffman, 2011; Koch and Nafziger, 2017).[11] In particular, participants are asked to count the number of 8s in a matrix of 8s and 6s. The task is embedded in the web application the author developed for the experiment.[12] An example of the work task is shown in Figure 1.

[11]A lot of other real-effort tasks are used in the lab. Some previous tasks include typing paragraphs (Dickinson, 1999), cracking walnuts (Fahr and Irlenbusch, 2000), stuffing letters into envelopes (Konow, 2000; Falk and Ichino, 2006; Carpenter, Matthews and Schirm, 2010), solving mazes (Gneezy, Niederle and Rustichini, 2003), pressing keys on the keyboard (Berger and Pope, 2011), encrypting words (Erkal, Gangadharan and Nikiforakis, 2011), adjusting sliders on a slider bar (Gill and Prowse, 2012), and picking virtual apples in a basket (Eriksson, Mao and Villeval, 2017).

[12]The website for the experiment: http://econ-exp-yml.herokuapp.com/. For more information, please refer to https://www.yimingliuecon.com/web-experiments

Each table completed correctly generates a 12 cent profit while a penalty of 6 cents is subtracted for each incorrect answer. After a subject completes a table, the accumulated individual earnings is updated so that she knows whether her answer is correct or not.

There are two difficulty levels: easy and hard.[13] Under the easy mode, there are 81 numbers in total in the matrix, while there are 144 numbers in the hard mode. On average, it takes 36.70 seconds to finish a easy task and 66.18 seconds to finish a hard one. The difficulty is selected randomly at the beginning of each 30-minute period and is i.i.d across days. Subjects are only informed of the difficulty at the beginning of a 30-minute period.

One reason for selecting the counting task in this paper is it is supposed to have a small learning-by-doing effect. However, as suggested by previous work (Corgnet, Hernán-Gonzalez and Rassenti, 2015b), learning may still exist. This could confound the results in two directions. On one hand, learning can be a potential explanation if subjects finish more tasks in the second hour on Day 1 when payment is immediate. On the other hand, we may observe that subjects finish more tasks at the beginning because they want to learn how painful this task is, which would work against finding an increasing pattern of effort. To avoid these two possibilities, there is a practice period before the start of the 2-hour session. In this period, period *practice*, subjects perform the counting task-as described above-and need to finish 20 successfully. A fixed $1 is paid.

Real Leisure Activity

At any point during the three periods, workers can switch from the task to a leisure mode. Under this leisure mode, they have the full freedom to choose their own activities and earn money at the same time. The rate is 3 cents per minute, which is much lower than the per minute rate of the counting task. To access the leisure activity, subjects must click the "take a rest" button. Subjects could switch back to work at any time by clicking the "back to work" button at the leisure screen. This switching design allowed us to keep track of the exact amount of time subjects spent on each activity.

[13] In the experiment, we refer easy and hard to "level 1" and "level 2" respectively to alleviate the framing effect.

This leisure activity mimics the real life leisure and temptation. We expect it to have positive utility for all subjects. Previous studies have introduced on-the-job leisure alternatives by giving subjects access to magazines (Eriksson, Poulsen and Villeval, 2009; Charness, Masclet and Villeval, 2010) and Internet on the experimental screen (Winter, Houser, Schunk and Xiao, 2010; Corgnet, Hernán-Gonzalez and Rassenti, 2015b; Corgnet, Gómez-Miñambres and Hernán-Gonzalez, 2015a). By allowing the subjects to work at home, we offer a unprecedented range of leisure options. Thus we avoid the case that some people don't value the leisure option.

In addition, subjects earned 3 cents for every minute they spend on the leisure activity. This design mimics real work environments in which only a portion of employees' compensation is pay-for-performance. The purpose of it is two-fold. First, it guarantees that everyone got strictly positive utility from the leisure activity and further reduces the heterogeneity in the value of leisure. Second, it makes sure that subjects are willing to switch to the leisure screen when they wanted to take a break. The existence of this on-leisure wage makes it a loss to stay on the work screen during a rest. This reduces the measurement error problem of not knowing whether people are taking a break or are just slow. [14]

Timeline

The experiment lasted 3 days. Subjects are recruited through MTurk on Day 1. They are informed that the study will last for 3 consecutive days and only those who are available between 6:00 and 11:00 pm on all three days are selected.[15] After the practice session, they can choose to start the 2-hour session at any time between 6:00 and 9:00 pm their local time. The payment for the first hour is delivered a week later but the payment for the second hour is sent around 11:00 pm on Day 1. At the end of Day 1, subjects are asked

[14] This is in the spirit of Mohnen, Pokorny and Sliwka (2008) who paid subjects 0.10 Euro to take a 25-second time-out during which they were not able to work on the incentivized counting task and Corgnet et al. (2015b) who paid subjects 5 cents each time they clicked on a yellow box that appeared every 25 seconds whether the subject was currently working or browsing the Internet.

[15] Being available means he/she has access to the internet, is able to work in front of a computer and has no other work to do. We only recruit those who have at least 3 available hours between 6:00 and 11:00 pm and at least 2 of the 3 hours are consecutive.

to set goals for Day 2 and Day 3 except for those who are in the *No Goal* treatment.

Day 1 serves three purposes: first, as the first hour's payment is delayed but the second hour's payment is immediate, we can elicit present bias through comparing hour 1 and hour 2 output.[16] Second, Day 1 enables the subjects to get sufficient exposure to the task so that when they set goals they are well informed. Otherwise, one may worry that they would set goals that are too high or too low if they are over-confident or under-confident respectively. Third, when they set goals we also provide them information regarding how much they earn in the first hour and in the second hour. Potentially, present-biased subjects would recognize their bias through observing that they earn more when the payment is immediate. Consequently, naiveté is a smaller concern and they are more likely to set goals that will later help them to work harder.

On Day 2 and Day 3, subjects who are invited conducted the same task for 2 hours on each day. We only invite those who are likely to be present-biased.[17] The main rational for this design is we aim to study the effect of goal-setting on counteracting present bias.[18] Besides, the theory also predicts that for people who are not present-biased, goal-setting should have no effect.The rule to determine whether someone is likely to be present-biased is the following. If a subject experiences the same difficulty levels in all four 30-minute periods, then she is seen as potentially present-biased if she finishes more tasks in the second hour than in the first hour. If she experiences 1 *hard* and 1 *easy* period in both hours, then comparing the total output also suffices. If two hours share one difficulty level but the total number of *hard* and *easy* periods are unequal, like (*easy*, *easy*, *easy*, *hard*), then we compare the average output under the difficulty level that is shared by the two hours. If there is no shared difficulty levels, like (*hard*, *hard*, *easy*, *easy*), then it is hard for us to tell whether she is present biased or not. In that case, we re-recruited all

[16] This assumes that there are no other reasons for time trends, but we have a control condition to verify that.

[17] We let the subjects know at the beginning that Day 2 and Day 3 participation is not guaranteed. But at the same time, we don't want them to think that they should work hard to secure a seat. We avoid deception through carefully wording. In the instruction on Day 1, we explicitly state that "You may or may not be selected to participate on Day 2 and Day 3. Being selected DOES NOT depend on the number of tasks you finished or got correct on the first day". Indeed, we select subjects by their effort profile (tasks finished in hour 1 vs hour2) but not the absolute level of performance.

[18] The goal of the paper is not to study how goals affect representative samples of Mturk workers.

the subjects. As we take a conservative and coarse approach in designing the exclusion rule, we still end up with around 15% of subjects in the treatment sample that shows no sign of present bias. Therefore, we are still able to test the effect of goal-setting on them.

The timing of payment is constant across hours within a day on Day 2 and Day 3: Day 2's payment is delayed by a week and Day 3's payment is immediate. By including two days under goal-setting, we can test the effect of goal-setting when there is a self-control problem (Day 2) and when there is no self-control problem (Day 3).

At the end of Day 3, subjects are asked to answer an exit questionnaire collecting basic demographic data as well as risk attitude, time preference and satisfaction with the job. We follow Dohmen et al. (2011) and Vischer et al. (2013) on risk attitude and time preference measures respectively.

The timeline of the experiment is summarized in Table 1.

Time Window

There is a 3-hour time window, 6:00 pm to 9:00 pm, for subjects to log into the study website. They can start the 2-hour session at any point in the 3 hours. Allowing the start time to be flexible instead of fixing it reduces the potential selection biases in recruiting subjects. It also makes our measure of leisure more accurate by reducing the uncertainty in schedule. For example, if someone has to deal with an emergency event from 7:30 pm to 8:00 pm and the 2-hour session is fixed at 7:00 to 9:00 pm, then we will observe a 30-minute rest that appears to be leisure. But now as the start time is flexible, she can start her session at 8:00 pm and the event won't affect her. However, unexpected events can still occur and it's hard to distinguish them from a pure rest. To deal with this problem, we add a question on unexpected events happened during the experimental period in the exit survey. Subjects are asked to report the nature of the event and its start and end time. We later use the reported events to correct the observed leisure in the analysis.

Goal Setting Treatments and No Goal Treatment

Subjects are encouraged to set goals in our two main treatments. A goal is a specific amount of money they aim to earn in a period. There is no monetary punishment in case of failing to reach the goal, nor reward in the event of success. Following van Lent and Souverijn (2017), we use the following exact wording in the experiment.

> Some people find it useful to set concrete goals. Setting a goal can help motivate you to perform better. Please set yourself a target amount of money to earn for each of Day 2 and Day 3. Please note that there are no monetary punishments or rewards associated with your goals. You are free to set $0 goals if you feel there is no need to set goals. Please note that this goal-setting stage is not in any way associated your performance today. We encourage every participant to set goals. The goals you set won't affect your chances of being invited to participated on Day 2 and Day 3 either.
>
> Your goals: My goal is earn at least $_____ on Day 2 and
> at least $_____ on Day 3

In Treatment 1 (Broad Goal Treatment), subjects are asked to set a goal for the total amount of money to earn over Day 2 and Day 3; in Treatment 2 (Narrow Goal Treatment), they are asked to set a goal for Day 2 and a goal for Day 3 separately. There is also a control condition (No Goal Treatment) in which they are not asked to set goals at the end of Day 1.

1-day Control Treatment

We also conducted an additional control treatment to check whether the present bias pattern we expected to observe on Day 1 can be explain by learning or fatigue. In our main design, the first hour's payment on Day 1 is delayed by a week but the second hour's payment is immediate. Present bias predicts that subjects exert more effort in the second hour, but learning by doing over time can also produce that pattern. To deal with this concern, we include a 1-day control treatment in which the subjects only work on the task for a day and the payment is delayed by a week in both hours. If learning is the cause of the present bias pattern, then we should observe that in the control treatment subjects also produce more in the second hour. The 1-day control treatment can also help us identify whether there is increasing fatigue from hour 1 to hour 2, in which case our measure of present bias may be a lower bound.

Experiment Procedure

The subjects were recruited through Amazon Mechanical Turk between August and October 2018. The subjects who responded to the Mturk advertisement first needed to report their available hours in the experiment period and those qualified were then asked to read the instruction and answer comprehension questions about the rules of the experiment. Those who passed the quiz got a unique account and a password to log onto the web application developed for the experiment. The tasks, the leisure mode and the goal-setting page are all embedded in the application. The subjects were paid through Mturk on the same day of the experiment or a week later.

Overall, 185 subjects were recruited for the 3-day experiment, including the *No Goal* treatment, the *Narrow Goal* treatment and the *Broad Goal* treatment. 16 subjects were recruited for the 1-day control treatment. 67 out of the 185 subjects showed no obvious sign of present bias. They were not invited to participate on Day 2 and Day 3. 118 subjects participated on Day 2 and Day 3. The *Narrow Goal* treatment, the *Broad Goal* and the *No Goal* treatment had 44, 45 and 29 subjects respectively. On average, the subjects who participated on all 3 days earned $38.16 in 6 hours.

4. Results

In this section we present results of the experiment. The main variable of interest is the amount of tasks finished in a minute and the amount of time spent on working in a minute. The complete record recorded by the online application enables us to construct an individual-day-minute dataset. We can measure how many tasks are finished in a specific minute, say minute 35. We are also able to observe the accurate working time in a minute, namely how many seconds are spent under the work mode and how many seconds are spent under the leisure mode.

Result1: Present Bias Exists

For us to test the effectiveness of goal-setting on counteracting the present bias, we firstly need to identify it. By comparing the effort provision in the delayed payment condition and instant payment condition on Day 1, we find that, on aggregate, present bias exists in effort provision behavior. As shown in Figure 2, in hour 1 of Day 1 when the payoff is delayed by a week, subjects on average finished 0.78 tasks in a minute. The number jumps to 0.87 in the second hour on Day 1 when the payment is immediate. The present bias is of course stronger among those subjects who are selected to participate on Day 2 and Day 3. The tasks completed per minute are 0.77 and 0.95 in hour 1 and hour 2 of Day 1 respectively. Both of the differences are significant at the 1% level.[19]

One concern is subjects may finish more tasks in the second hour for some other reasons besides present bias, for example, learning by doing. If this were true, we would expect to see a similar time trend even without varying the timing of payments across hours. We compare the output in the first and second hour in the 1-day control treatment in which earnings in both hours are delayed by a week. We do not find a significant difference there.[20] So there is no evidence of a confound in the form of a time trend that is independent of payment timing.

Another potential concern is that the instant payment effect reflects standard exponential discounting, not present bias. However, since payments are delayed by a week, the gap between instant payment and delayed payment is only 7 days. One needs to be extremely myopic for exponential discounting to explain a spike of 11.5% for a 7-day

[19]The significance is derived from the following regression: $y_{it} = \gamma InstantPay_t + \epsilon_{it}$, where y_{it} is the amount of task individual i finishes in minute t and $InstantPay_t$ is the dummy for immediate payment. The standard errors are clustered at the individual level.

[20]A Difference-in-Difference analysis also shows that the significant difference found in the main treatments across the two hours and the insignificant difference in the 1-day control treatment is significantly different at the 1% level.

advanced payment.[21]

Another piece of evidence that present bias exists comes from comparing day 2 and day 3 in the *No Goal* treatment. As there are no goals in this treatment on Day 2 and Day 3, present bias predicts that we should still observe that subjects work harder on Day 3 when the payment is immediate. Indeed, as shown in Figure 2, subjects finish more tasks on Day 3 and the difference is significant at 1% level.[22]

Result 2: Narrow goal-setting significantly increases output when the payoff is delayed but has no effect when the payoff is immediate. The gain in output in the delayed payment case is mainly driven by the increase in working time or labor supply.

Turning to the impact of narrow goals in terms of counteracting present bias, we compare outcomes on Day 2 with narrow goal versus outcomes on Day 1 when subjects have not been asked to set goals and payments are also delayed (hour 1).

In the *Narrow Goal* treatment, subjects on average finish 0.22 or 31.0% more tasks in a minute on Day 2 compared to hour 1 of Day 1. This is consistent with the narrow goals helping to counteract the self-control problem when payments are delayed. However, a natural concern is subjects finish more tasks on Day 2 due to learning by doing or other time trends. We use the *No Goal* treatment to deal with this issue. In that treatment, we observe that the task per minute increases by 0.10 tasks or 15.6 percent relative to hour 1 of Day 1. This is substantially smaller than the corresponding increase for narrow goal, suggesting that the latter result does not reflect learning but rather ameliorated self-control problems.

To test the statistical significance of the differences in output between *Narrow Goal* treatment and the *No Goal* treatment, we adopt a Difference-in-Difference regression

[21] Another piece of evidence against exponential discounting is that goals should have no effect if the pattern on Day 1 is caused by it. If subjects are time-consistent but impatient, then it is optimal to exert more effort when the payment is instant and exert less effort when it's not. Then there is no need to set goals and goals should have no influence. However, as we will show later, goals do motivate more efforts when the payment is delayed, supporting the time inconsistency explanation.

[22] The regression analysis is similar: $y_{it} = \gamma InstantPay_t + \epsilon_{it}$. The only difference is in the previous regression, $InstantPay_t$ equals to 1 for hour 2 of Day 1. Here $InstantPay_t$ is the dummy for Day 3. The standard errors are also clustered at the individual level.

approach. The regression framework also allows adding additional controls, such as task difficulty and day of the week.

As stated above, an observation in our dataset describes an individual's work/leisure behavior in a minute t on a day d. The empirical specification is as follows:

$$\begin{aligned} y_{idt} &= \alpha_0 treatment_i + \alpha_1 treatment_i \times day2_d + \alpha_2 treatment_i \times day3_d \\ &+ \gamma_1 day2_d + \gamma_2 day3_d + \gamma_3 easy_{idt} + \gamma_4 weekday_{id} + \gamma_5 InstantPay_{dt} + \sum_t \delta_t \\ &+ (\gamma'_3 easy_{idt} + \gamma'_4 weekday_i + \gamma'_5 InstantPay_{dt} + \sum_t \delta'_t) \times treatment_i + \epsilon_{idt}. \end{aligned} \tag{13}$$

where y_{idt} is the amount of tasks completed by individual i on Day d in minute t. $easy_{idt}$ specifies the difficulty of the task for individual i on Day d in minute t. $treatment_i$ equals 1 for the *Narrow Goal* treatment and 0 for the *No Goal* treatment. $day2_d$ and $day3_d$ are the dummy variables for Day 2 and Day 3. After controlling for these two variables, $InstantPay_{dt}$ means the second hour on Day 1. $weekday_i$ represents the weekday of Day 1 for subject i. We randomize the start day of the experiment over the whole week. Full interaction with the treatment variable allows for heterogeneous effects of the control variables among the treatments.

α_1 and α_2 are the two parameters of the variables of interest. α_1 measures the effect of narrow goal-setting on outcomes when the payment is delayed (Day 2 versus hour 1 of Day 1), relative to the corresponding difference for *No Goal* condition. α_2 measures the impact of goals when the payment is immediate.

The results are reported in Table 2. As we can observe in column (1), compared to the *No Goal* treatment, the suggestion to set a narrow goal increases the output when payment is delayed by 0.124 tasks per minute and this is significant at the 5% level. It is also interesting to see that the gain in output is driven by increase in working time. On Day 2, narrow goal-setting increases the the working time per minute by 7.48 seconds and the effect is significant at 1% level. At the same time, there is no significant increase in task speed under narrow goal-setting, which is measured by the seconds it takes for a subject to finish one task. If we interpret speed as the intensive margin of labor supply and working time as the extensive margin of labor supply, then the increase in labor supply is driven by the extensive margin instead of the intensive one.

When the payoff is instant, by contrast, narrow goal-setting has no effect. As we can observe in column (1) of Table 2, the parameter α_2 of the interaction term of narrow goals and Day 3 is small (0.034) and insignificant.[23]

Result 2 implies two points. First, the effect of narrow goal-setting we find in this paper is not generic but specific to the self-control problem. It only increases effort provision when the payoff is delayed. It has no effect when the payoff is instant. This suggest that goal matters because it counteracts self-control problems, in line with the model. Second, as the goals have no effect when the payoff is instant, one does not need to worry about the possibility that goal-setting would backfire. This result complements Koch and Nafziger (2011) and Hsiaw (2013)'s models, where the goal is assumed to be rational expectations. Their models predict that when there is no self-control problem, rational expectation goals would backfire and the short-run self would exert more than optimal effort. Our finding indicates that when narrow goals can be self-chosen, the long-run self can just set a minimum goal that won't affect the short-run self.

Result 3: Broad goal-setting has no significant motivational effect under delayed payment and leads to procrastination.

Result 3 partially supports Hypothesis 2. We test the effect of broad goal-setting with a similar method to the one with narrow goal-setting. As shown in Figure 3, the increase in output under broad goal-setting when the payoff is delayed is 0.12 (from 0.81 in hour 1 of Day 1 to 0.93 on Day 2), which is only slightly higher than the increase in the *No Goal* treatment (0.10). But in the regression analysis displayed in Table 2 column (2), the sign is reversed. Broad goal-setting even leads to a small decrease in output with delayed payment. But the effect is very close to 0 and is not significantly different from 0. This contrasts with our prediction that broad goal-setting can still counteract present bias. But our model also predicts that the effect is smaller than that of narrow goals.

We find support for the other prediction regarding broad goal-setting, procrastination.

[23]For the summary statistics of difference in output on Day 3 compared to hour 2 of Day 1, please refers to Figure A1 in the appendix.

Day 3 is the later date under broad goal-setting. On average, subjects complete 1.18 tasks per minute on Day 3 with a broad goal. While in hour 2 of Day 1 when the payoff is also instant as on Day 3 but goal-setting has not been introduced, the average tasks per minute is 0.96. The 0.22 increase on Day 3 is much larger than the 0.10 increase (0.90 to 1.00) in the *No Goal* treatment. The regression analysis in Table 2 shows that the difference is significant at 10% level. The difference in output is driven by the difference in labor supply. In the *Broad Goal* treatment, subjects spend 9.67 more seconds in a minute on working on Day 3 than those in the *No Goal* treatment and the difference is significant at 1% level. Procrastination is harmful in our theoretical setup as the initial effort provision is optimal on Day 3 when the payment is instant. Pushing the short-run self work too hard hurts both Day 3 self and the long-run self.

Result 4: In terms of welfare, narrow goals are better than broad goals: narrow goal-setting motivates more effort when the payment is delayed and less effort when the payment is instant. In terms of aggregate productivity, there is no significant difference between the two goal goal-setting methods.

Result 2 and Result 3 already establish that narrow goal-setting can counteract present bias but broad goal-setting cannot and broad goal-setting leads to procrastination but narrow goal-setting does not. But we still need to show that the differences between the two are significant. Table 3 presents the result of the comparison. The regression is similar to the ones used in Result 2 and 3 sections. The only difference is we now compare narrow goals with broad goals, while in Result 2 (3) section we compare narrow goals (broad goals) with no goals. Therefore, the parameters of interest are still those of the interaction terms of *Narrow Goal* treatment with Day 2 and Day 3.

As can be seen from the first column of Table 3, narrow goal-setting is able to motivate more output than the broad with delayed payment (Day 2) and the difference is significant at 5% level. The difference in output is driven by the difference in work time. Under narrow goals, subjects work 7.52 seconds more in a minute under delayed payment and the effect is significant at 1% level. Meanwhile, broad goal-setting motivates more effort on Day 3 when the payment is instant and the difference is significant at 10% level.

The finding indicates that, as predicted by the model, narrow goal-setting is better than broad goal-setting from the long-run self's perspective. Period 2 self's effort provision is sub-optimally low from the long-run self's perspective. Narrow goal-setting is better at dealing with this self-control problem. Period 3 self's interest is aligned with the long-run self and thus is already exerting the optimal level of effort. Broad goal-setting makes period 3 self works sub-optimally hard, which is costly for both period 3 self and the long-run self. In the exit survey on Day 3, we also ask subjects to report their satisfactions with the task and their performance. These two self-reported questions allows us to test the effect of narrow goals on welfare. Consistent with the theory prediction, we find that under narrow goals, the subjects are more satisfied with their own performance and feel the task is less boring.[24] But both of the gaps are not significantly different from 0.

The other dimension of interest, in addition to welfare, is productivity. If all we care about is motivating the short-run selves to work harder, then we need to compare the two goal-setting methods based on the aggregate output on Day 2 and Day 3. To do this, we add a specification to the regression analysis. Instead of letting *Narrow Goal* treatment interact with Day 2 dummy and Day 3 dummy separately, we let it interact with a new dummy variable Day2/Day3, which equals to 1 if the day is Day 2 or Day 3. Then the parameter of this new interaction term measures the overall effect of narrow goals on effort provision compared to broad goals. The results are shown in Table 3, column (2), (4) and (6). The narrow goal-setting effects on Day 2 and Day 3 cancel out. Overall, narrow goals and broad goals are equally effective in motivating effort.

However, it is important to note here that what we estimate is the lower bound of the narrow goal effect. In our experiment, there is only one delayed payment day and one payday. However, in reality, there are usually many more delayed payment days than the paydays. We know narrow goal-setting is better when the payment is delayed. If the number of delayed payment days is multiplied in our experiment, we expect to see that narrow goals are still better than broad goals even in terms of aggregate productivity.

[24]We ask the subjects, on a scale of 1 to 10, how satisfied they are with their own performance in the study. In the *Narrow Goal* treatment, the average satisfaction is 6.81 and in the *Broad Goal* treatment, the average rating is 6.69. We also ask subjects to rate how boring the task is with a larger number means less boring. In the *Narrow Goal* treatment, the average report is 4.33 and in the *Broad Goal* treatment, the average is 4.02.

Result 5: Goals work as reference points

In Result 2, we show that narrow goal-setting can counteract present bias. But it is not yet clear whether the mechanism through which goal-setting motivates efforts is reference-dependence. As we ask the subjects to set their own goals and report that to us, we are able to observe their goals and investigate whether goals act as reference points. In Figure 4, we plot the number of tasks per minute in the 10 minutes before the subjects reach a goal and in the 10 minutes after they reach a goal. [25] As one can see from the graph, the output drops sharply after reaching a goal in the first 3 minutes and continue to drop during the whole period. The pattern is similar for the work time, which is shown on Figure A2.

One potential concern is that after the subjects reach a goal, they also tend to be closer to the end of the 2-hour session compared to the time before they reach a goal. Therefore, the drop we observe could be driven by fatigue or some other factors that arise in the later part of the session. To deal with this issue, we use the following non-parametric regression to control for the minute fixed effects.

$$y_{idt} = \sum_{b=-10}^{10} \phi_b D_{ibt} + \phi_{-11} control_i + \gamma_1 day3_d + \gamma_2 easy_{idt} + \gamma_3 weekday_{id} + \sum_t \delta_t + \mu_i + \epsilon_{idt} \tag{14}$$

where y_{idt} is the amount of tasks completed by individual i on Day d in minute t or the corresponding labor supply. D_{ibt} is the distance to the goal. ϕ_b coefficients are the key parameters of interest. In the regression, the 0 distance dummy is omitted, so all the parameters ϕ_b measure the output of a minute relative to that of the point when the goal is reached. If the goal serves as a reference point, we would expect the coefficient ϕ_b to be negative after the goal is reached $(b > 0)$. $control_i$ is the dummy for the *No Goal*

[25] We focus on the 10 minutes interval as for those who actually achieve their goals, more than 90% of them have 10 or more minutes left in their 2-hour session. If we look at a bigger interval, then we will face a bigger selection problem. The data at the right tail will over-represent those who finish their goals early so that there are 10 or more minutes left in their session. Then the difference between those people and the others will confound the pattern of output we observe after the goal is reached.

treatment. δ_t measures the minute fixed effect.

We plot the coefficients and associated 95% confidence intervals in Figure 5. As one can see, output drops significantly in most minutes after the goal is reached and it decreases in a monotonic fashion.

Result 6: The goal effect shows significant inter-personal heterogeneity: more present-biased subjects benefit more from narrow goal-setting. In terms of the comparison between narrow and broad goal-setting, we find 1) narrow goals always motivate more effort than broad goals under delayed payment regardless of β; 2) the gap in motivating effort under delayed payment decreases as β goes to 1.

To access the heterogeneous effect of goal-setting, we firstly need to estimate the present bias. An individual's β is measured by comparing the number of tasks completed in hour 1 of Day 1 (delayed payment) with the number completed in hour 2 of Day 1 (instant payment). Recall that in Figure 2, when the payment is constant across the 2 hours on Day 1 (the 1-day control treatment), the output is not significantly different across the 2 hours. This suggests that there is no trend of learning or fatigue over the 2 hours. Therefore, the difference in output can be attributed to present bias.

Recall that the optimal effort of the short-run self when the payment is delayed, e^{sr}, satisfies

$$c_e(e_t^{sr}(s_t), s_t) = \beta v'(e_t^{sr}(s_t)).$$

where $c(e_t, s_t)$ is the effort cost and $v(e_t)$ is the payoff. When the payment is instant, the optimal effort $e^{sr'}$ satisfies

$$c_e(e_t^{sr'}(s_t), s_t) = v'(e_t^{sr'}(s_t)).$$

Combining these two equations, we get

$$\frac{c_e(e_t^{sr}(s_t), s_t)}{v'(e_t^{sr}(s_t))} / \frac{c_e(e_t^{sr'}(s_t), s_t)}{v'(e_t^{sr'}(s_t))} = \beta. \tag{15}$$

$\frac{c_e(e_t^{sr}(s_t),s_t)}{v'(e_t^{sr}(s_t))} / \frac{c_e(e_t^{sr'}(s_t),s_t)}{v'(e_t^{sr'}(s_t))}$ is a monotonic transformation of $\frac{e_t^{sr}}{e_t^{sr'}}$ and $\frac{e_t^{sr}}{e_t^{sr'}}$ can be estimated by $\frac{effort\ in\ hour\ 1\ of\ Day\ 1}{effort\ in\ hour\ 2\ of\ Day\ 1}$. Therefore, the larger is $\frac{effort\ in\ hour\ 1\ of\ Day\ 1}{effort\ in\ hour\ 2\ of\ Day\ 1}$, the larger is β. In fact, if we assume that the effort cost is quadratic and the payoff is linear, then we can directly measure β using hour 1 and hour 2 output:

$$\frac{e_t^{sr}}{e_t^{sr'}} = \frac{effort\ in\ hour\ 1\ of\ Day\ 1}{effort\ in\ hour\ 2\ of\ Day\ 1} = \beta. \tag{16}$$

We firstly test that whether more present-biased subjects benefit more from narrow goal-setting. We re-run our regression equation (13) in Result 2 section, but with different values of β. As our *No Goal* treatment has only 29 subjects, the variation in individual present bias is quite limited. We are only able to run the regression for subjects with smaller than 0.5 β and subjects whose β is no less than 0.5. The main variable of interest is the interaction term of *Narrow Goal* treatment and Day 2 as Day 2 is the day that the long-run self faces the self-control problem. We plot the estimated coefficients in Figure 6. The figure shows that the effect of goal-setting is much larger for those with a stronger present bias, or a smaller β. The results are similar if we replace output with work time, as shown in Figure A3.

The results in Result 4 Table 3 only show that narrow goal-setting is better in counteracting present bias than broad goal-setting on average. However, what really separates our model from Koch and Nafziger (2016) and Hsiaw (2018) is how the optimal goal-setting methods depend on β. Their models predict that when the goal is rational expectations, the optimal goal-setting method depends on β: when β is small, narrow goals are better and when β is large, broad goals are better. We complement their results by showing that when the goals are self-chosen, the optimal goal setting rule, from the long-run self's perspective, is always narrow goal-setting regardless of β. To test this prediction, we need to conduct the comparison between narrow goals and broad goals for different ranges of β. Our model also predicts that even though narrow goal-setting is always better, the gap between narrow and broad decreases as β goes to 1.

We find support for our predictions. We cut β into 5 ranges: $0-0.2$,$0.2-0.4$, $0.4-0.6$, $0.6-0.8$, $0.8-1$ and plot the point estimation coefficients in Figure 7. The dependent variable is output and we plot the coefficients and their 95% confidence intervals of the interaction term of narrow goal and Day 2. The coefficient is always positive in all five ranges of β, suggesting that narrow goal-setting is always better in counteracting present bias than broad goal-setting. But at the same time, the coefficient becomes smaller and less significant as β goes to 1, which indicates that there still exists a trade-off between commitment and flexibility. When β is large enough, there is no big difference between the two goal-setting methods. We replace output with work time in Figure A4. The results are quite consistent.

5. Conclusion

Present bias leads to intra-personal conflict when costs are immediate but payoffs are in the future. Surprisingly, even though self-control is an everyday problem for many people, hard commitment devices are rarely offered on the market. In this paper, we show that one potential explanation for this situation is that people have soft commitment devices they can use to control themselves. The device we study in this paper is self-chosen goals. By "nudging" people to set themselves goals, we are able to increase their effort provision when they face the self-control problems. No monetary punishments or rewards are provided. The findings suggest people do know how to set narrow goals to control themselves and the goals they set do work if they are reminded to do so. But this raises a different puzzle, which is why individuals need to be reminded to set narrow goals. One explanation is that individuals are naïve not about their present bias, but about the effectiveness of goals.

Another issue raised by this paper is even though goals can be valuable, the form of goals do matter. We find that narrow goal-setting is quite effective in dealing with self-control problems. It also does not lead to over-working when the the self-control problem does not exist. However, we also show that broad goal-setting is not as effective as narrow goal-setting in counteracting present bias, and it leads to costly procrastination. Therefore, one way of setting goals can be better than another. One potential policy implication is we should not only "nudge" people to set goals but also should suggest the optimal way of doing that.

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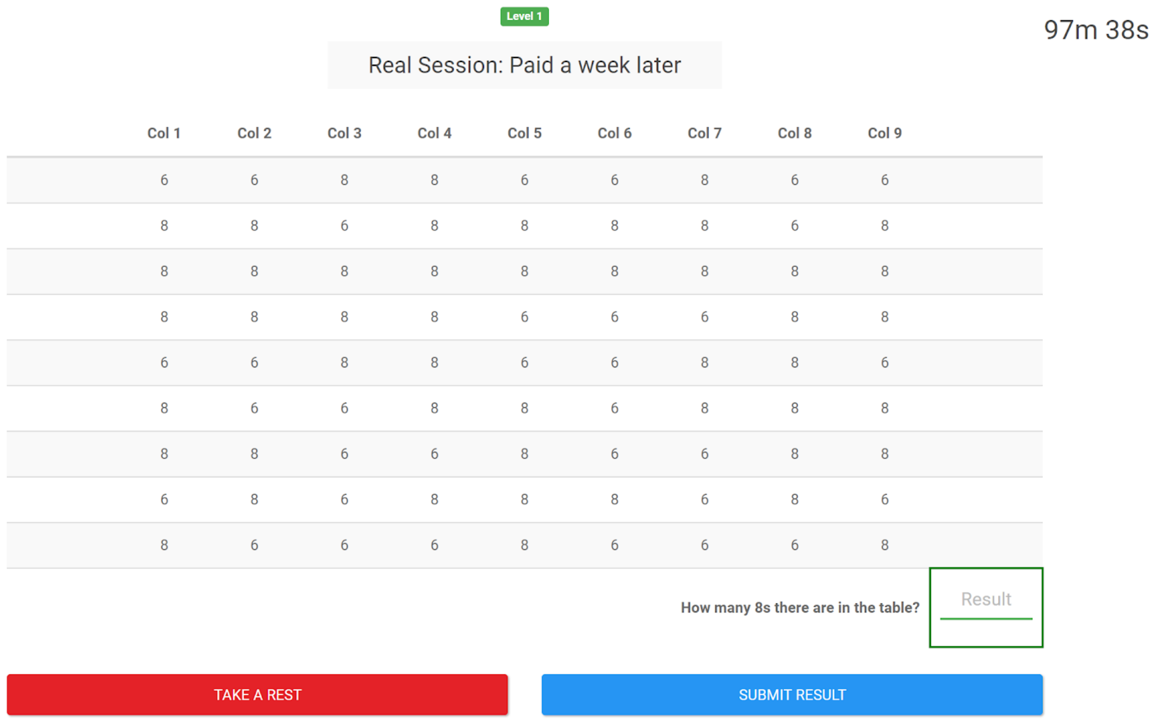
Figure 1: An Example of the Task

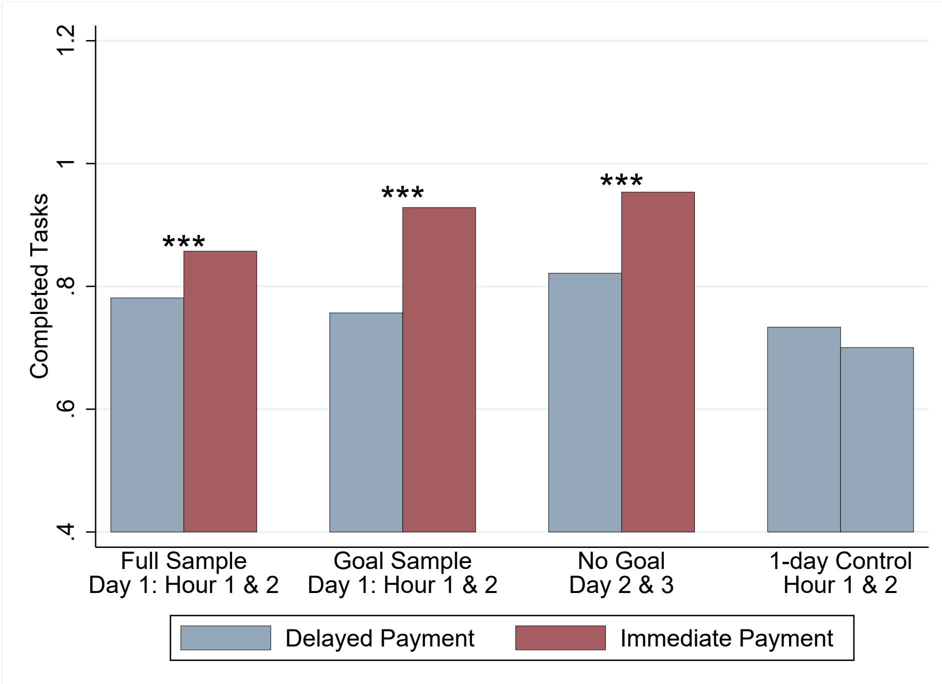


Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9
6	6	8	8	6	6	8	6	6
8	8	6	8	8	8	8	6	8
8	8	8	8	8	8	8	8	8
8	8	8	8	6	6	6	8	8
6	6	8	8	6	6	8	8	6
8	6	6	8	8	6	8	8	8
8	8	6	6	8	6	6	8	8
6	8	6	8	8	8	6	8	6
8	6	6	6	8	6	6	6	8

Table 1: Timeline

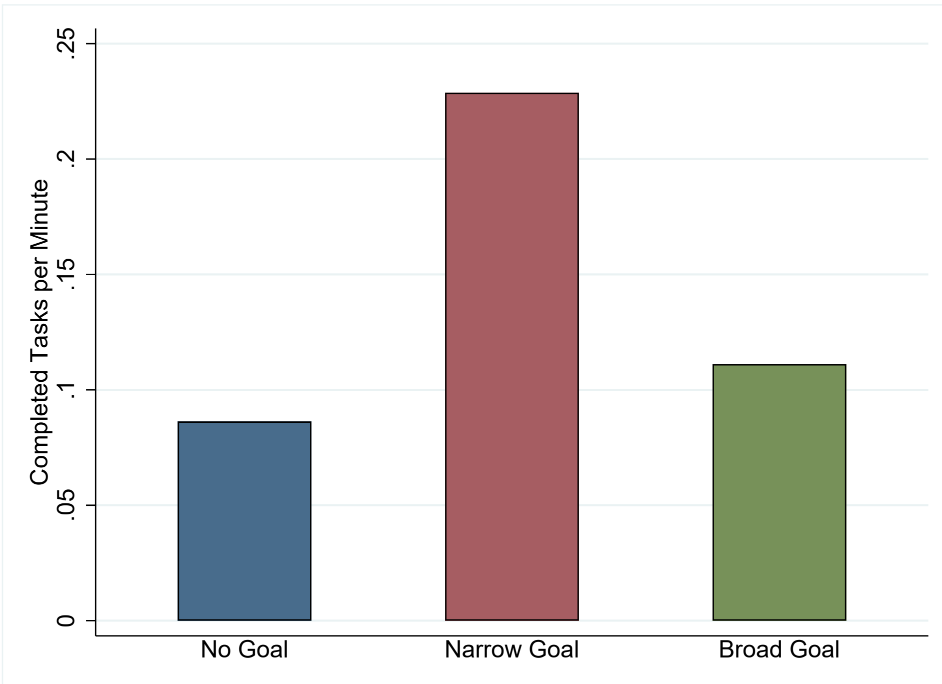
Day1	Randomly assign to treatments
	One hour practice session
	Hour 1 : paid a week later
	Hour 2 : paid immediately
	Ask to set goals for Day 2/3
	Invite present-biased subjects
Day2	2 hours, paid a week later
Day3	2 hours, paid immediately
	Exit Survey

Figure 2: Output for Delayed and Immediate Payment



This figure shows the mean output (tasks finished per minute) under delayed payment and immediate payment without goal-setting. * denotes the two outputs are significantly different at 10%, **5%, and ***1% levels. The "Full Sample" and "Goal Sample" bar graphs compare the output in hour 1 and hour 2 on Day 1, where the goal sample refers to the sample that are invited to Day 2 and Day 3. The No Goal bar graph compares the output in the *No Goal* treatment on Day 2 when the payment is delayed and Day 3 when the payment is immediate. The last graph shows the mean output in the 1-day control treatment in the first and second hour.

Figure 3: Changes in Output on Day 2 in Different Treatments



This figure plots the difference in mean tasks finished per minute on Day 2 with respect to hour 1 of Day 1.

Table 2: Goal Treatments VS the No Goal Treatment

VARIABLES	Task/min		Worktime/min		Speed (time/task)	
	Narrow	Broad	Narrow	Broad	Narrow	Broad
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.136	0.027	-6.969	0.688	2.237	-5.025
	(0.179)	(0.178)	(5.667)	(5.696)	(8.202)	(7.693)
Day 2	0.151***	0.151***	1.443	1.443	-7.047	-7.047
	(0.046)	(0.046)	(1.668)	(1.668)	(4.446)	(4.446)
Day 3	0.014	0.014	-8.428***	-8.428***	-17.815***	-17.815***
	(0.075)	(0.075)	(2.837)	(2.837)	(5.407)	(5.406)
Treatment	0.125**	-0.009	7.502***	-0.013	-1.727	-0.660
*Day 2	(0.061)	(0.066)	(2.603)	(2.438)	(5.425)	(4.710)
Treatment	0.035	0.176*	5.394	9.480***	11.263*	9.530*
*Day 3	(0.097)	(0.094)	(3.586)	(3.506)	(5.895)	(5.713)
Observations	24,888	24,739	24,888	24,739	18,922	19,142
R-squared	0.302	0.292	0.087	0.070	0.350	0.368
Mean DV	0.958	0.958	43.119	43.119	54.389	54.389
Std.Dev. DV	0.723	0.723	25.471	25.471	27.920	27.920

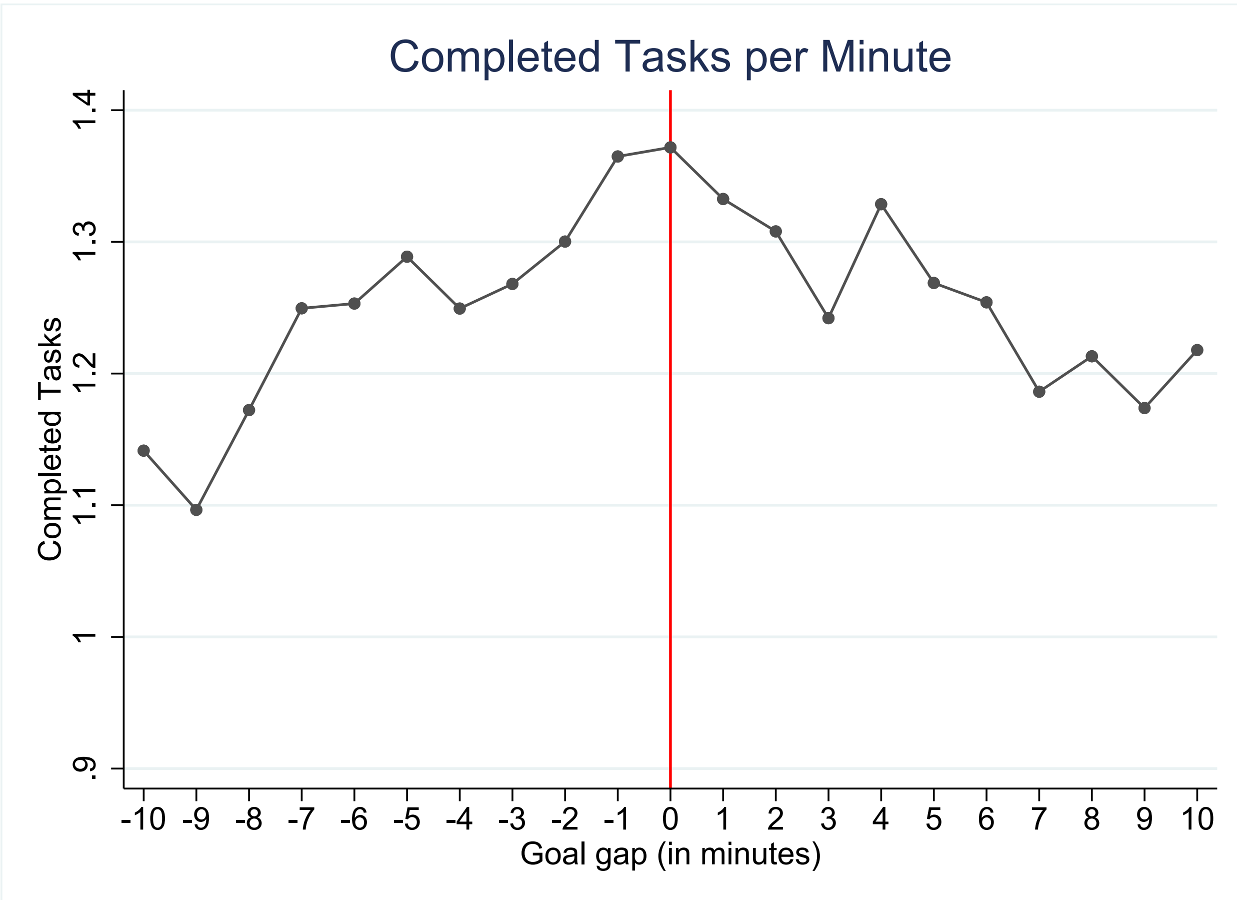
The table reports the effect of narrow goal-setting on counteracting present bias. Task/min is the amount of tasks finished in a minute. Worktime/min is the seconds spend on working in a minute. Speed is defined as the seconds one spends to finish one task. Treatment is the dummy variable for *Narrow Goal* treatment or *Broad Goal* treatment. In column (1), (3) and (5), it refers to the *Narrow Goal* treatment and in column (2), (4) and (6), it means the *Broad Goal* treatment. It equals to 0 if the treatment is *No Goal*. Day 2 and Day 3 are the indicator variables for Day 2 observations and Day 3 observations respectively. All regressions control for session difficulty level, immediate payment dummy, weekday fixed effects, minute fixed effects and their interaction terms with Treatment. *denotes significance at 10%, **5%, and ***1% levels. Standard errors are in brackets, clustered at the individual level.

Table 3: Narrow VS Broad

VARIABLES	Task/min		Worktime/min		Speed (time/task)	
	(1)	(2)	(3)	(4)	(5)	(6)
Narrow goal	-0.163*	-0.090	-7.657**	-4.580	7.262	6.503
	(0.098)	(0.098)	(3.648)	(3.629)	(5.747)	(5.977)
Day 2	0.141***	0.209***	1.430	4.310**	-7.707***	-8.408***
	(0.048)	(0.043)	(1.775)	(1.704)	(1.552)	(1.562)
Day 3	0.189***	0.119**	1.052	-1.913	-8.284***	-7.612***
	(0.057)	(0.047)	(2.056)	(1.838)	(1.844)	(1.702)
Narrow goal * Day 2	0.134**		7.515***		-1.067	
	(0.063)		(2.669)		(3.468)	
Narrow goal * Day 3	-0.141*		-4.086		1.732	
	(0.083)		(3.002)		(2.982)	
Narrow goal*Day2/Day3		-0.002		1.766		0.366
		(0.052)		(1.899)		(2.401)
Observations	30,139	30,139	30,139	30,139	23,530	23,530
R-squared	0.316	0.314	0.085	0.083	0.372	0.371
Mean DV	0.958	0.958	43.119	43.119	54.389	54.389
Std.Dev. DV	0.723	0.723	25.471	25.471	27.920	27.920

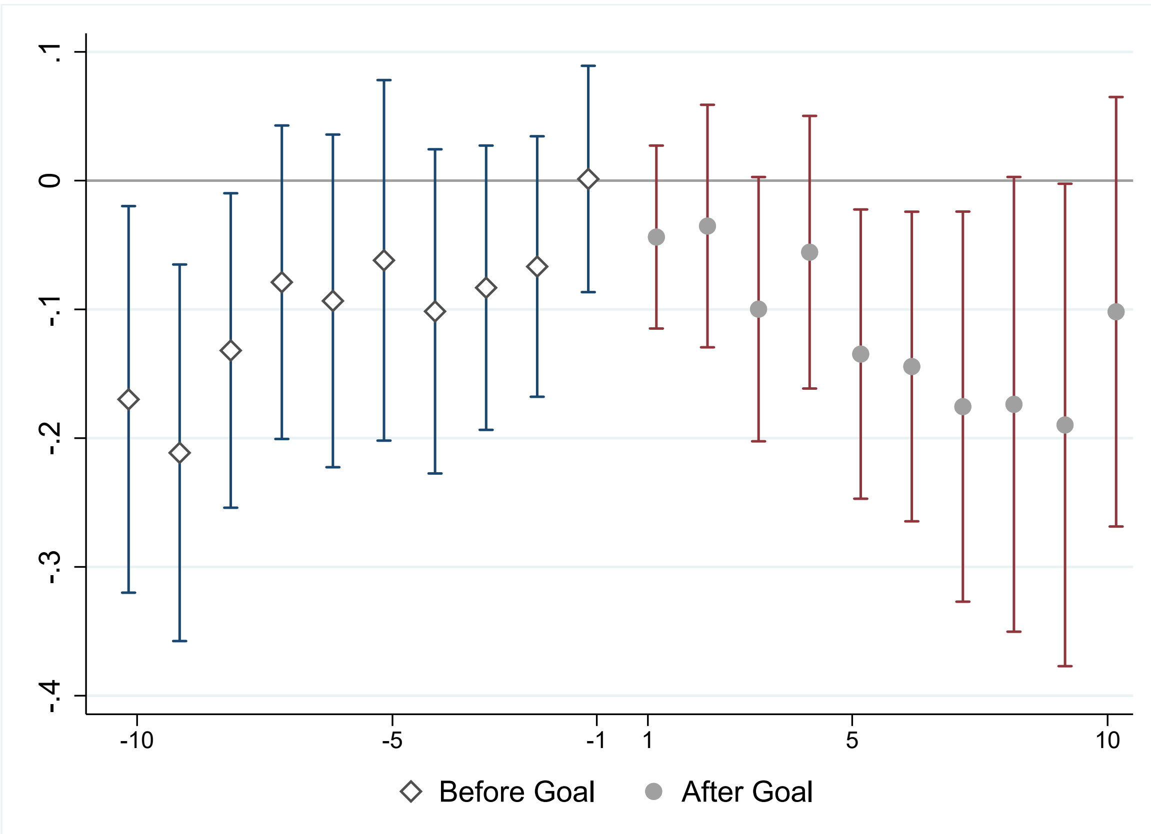
The table reports the comparison between narrow goal-setting and broad goal-setting. Task/min is the amount of tasks finished in a minute. Worktime/min is the seconds spend on working in a minute. Speed is defined as the seconds one spends to finish one task.Day2/Day3 is the dummy variable for Day2 or Day3. All regressions control for session difficulty level, immediate payment dummy, weekday fixed effects, minute fixed effects and their interaction term with Treatment. *denotes significance at 10%, **5%, and ***1% levels. Robust standard errors are in brackets, clustered at the individual level.

Figure 4: Number of Completed Tasks around Goals



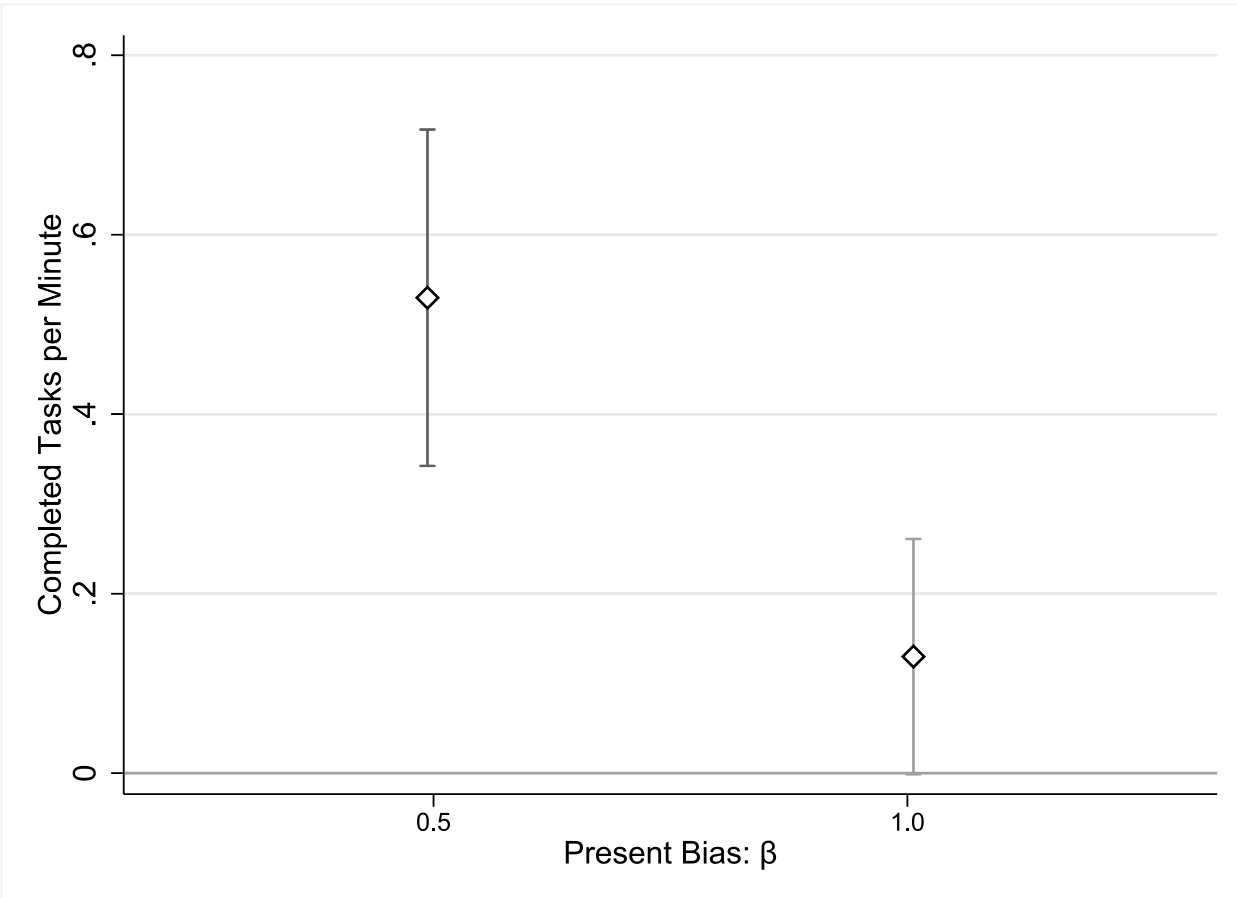
This figure plots the average output in the 20 minutes interval around the goal. A negative goal gap means the goal has not been reached and a positive one means the goal has been reached. 0 is the minute in which the goal is reached.

Figure 5: Coefficients of the Distance to Goal Dummies Variables



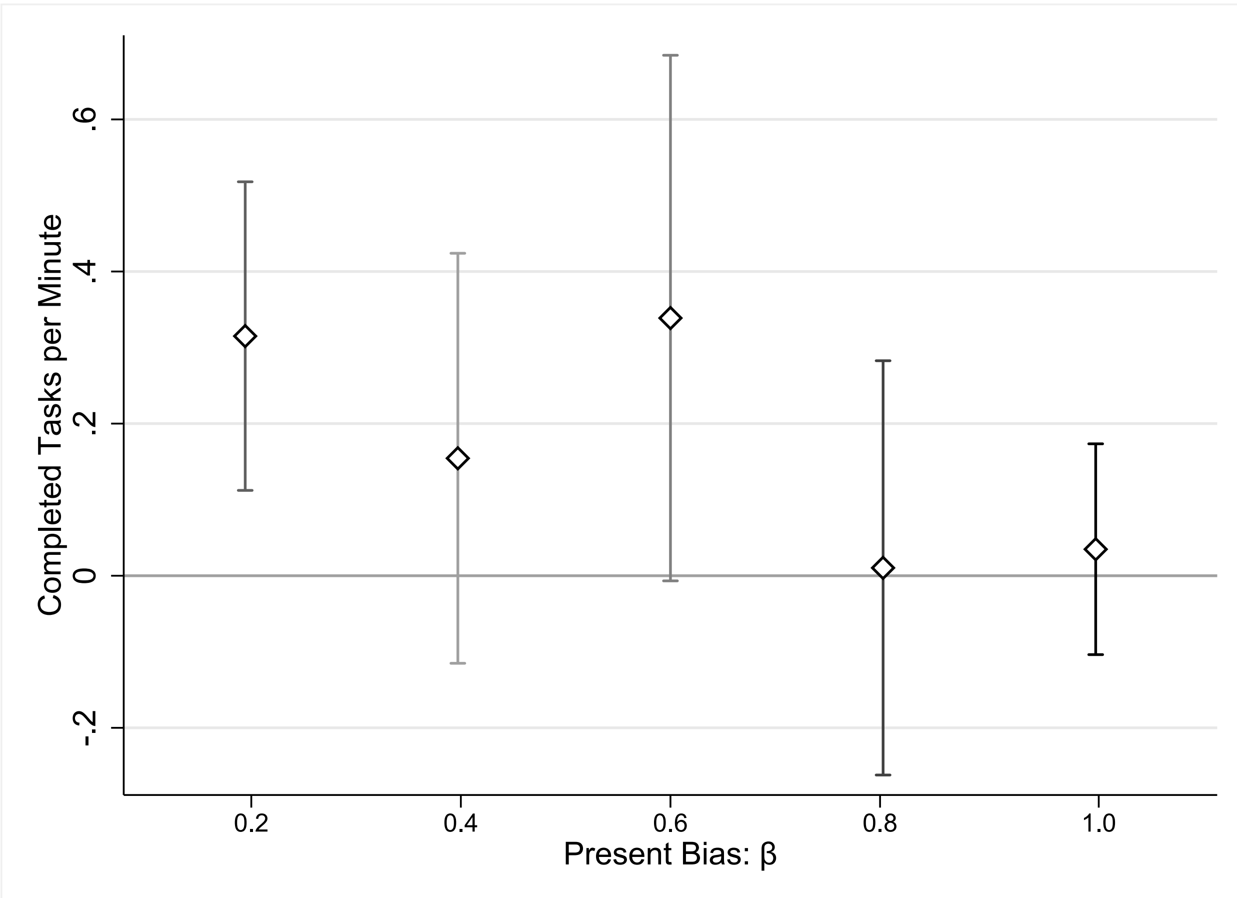
This figure plots point estimates and 95% confidence intervals for the effect of distance to goal dummies on output. All regressions control for individual fixed effects, minute fixed effects, session difficulty level, Day 3 dummy and *No Goal* treatment dummy. Standard errors are clustered at the individual level.

Figure 6: Heterogeneous Effect of Narrow Goal-setting- Output



This figure plots point estimates and 95% confidence intervals for the effect of narrow goals on counteracting present bias for different values of β. The first bar and the second bar correspond to subjects with $0 \leq \beta < 0.5$ and $0.5 \leq \beta \leq 1$ respectively. All regressions control for minute fixed effects, session difficulty level, weekday dummies, immediate payment dummy and their interaction terms with narrow goal. Standard errors are clustered at the individual level.

Figure 7: Gap between Narrow and Broad Goal-Setting for Different β- Output



This figure plots point estimates and 95% confidence intervals for the effect of narrow goal-setting on addressing the self-control problem compared to that of broad goal-setting. The fives bars, from left to right, represent the results for the subject whose β is in the range of 0-0.2, 0.2-0.4, 0.4-0.6, 0.6-0.8 and 0.8-1 respectively. All regressions control for minute fixed effects, session difficulty level, weekday dummies and their interaction terms with narrow goal. Standard errors are clustered at the individual level.

Appendices

A. Optimal Narrow Goals

To fully characterize the optimal goals in both the broad and narrow scenario, we start by analyzing the narrow or stage optimal goal. Later when we study the optimal goal in the broad case, the optimal stage goal can serve as a benchmark.

In the narrow goal-setting case, there is no dynamic considerations when setting goals. As each short-run self needs to deal with his own goal, his choice of effort provision has no impact on future or past short-run selves. From the long-run self's perspective, she sets two goals: one for self 3 with whom she is perfectly aligned and one for self 2 who is present biased.

If there is no present bias, self 2 chooses the optimal e_2^{lr} in state s_2 by trading off the effort cost $c(e_2, s_2)$ and the benefit $v(e_2)$. When present bias exists but not goal-setting, he chooses the effort level e_2^{sr}. After a goal is set, the marginal payoff of effort increases by η for $e \in [0, g_1^N]$, where η is the weight of reference-dependence utility. For $e > g_2^N$, the marginal payoff is unaffected. Therefore, with a narrow goal, self 2's welfare maximizing effort level is $e_2^g(s_2)$ that solves $c_e(e,s) = \beta v'(e) + \mathbb{1}_{e \leq g^N}\eta$ in case the solution is interior.

In reality, the reference-dependence utility should not be too large. In particular, we make the following assumption

$$\textit{Assumption 1}: e^g(s) < e^{lr}(s) \text{ for } s \in \{H, L\} \text{ if } \beta = 0.$$

Assumption 1 indicates that reference-dependence utility alone is not enough to induce e^{lr}.

The optimal goal for period 3 is simple. As self 3 has no present bias problem, the long-run self only needs to make sure that the goal set does not intervene the way she takes of advantage of her private information. Or in other words, the goal is non-binding in both states. To this end, the goal for self 3 g_3^N can be any value between 0 and the optimal effort level in the high cost state $e^{lr}(H)$.

The optimal goal for self 2 depends on the degree of present bias β. If $\beta = 1$, which means there is no present bias, then the optimal goal coincides with the one for self 3.

For all other β values, the optimal goal is not instantly clear.

Optimal Narrow Goal When $\beta = 0$

If $\beta = 0$, which means each short-run self has no incentive to exert effort, then the optimal goal must be binding in at least one state. We can show that the optimal goal is in the range of $[e^g(H), e^g(L)]$. All goals below $e^g(H)$ are strictly worse than $e^g(H)$; all goals above $e^g(L)$ are strictly worse than $e^g(L)$. For the former, the intuition is that, $e^g(H)$ can induce more efforts than lower goals but does not cause overproduction or loss in reference-dependence utility in any states. No overproduction is directly implied by Assumption 1. The no loss result is due to the fact that $e^g(H)$ can induce the short-run self to exert at least $e^g(H)$ amount of efforts in both states. The logic for all goals above $e^g(L)$ are worse than it is similar. $e^g(L)$ is the highest effort level the reference-dependence utility is able to motivate. A goal higher than it leads to a loss without inducing more efforts.

To determine the optimal goal within the range $[e^g(H), e^g(L)]$, we need to consider the marginal benefit and cost of increasing the goal. The marginal benefit at $g^N \geq e^g(H)$ is given by $(1-p)[v'(g^N) - c_e(g^N, L)]$ as a higher goal can induce more efforts when the state is L. However, when the state is H, a goal high than $e^g(H)$ is not able to motivate more efforts than it. The marginal cost is a unit loss in reference-dependence utility in state H, $p\eta$. The reason is in this state, the short-run self is motivated to achieve $e^g(H)$ but will take the loss to avoid going above it. As $v'(e) - c_e(e, L)$ is a decreasing function of e, we reach the following conclusion

Lemma A1. *Define $\hat{e}$ as the unique solution of the equation $p\eta = (1-p)[v'(e) - c_e(e, L)]$. When $\beta = 0$, the optimal narrow goal g^{N*} when $\beta = 0$,*

- *(i) equals to the highest effort level achievable in state H with reference-dependence utility alone $e^g(H)$ when $\hat{e} \leq e^g(H)$*
- *(ii) equals to the highest effort level achievable in state L with reference-dependence utility alone $e^g(L)$ when $\hat{e} \geq e^g(L)$*
- *(iii) equals to $\hat{e}$, when $e^g(H) < \hat{e} < e^g(L)$.*

Optimal Narrow Goal When $\beta \in (0,1)$

If $\beta \in (0,1)$, the short-run self is motivated by two forces to exert effort: earning the discounted future benefit of effort $\beta v(e)$ and avoiding the loss of failing to reach a goal, η. The optimal goal is still in the range $[e_H^g(0), e_L^g(0)]$ due to the same reasoning as stated above. There are two cases.

The first case is when β is small enough so that the first best is still not achievable in either states, $e_s^g(\beta) < e_s^{lr}$ for $s \in \{H, L\}$. In this case, the trade-off is exactly the same with the case of $\beta = 0$. One only needs to replace $e_s^g(0)$ as in *Lemma 1* with $e_s^g(\beta)$ and all the results in the $\beta = 0$ case can go through.

The second case is when β is large enough such that at least in state H, the first best effort level e_H^{lr} is achievable by properly setting a goal, or $e_H^g(\beta) \geq e_H^{lr}$. The trade-off is altered. The benefit of a higher goal remains the same. However, the cost of a higher goal becomes the minimum of two potential costs. When the short-run self faces a goal g^{N*} high than e_H^{lr} in state H, she has two choices: achieving the goal but exerting some inefficient efforts or giving up the goal and take the loss in reference-dependence utility. The short-run self will chooses the one that cost less, which is also consistent with the interest of the long-run self as both costs are instantaneous.

We take three steps to solve the optimal goal in this more complicated situation. First, we show that goals in $(e_H^{lr}, e_L^{sr}(\beta))$ are never optimal, where $e_L^{sr}(\beta)$ is the optimal effort level of the present-biased short-run self. Second, we derive the optimal goal in $[e_L^{sr}(\beta), e_L^{lr}]$. Third, we compare the optimal goal in $[e_L^{sr}(\beta), e_L^{lr}]$ to e_H^{lr}.

The first step is straightforward. All goals in $(e_H^{lr}, e_L^{sr}(\beta))$ are inferior compared to e_H^{lr}. In state H, a goal in $(e_H^{lr}, e_L^{sr}(\beta))$ leads the short-run self to exert more effort than e_H^{lr} as $e_H^g(\beta) \geq e_H^{lr}$, which is inefficient as e_H^{lr} is the long-run self's optimal effort level. In state L, a goal in $(e_H^{lr}, e_L^{sr}(\beta))$ is not able to induce more effort than e_H^{lr} as the short-run self will exert $e_L^{sr}(\beta)$ without any reference-dependence utility.

In the second step, for a goal in $[e_L^{sr}(\beta), e_L^{lr}]$, the marginal benefit of a higher goal is the marginal utility of a higher effort in state L: $(1-p)[v'(e) - c_e(e, L)]$. The marginal cost of a higher goal is minimum of two potential losses in state H: a loss in reference-dependence utility $p\eta$ or a loss in the marginal consumption utility due to overshooting, $p[c_e(e,H)-v'(e)]$. The optimal goal has two candidates: $\bar{e}^{lr}$, where $(1-p)[v'(\bar{e}^{lr})-c_e(\bar{e}^{lr},L)] = p[c_e(\bar{e}^{lr},H)-v'(\bar{e}^{lr})]$ and $\hat{e}^{lr}$, where $(1-p)[v'(\hat{e}^{lr})-c_e(\hat{e}^{lr},L)] = p\eta$. To determine the optimal goal, we need to rank $(1-p)[v'(e)-c_e(e,L)]$, $p[c_e(e,H)-v'(e)]$ and $p\eta$. To simplify the comparison, we make Assumption 2. As stated at the beginning of this section, we consider a small η. Assumption 2 further describes what we mean by "small".

Assumption 2: $c_e(\bar{e}^{lr},H)-v'(\bar{e}^{lr}) > \eta$.

Assumption 2 immediately implies that $p[c_e(\bar{e}^{lr},H)-v'(\bar{e}^{lr})] > p\eta$, which means the marginal cost in consumption utility $p[c_e(\bar{e}^{lr},H)-v'(\bar{e}^{lr})]$ is larger than the marginal cost in reference-dependence utility $p\eta$ at $\bar{e}^{lr}$. Therefore, the short-run self is willing to suffer the loss in reference-dependence utility at this point. Meanwhile, $\bar{e}^{lr}$ is also the point where $(1-p)[v'(e)-c_e(e,L)]$ meets $p[c_e(e,H)-v'(e)]$. Consequently, $\bar{e}^{lr}$ cannot be the optimal goal because at this point the marginal benefit $(1-p)[v'(e)-c_e(e,L)] = p[c_e(e,H)-v'(e)] > p\eta$. Therefore if Assumption 2 holds, $\hat{e}^{lr}$ is the optimal goal as long as it is in the range $[e_L^{sr}(\beta), e_L^{lr}]$. If instead, $\hat{e}^{lr} < e_L^{sr}(\beta)$ or $\beta > 1-\frac{p}{1-p}\frac{\eta}{v'(\hat{e}^{lr})}$, then the marginal cost of a higher goal is larger than the marginal benefit for all $g^N \in [e_L^{sr}(\beta), e_L^{lr}]$. It is optimal to choose the lowest goal in the interval, namely $e_L^{sr}(\beta)$.

In the third step, we compare e_H^{lr} with the optimal goal in $[e_L^{sr}(\beta), e_L^{lr}]$, which can be $\hat{e}^{lr}$ or $e_L^{sr}(\beta)$ depending on β. We have showed in step 1, $e_L^{sr}(\beta)$ is worse than e_H^{lr}. Therefore, if $\beta > 1-\frac{p}{1-p}\frac{\eta}{v'(\hat{e}^{lr})}$, the optimal goal is e_H^{lr}. If instead, $\beta \leq 1-\frac{p}{1-p}\frac{\eta}{v'(\hat{e}^{lr})}$, we now need to compare $\hat{e}^{lr}$ with e_H^{lr}. By raising the goal from e_H^{lr} to $\hat{e}^{lr}$, the gain is

$$(1-p)\int_{e_H^{lr}}^{\hat{e}^{lr}} v'(e)-c_e(e,L)de$$

, the loss is

$$p\int_{e_H^{lr}}^{\hat{e}^{lr}} \min\{\eta, c_e(e,H)-v'(e)\}de$$

As $(1-p)[v'(\hat{e}^{lr})-c_e(\hat{e}^{lr},L)] = p\eta$ and $v'(e)-c_e(e,L)$ is a decreasing function of e, $v'(e)-c_e(e,L) > \frac{p}{1-p}\eta$ for $e \in [e_H^{lr}, \hat{e}^{lr}]$. At the same time, Assumption 2 implies for e such that $c_e(e,H)-v'(e) < \eta$, the marginal benefit $v'(e)-c_e(e,L)$ is larger then the marginal cost in consumption utility $c_e(e,H) - v'(e)$. As a result,

$$(1-p)\int_{e_H^{lr}}^{\hat{e}^{lr}} v'(e) - c_e(e,L)de > \int_{e_H^{lr}}^{\hat{e}^{lr}} \min\{\eta, c_e(e,H) - v'(e)\}de$$

, which implies that $\hat{e}^{lr}$ is the optimal goal when $\beta \le 1 - \frac{p}{1-p}\frac{\eta}{v'(\hat{e}^{lr})}$.

To summarize, we reach the following conclusion of the optimal narrow goal.

Proposition 1. *Given Assumption 1 and Assumption 2,*

(i) The optimal narrow goal g^{N*} converges to $e^{lr}(H)$ as $\beta \to 1$, when $\beta \in [max\{1 - \frac{\eta}{v'(e_H^{lr})}, 1 - \frac{p}{1-p}\frac{\eta}{v'(\hat{e}^{lr})}\}, 1]$. Therefore, for high β, or week present bias, the goals is not bidding on equilibrium path.

(ii) If $\hat{e} \le e^g(H)$ at $\beta = 0$, then the optimal goal is nonbinding for any degree of present bias. For $\beta \in [0, 1 - \frac{\eta}{v'(e^{lr}(H))}]$, the optimal narrow goal g^{N*} equals to the highest effort level achievable in state H with goal-setting $e^g(H)$. For $\beta > 1 - \frac{\eta}{v'(e^{lr}(H))}$, the optimal goal is $e^{lr}(H)$.

(iii) If $\hat{e} > e^g(H)$ at $\beta = 0$, then the optimal goal is binding for low β. In particular, if $\hat{e} \ge e^g(L)$, then the optimal goal is $e^g(L)$ for $\beta \in [0, 1 - \frac{1}{1-p}\frac{\eta}{v'(\hat{e})}]$. For $\beta \in [1 - \frac{1}{1-p}\frac{\eta}{v'(\hat{e})}, 1 - \frac{\eta}{v'(e^{lr}(H))}]$, the optimal goal is $e^g(H)$ if $p\eta(\hat{e} - e^g(H)) > (1-p)\int_{e_L^{sr}(\beta)}^{\hat{e}} v'(e) - c_e(e,L)de$; it is $\hat{e}$ if otherwise. For $\beta \in [1 - \frac{\eta}{v'(e^{lr}(H))}, 1 - \frac{p}{1-p}\frac{\eta}{v'(\hat{e}}]$, the optimal goal is still $\hat{e}$.

(iv) If $e^g(H) < \hat{e} < e^g(L)$ at $\beta = 0$, the optimal goal is $\hat{e}$ for $\beta \in [0,]$. Then for larger β, the optimal goal is $e^g(H)$ or $e^{lr}(H)$ as in the case where $\hat{e} \le e^g(H)$ at $\beta = 0$.

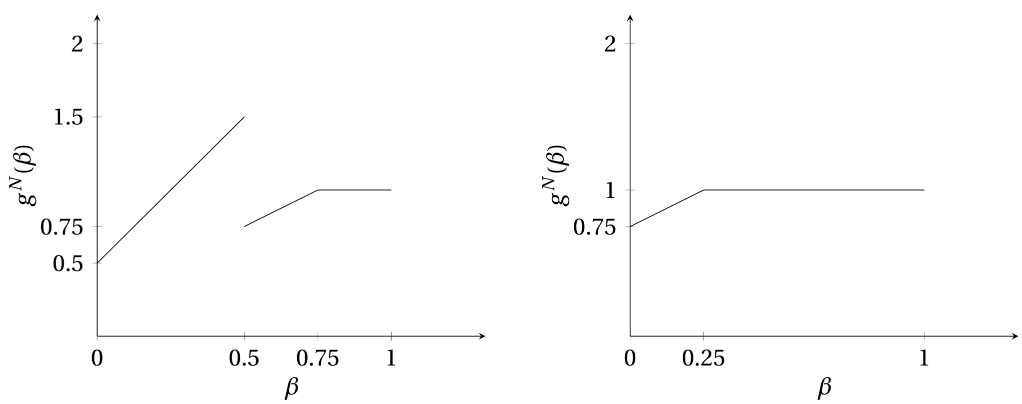
Illustrative Example

This section presents an illustrative example. The payoff of efforts $v(e)$ is $v(e) = 2e + m$, where m is a constant. The cost of efforts is $c(e,H) = e^2$ in the H state and $c(e,L) = \frac{e^2}{2}$ in the L state. The probabilities of H and L states are set to be equal to 0.5. The weight of reference-dependence utility η is 0.5. The marginal benefit of effort $v'(e) = 2$ and the marginal costs are $c_e(e,H) = 2e$ and $c_e(e,L) = e$ in states H and L respectively. Thus the optimal effort from the long-run self's perspective is $e^{lr}(H) = 1$ in state H and $e^{lr}(L) = 2$ in state L. But a present-biased short-run self's optimal efforts are $e^{sr}(H) = \beta$ and $e^{sr}(L) = 2\beta$

in states H and L, respectively.

We first look at optimal narrow goals in this example. For $\beta \in [0, 0.5]$, the optimal goal equals to highest effort level that can be induced by narrow goals in state L. Formally, $g^N = e^g(L) = 0.5 + 2\beta$. For $\beta \in [0.5, 0.75]$, the optimal goal g^N is the highest effort level that can be induced by narrow goals in state H, $g^N = e^g(H) = 0.25 + \beta$. For $\beta \in [0.75, 1]$, the optimal goal g^N is the long-run self's efficient effort in state H, $e^{lr}(H) = 1$. If we vary the value of the weight of reference-dependence utility η, the optimal goals change. If $\eta = 1.5$, then it is optimal to set g^N to be $e^g(H)$ for $\beta \in [0, 0.25]$ and $e^{lr}(H)$ for $\beta \in [0.25, 1]$.

Optimal Narrow Goal When $\eta = 0.5$ **Optimal Narrow Goal When** $\eta = 1.5$



B. Optimal Broad Goal

To solve the optimal broad goal, we firstly need to consider the incentives of the short-run selves under a broad goal. The major deviation from the narrow goal situation is that when a short-run self faces a goal which is higher than his optimal effort, he may rely on the future selves to complete the goal, or in other words, to procrastinate. It could be sub-optimal from the long-run self's perspective. It not only reduces the effectiveness of goal-setting, but also could lead to over-work of the time-consistent short-run selves. As in the model, self 3's effort provision is *ex ante* optimal. Under broad goal, he may need to go beyond the optimal level to avoid the loss induced by the goal.

For self 2, who is present-biased, the broad goal creates a trade-off. Procrastination can save him some effort cost but will lower the welfare of the future selves who he also cares about. The benefit of the extra work is same or larger if self 2 conducts it. The reason is the benefit is discounted by β no matter who does the extra work. The pre-goalsetting effort level $e_2^{sr} \le e_3^{sr}$ as self 3 is time consistent, which means $v'(e_2^{sr}) \ge v'(e_3^{sr})$ due to the concavity of $v(.)$. The comparison of the cost is more complicated. As $e_2^{sr} \le e_3^{sr}$, the marginal cost is higher for self 3 due to the convexity of the cost function. However, the cost is discounted by two factors. One is obviously the present bias β. The other factor, which is less obvious, is luck. If the goal is only bidding in some but not all state profiles, then potentially procrastination won't lead to over-work from self 3. For example, if the broad goal is only bidding in (H,H) and $g^B < e^{sr}(H) + e^{lr}(L)$, then a H type self 2 may count on the state in period 3 to be L. In such case, the cost of letting self 3 do the extra work is also discounted by $(1-p)$, which is the probability of $s_3 = L$.

Procrastination is not only profitable, but also plausible for two reasons. First, self 3 cares more about the broad goal than self 2. The reference-dependence utility is realized in period 3, which is in the future for self 2 but is present for self 3. Second, future selves has less uncertainty regarding whether the goal will be binding or not. Unlike Self 2, Self 3 perfectly knows whether the broad goal is binding or not and cannot count on luck in the future to meet the goal.

Lemma A2. *For any broad goal g^B, if $e_2^g(s) > e^{sr}(s)$ in some state s, then $Ee_3^g > Ee^{lr}$.*

Lemma A2 summarizes the above analysis. It states that there is no way to motivate self 2 using a broad goal without letting self 3 works too hard. Thus the long-run self, self 1, also faces a trade-off between self 2 welfare and self 3 welfare when setting the broad goal. The optimization problem can be broken down into four cases: the broad goal g^B is at most bidding in $(s_2, s_3) = (H,H)$, g^B is binding in (L,H) but not (H,L) or (L,L), g^B is binding in (H,L) but not (L,L) and it is binding in all state profiles. Comparing the optimal goals in the four cases will then conclude the problem.

The optimal goal is fairly straightforward when β is large or small. It at most binds in state profile (L,H). To see the intuition, consider a goal that is binding in (H,L). When the true state is (H,H), self 2 and self 3 needs to work a lot to meet the goal. When β is really small, most of the burden will fall on self 3, which hurts the long-run self. So for small β, it does not worth it to raise the goal to that high. When β is really large, the goal is only binding in (H,H). The reason is as β goes to 1, the difference between $e^{sr}(H)$ and $e^{sr}(L)$ approaches that of $e^{lr}(H)$ and $e^{lr}(L)$. The gap in effort provision between (L,H) and (H,H) also becomes substantial. Even though large β makes self 2 be willing to work hard, the potential benefits of more efforts from self 2 shirks as β goes to 1. At some point, the benefits of goal-setting won't offset the cost in (H,H) and the goal will only be binding in that state. We summarize the intuition in the following lemma.

Lemma A3. *There exist two cutoffs β_1 and β_2 with $0<\beta_1\leq\beta_2<1$ such that for $\beta\leq\beta_1$, the goal is at most binding in state profile (L,H); for $\beta\geq\beta_2$, the goal is only binding in (H,H).*

Proof: We first show that for small enough β, a goal g^B that is larger than $e^{sr}(H)+e^{lr}(L)$ is worse than a 0 goal. To see that, we focus on the case when the state profile is (H,H), which happens with probability p^2. As shown by Lemma A2, when the state is H in period 2, the goal induced effort $e_2^g(H)$ is not enough to fill the gap between $g^B-e_2^g(H)$ and $e^{lr}(H)$ and self 3 in state H needs to exert more efforts than $e^{lr}(H)$. Formally, $e^{lr}(H)<g^B-e_2^g(H)$. Without loss, we assume η is large enough so that self 3 is always willing to exert efforts to make $e_3^g(H)=g^B-e_2^g(H)$. For self 2 in state H, the optimal effort given g^B satisfies

$$\beta v'(e_2(H))-c'(e_2(H),H)=\beta p[v'(e_3(H))-c'(e_3(H),H)].$$

As $e_3^g(H)=g^B-e_2^g(H)$, the equation can be rewritten as

$$\beta v'(e_2(H))-c'(e_2(H),H)=\beta p[v'(g^B-e_2^g(H))-c'(g^B-e_2^g(H),H)].$$

Then the loss from self 1's perspective is $p^2\int_{e^{lr}(H)}^{g^B-e_2^g(H)}c_e(e,H)-v'(e)\,de$.

The next question is what happens when β is between β_1 and β_2. The optimization problem when the goal is binding in (L,H) (but not (H,L) or (L,L)) can be rewritten as follows:

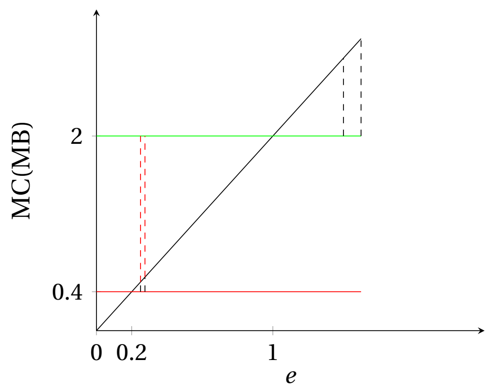
$$
\begin{aligned}
\max_{g} \quad & \int_{e^{sr}(H)}^{e_2(H)} p[c_e(e,H) - v'(e)]\, de + \int_{e^{sr}(L)}^{e_2(L)} (1-p)[c_e(e,L) - v'(e)]\, de \\
& + \int_{e^{lr}(H)}^{e_3(H,H)} p^2[c_e(e,H) - v'(e)]\, de + \int_{e^{lr}(H)}^{e_3(L,H)} p(1-p)[c_e(e,H) - v'(e)]\, de \\
\text{s.t.} \quad & \beta v'(e_2(H)) - c'(e_2(H),H) = \beta p[v'(e_3(H,H)) - c'(e_3(H,H),H)] \qquad (1) \\
& \beta v'(e_2(L)) - c'(e_2(L),L) = \beta p[v'(e_3(L,H)) - c'(e_3(L,H),H)] \qquad (2) \\
& e_2(H) + e_3(H,H) = g \qquad (3) \\
& e_2(L) + e_3(L,H) = g \qquad (4)
\end{aligned}
$$

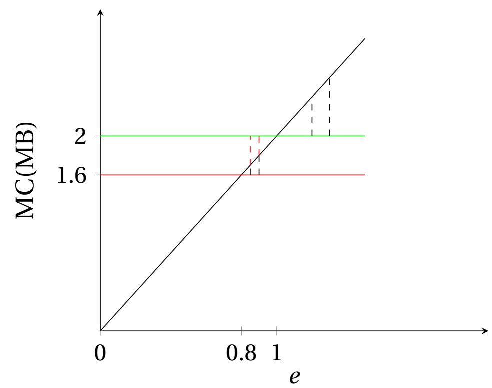
Illustrative Example

Despite the incentives to procrastinate and let the future selves to work, the short-run selves with present bias still care about the future selves. By building a link between them, broad goal-setting can motivate the earlier selves by the (potential) loss of the last self or self 3. This loss is the minimum of two forms of loss: the loss from exerting more than efficient effort and the loss in reference-dependence utility. When deciding how much effort to provide, self 2 and self 3 trade off the expected loss of self 3 and the loss of exerting more effort. Higher expected loss of self 3 is able to motivate more efforts from self 2 and self 3. However, the loss imposed on self 3 also affects the long-run self as she also cares about him. Therefore, for the long-run self it is a trade-off between extra effort provision from the earlier selves and the loss of self 3.

When β increases, there are two forces to the optimal broad goal. On the one hand, a higher β means that self 2 and self 3 care more about self 3 and it is easier for the long-run self to induce them to work. On the other hand, the benefits of extra effort of self 2 and self 3 diminish as e^{sr} increases with β and marginal benefit minus marginal cost is smaller for a larger e. These two conflicting forces can be seen in the following figure.

Optimal Broad Goal When $\beta = 0.2$ **Optimal Broad Goal When** $\beta = 0.8$





C. Narrow Goal vs Broad Goal

In the two earlier sections, we characterized the properties of the optimal narrow goals and optimal broad goals. In this section, we compare the two schemes from the perspective of the long-run self, self 1. Even though there seems to be a trade-off between flexibility and commitment, the results are surprising: narrow goal-setting is always better regardless of the value of β.

Proposition 2. *For any* $\beta \in [0,1)$*, narrow goal-setting is always better than broad goal-setting in terms of the long-run self's utility.*

We provide the proof of this proposition when there are only two periods: present-biased self 2 and unbiased self 3.

Proof: The general idea of the proof is to show that for any optimal broad goal there is always a series of optimal narrow goals that can achieve the same level of effort motivation with a lower cost. If the optimal broad goal is not binding in any state profiles, the narrow goals are definitely better as they can be only binding in state H, which motivates effort with no cost. In the later analysis, we look at four different cases: the optimal broad goal is only binding in (H,H), the optimal broad goal is binding in (L,H), the optimal broad goal is binding in (H,L) and the optimal broad goal is binding in (L,L). As the effort without goal-setting is ranked as $e^{sr}_{2,H} + e_{3,H} < e^{sr}_{2,L} + e_{3,H} < e^{sr}_{2,H} + e_{3,L} < e^{sr}_{2,L} + e_{3,L}$, a goal is binding in a higher effort state also indicates that it is binding in all lower effort states.

The optimal broad goal is only binding in (H, H)

When the optimal broad goal g^{B*} is only binding in (H, H), a narrow goal $g_2^N = g^{B*} - e_{3,H}$ is strictly better than it from self 1's perspective. To see this, we can look separately at self 2 and self 3 as self 1 cares about both. For self 3, narrow goal is better as the optimal narrow goal is not binding in period 3 and the effort provision is optimal as there is no present bias. However, under broad goal-setting, self 3 needs to exert more efforts than e_H^{lr} in state $s_3 = H$ as otherwise self 2 would not exert more effort than e_H^{sr} in state $s_2 = H$.

For self 2, the narrow goal $g^{B*} - e_{3,H}$ can achieve the same effort level as g^{B*}. Under broad goal, the effort level of self 2 satisfy the following equation

$$c_e(e_{2,H}^{g^B}, H) - \beta v'(e_{2,H}^{g^B}) = \beta p(c_e(e_{3,H}^{g^B}, H) - v'(e_{3,H}^{g^B}))$$

To ensure $e_{2,H}^{g^B}$ with a narrow goal, the marginal cost induced by it, which is η, needs to be equal or larger than $\beta p(c_e(e_{3,H}^{g^B}, H) - v'(e_{3,H}^{g^B}))$. This is indeed the case as $(c_e(e_{3,H}^{g^B}, H) - v'(e_{3,H}^{g^B})) \leq \eta$ as otherwise self 3 would find it optimal to just ignore the goal and bear the cost in reference-dependence utility. In that case, a lower g^B could improve efficiency and g^{B*} was not optimal anymore.

In addition, in state L both self 2 and self 3's effort choices are unaffected by either the broad goal or the narrow goal. Therefore, we conclude that when the optimal goal is only binding in (H, H), narrow goals are better.

The optimal broad goal is binding in states (H, H) **and** (L, H)

In this case, a narrow goal $g_2^N = e_{2,L}^{g^B}$ for self 2 and a non-binding goal for self 3 is better than g^{B*}. It is straightforward to see that in state (L, H), this leads to an improvement as self 2 is equally motivated without forcing self 3 to work too much. In state (H, H), the narrow goals are still better. The broad goal g^{B*} is at least as large as $e_{2,L}^{g^B} + e_H^{lr}$ because otherwise it would not be binding in (L, H). Therefore, under broad goal-setting, the two selfs need to finish $g^{B*} > e_{2,L}^{g^B} + e_H^{lr}$, while under narrow goal-setting, only completing $e_{2,L}^{g^B} + e_H^{lr}$ is enough by construction. Besides, under the narrow one, self 2 takes all the extra work and self 3 remains optimal. Consequently, the narrows goals are better for self

1 in both states.

The optimal broad goal is binding in states (H,H), (L,H) and (H,L)

The constructed narrow goals in this situation is similar to the former case: $g_2^N = e_{2,L}^{g^B}$ and g_3^N is non-binding. As g_2^N mimics the motivation effect of g^{B*} in state L in period 2, the narrow goals are better in (L,H) and (H,H) as shown above. In (H,L) which goal-setting schemes is better is uncertain. If $e_{2,L}^{g^B} < e_H^{g^N}$, then g_2^N motivates self 2 better than the broad goal g^{B*}. As g_2^N also performs better in period 3, the proof is finished. Now we just need to discuss whether $e_{2,L}^{g^B}$ is smaller than $e_H^{g^N}$ or not. From **??** we know that the optimal narrow goal g^{N*} is either only binding in state H or is binding in both states. If $g^{N*} \leq e_H^{lr}$, then $e_{2,L}^{g^B}$ could be larger than $e_H^{g^N}$. However, in this case, we can modify our narrow goal and let $g_2^N = g^{N*}$, then the narrow goals are still better. If $g^{N*} > e_H^{lr}$, then it means letting self 2 over-work is sufficient and we know that $e_{2,L}^{g^B} < e_H^{g^N} = g^{N*}$. We can then conclude that in (H,L) the narrow goal is better.

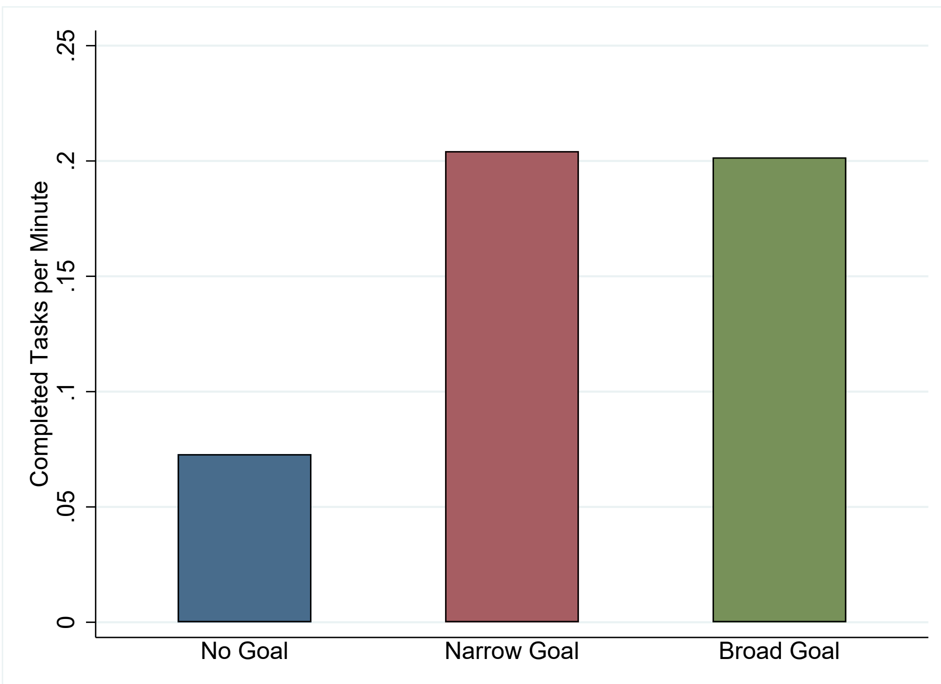
The optimal broad goal is binding in all states

I adopt the same construction used in the previous two cases. A narrow goal $g_2^N = e_{2,L}^{g^B}$ for self 2 and a non-binding goal for self 3 is better than g^{B*}. To see this, we can look at state L and state H one by one. In state L in the first period, g_2^N is as effective as g^{B*} as it simply replicates the effort induced by g^{B*}. As shown earlier in the first case, for a given effort level, if it can be enforced by a broad goal, then it can also be enforced by a narrow goal. In state L in the second period, narrow goal is surely better as broad goal causes loss in self 3 but narrow goal does not.

In state H, the advantage of the narrow goal in the second period is identical. However, for self 2, the narrow goal is potentially inferior to g^{B*}. If $e_{2,L}^{g^B}$ is smaller than e_H^{lr}, then the narrow goal is better as g^{B*} is not able to induce $e_{2,L}^{g^B}$ in state H. If instead $e_{2,H}^{g^B} > e_{2,L}^{g^B}$, then we can let the narrow goal be $e_{2,H}^{g^B}$ and all previous proofs also apply here. If $e_{2,L}^{g^B}$ is larger than e_H^{lr}, then g_2^N is too high for self 2 in state H, which causes a loss for both self 2 and self 1. Nevertheless, even in this case, it is still better to set a narrow goal. The reason is that compared to g^{B*}, the loss caused by the narrow goal for self 2 is smaller than the gain in the second period. Recall that g^{B*} is binding in (L, L), which means $g^{B*} - e_{2,L}^{g^B} \geq e_{3,L}$. Therefore, for self 3 in state H, the cost induced by g^{B*} is at least $[v(e_H^{lr}) - c(e_H^{lr}, H)] - [v(e_L^{lr}) - c(e_L^{lr}, H)]$. The cost caused by $g_2^N = e_{2,L}^{g^B}$ in period 2 is smaller as $e_{2,L}^{g^B} < e_L^{lr}$ and the initial effort choice by self 2 is not optimal. As state H is equally likely in both periods and self 1 value the two periods the same, the narrow goals are also better for state H.

D. Appendix Tables and Figures

Figure A1: Changes in Output on Day 3 in Different Treatments

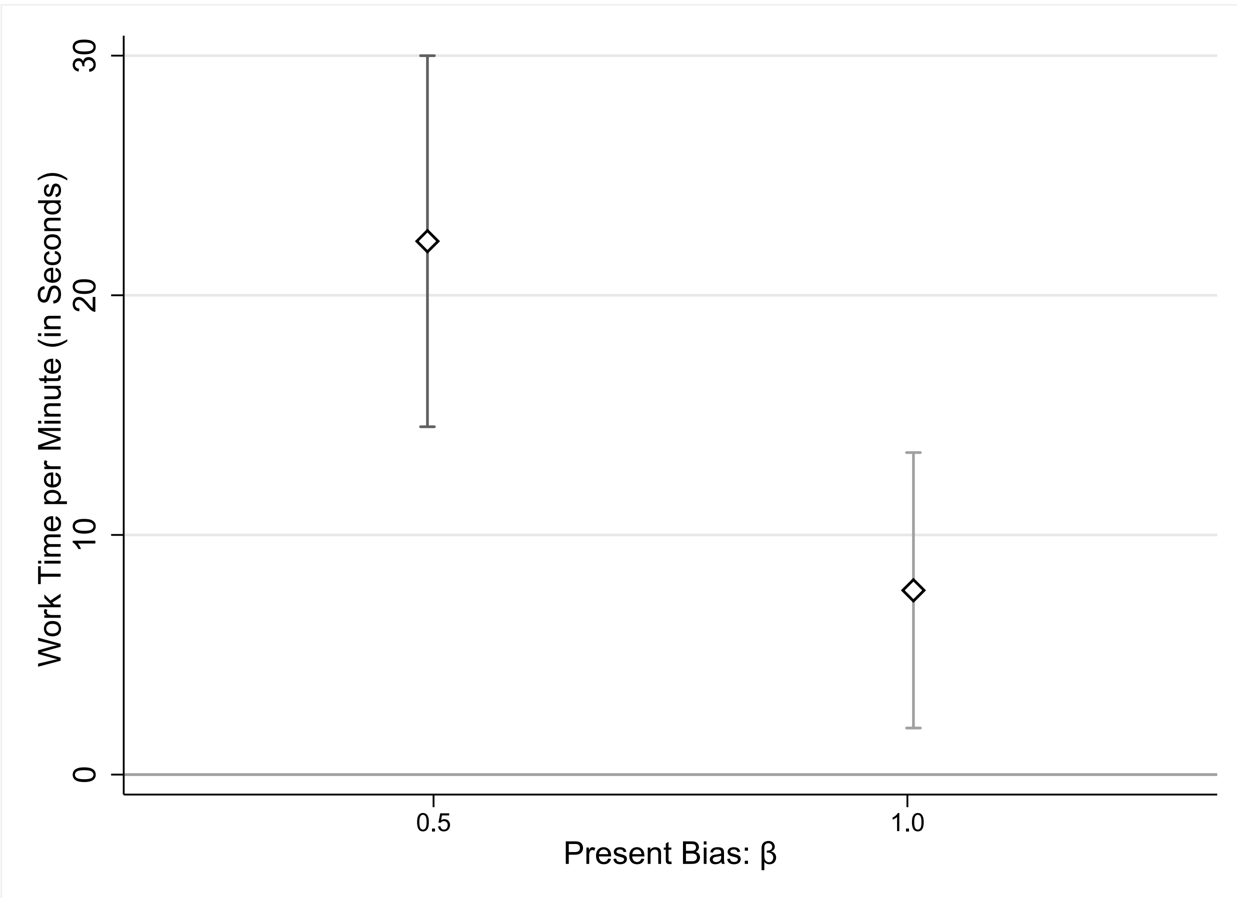


This figure plots the difference in mean tasks finished per minute on Day 3 with respect to hour 2 of Day 1.

Figure A2: Work Time around Goals

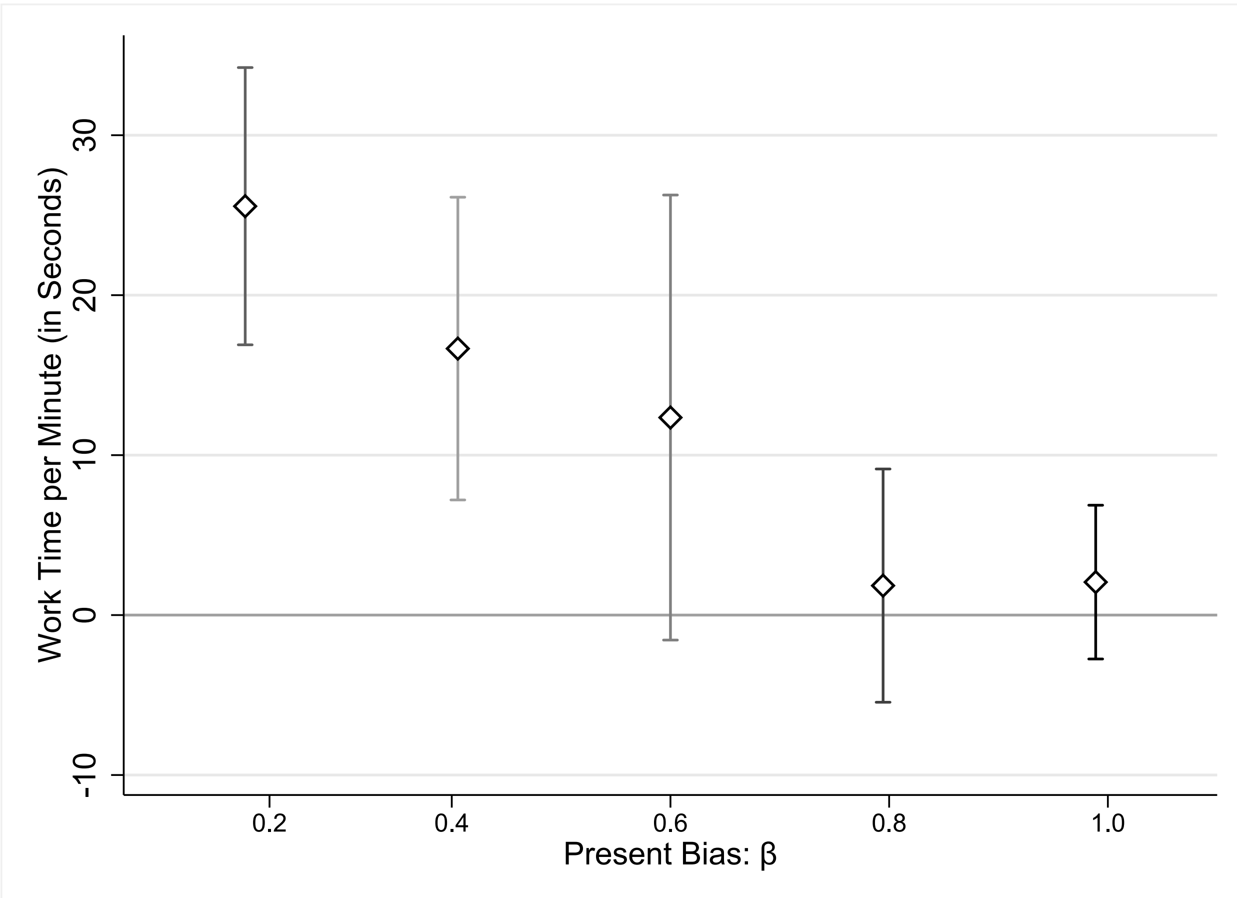
This figure plots the average work time in a minute in the 20 minutes interval around the goal. A negative goal gap means the goal has not been reached and a positive one means the goal has been reached. 0 is the minute in which the goal is reached.

Figure A3: Heterogeneous Effect of Narrow Goal-setting: Work Time



This figure plots point estimates and 95% confidence intervals for the heterogeneous effect of narrow goal-setting on counteracting present bias. The dependent variable is work time. All regressions control for minute fixed effects, session difficulty level, weekday dummies, immediate payment dummy and their interaction terms with narrow goal. Standard errors are clustered at the individual level.

Figure A4: Gap between Narrow and Broad Goal-Setting for Different β- Work Time



This figure plots point estimates and 95% confidence intervals for the effect of narrow goal-setting on addressing the self-control problem compared to that of broad goal-setting. The fives bars, from left to right, represent the results for the subject whose β is in the range of 0-0.2, 0.2-0.4, 0.4-0.6, 0.6-0.8 and 0.8-1 respectively. The dependent variable is work time. All regressions control for minute fixed effects, session difficulty level, weekday dummies and their interaction terms with narrow goal. Standard errors are clustered at the individual level.