Rational Procrastination on Self-signaling

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Abstract

Bénabou and Tirole (2004) explain that people in the face of self-control problems could commit to rational choices with concern for self-reputation. The key of the mechanism is uncertainty of one's willpower and induced signaling effect of willpower-related actions. We suggest that this mechanism with self-reputation potentially explains a wide range of the decision making under biases. One of the example is procrastination. In a certain situation, procrastination works as a signal of low self-control power and induces precaution of doing the job early in the next time. Conversely, this strategic pretending to be low willpower might be used as an excuse of procrastination and then concern for self-reputation may induce ambivalent effects on one's welfare, contrasted with the result in Bénabou and Tirole (2004). We suggest that patience determines the effect on one's welfare and welfare may worsen for strategic but impatient people.

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1 Introduction

Bénabou and Tirole (2004) (referred to as BT model) shows that a kind of commitment strategy, called psychological commitment or soft commitment that restricts one's behavior but is governed internally as a personal rule can be explained through a mechanism called *self-signaling*. The concept of the self-signaling is developed from the discussions by Ainslie that how people with hyperbolic discounting may behave with conflict within an impulsive self and a rational self. The impulsive self tends to choose immediate gratification, while rational self prefer desirable choice in the long run. Think about diet. Then the former choices are such as eating snacks and watching TV in the house. The later choices are having healthy meals and going for walks. The point is that hyperbolic discounting people are subject to such immediate gratification but may make a long-term oriented decision when they consider self-reputation judged by future self. Agents who want to be thought patient by future self can choose a desirable action against immediate gratification, therefore can keep good habit for a long period.

We show another aspect of the self-signaling strategy, taken in a cost-salient situation. We assume in our model that an expectation of low willpower induces risk-avoiding behavior, which is desirable in terms of *ex ante* judgement. Such the situation is not a special case and simple when-to-do problem with an increasing cost is our assumption. For example, it is tidying up of one's room while one is busy or studying for the exam, where we can expect some cost of procrastination. Here, desirable case is doing the job as soon as possible and the worst case is giving up finishing it. If future self may yield to the temptation and tend to procrastinate, then leaving the job until the next time is a costly choice since it may result in additional postponement or giving up. Then a negative expectation of low self-control is the key to reduce the initial procrastination, therefore intentional procrastination, or designed failure can work as a strategic behavior in this situation.

In this paper, we show that there is an equilibrium in which such a behavior of an intentional lapse is taken. A notable difference of our model from BT model is that this low-pretending equilibrium may worsen one's welfare with an intentional lapse, especially for impatient people. Such a strategy may imitate procrastination with excusing, or behavior such as "don't do it now but do it later". Here self-signaling effect works not only as a commitment but as an excuse for bad behavior.

The early notice for the problem of time-inconsistency and induced commitment problems are remarked by Strotz (1956), discussing the specificity of the exponential discounting model. In the field of psychology, Ainslie developed a form of hyperbolic discounting function from animal experiments and Ainslie (2001) discuss its impact on human behavior. The idea of interpersonal negotiation and also effectiveness of personal rule is conceived here. Fudenberg and Levine (2006) is one of the approaches that attempt to deal with time inconsistency along with a systematic decision problem. They adopt a dual-self model of long-run selves and short-run selves in an extensive form game. Like our model, their model considers the game within selves, however, they assume short-run selves have no strategic concern over periods while in our model, all selves are strategic, and in their model there are no uncertainty in agents' behavioral disposition while we assume contingent willpower. These differences come mainly from the purpose of the model; they aim to present a simple and general model of time-inconsistent agents while we attempt to clarify strategic behavior peculiar to time-inconsistent agents. O'Donoghue and Rabin (1999) explain how present-biassed agents procrastinate in when-to-do model. We have shown another aspect of procrastination from the self-signaling model such that agents procrastinate because it paradoxically induces early completion. Concerned with self-signaling effect, Bodner and Prelec (2003) give a more psychologically motivated model of the internalized utility of self-image.

Our model also sheds light on the problem of self-image since it is suggested that positive self-image is not always appropriate, especially considered cost-avoiding situations.

2 The Model

To contrast our result with the BT model, the baseline assumptions remain the same as that assumed in BT model. The difference is that agents take willpower-contingent task of *costs*, not benefits.

The entire game consists of two periods ($i = 1, 2$). First, we formulate the following *period game*. At each period, agents will decide when to consume goods which yield negative utility (for example, tidying up a room, studying hard for an examination, or exercising self-control not to shop excessively). One period consists of two parts: morning and afternoon. In the morning, agents may choose (1) no-willpower (NW) option for which agents incur an immediate cost a and end the period. In this choice, the outcome of the decision is determined in the morning and does not depend on future self. Here agents finish their job of tidying up well in advance. Alternatively agents may choose (2) willpower-dependent (W) option for which the agent passes the right of the decision to their later self and cost is consumed later. Here agents procrastinate their job of tidying up, and the time until the finish depends on their future diligence. If NW is chosen in the morning, period game ends just in the morning, and if W option is chosen, the game goes on to the afternoon. In the afternoon, agents may (1) practice their job (P) in which agents incur an immediate cost $c(> a)$ and end the afternoon, or (2) give up their job (G) in which agent incur a large cost $D(> c)$ later on. The increasing cost $(D > c > a)$ means procrastination of tidying up yields additional costs, for example, another work comes up and arrangement cost may be needed.

Another important assumption is that, in discounting cost, agents exert a salience of the present, or *present bias*.

- In the morning where agents choose NW or W, the immediate cost of NW (cost a) is increased to $\frac{a}{\gamma}$ where $\gamma < 1$.
- In the afternoon where agents choose P or G, the immediate cost of P (cost c) is increased to $\frac{c}{\beta}$ where $\beta \leq 1$.

Assumption 1. $\beta = \beta_L$ or $\beta = \beta_H$ where $\beta_H > \beta_L$, and the value β is fixed over periods. Agents do not know β initially and have belief of ρ_i on β_H and $1 - \rho_i$ on β_L at each beginning of the period ($i = 1, 2$).

About β, we also assume that behavior of agents virtually informs later herself, or *self-signalling* situation. It is assumed that willpower β is imperfectly recalled.

Assumption 2. Agents experience β at afternoon of the period, but cannot recall this value directly after that period.

Then, agents have to infer their true β through what they chose (P or G) in the past period.

On biases and payoffs, we restrict the values of them for our interests.

Assumption 3. $c < \frac{a}{\gamma} < D$

As noted above, agents choose W if and only if the probability of $\beta = \beta_H$ is satisfyingly high. This assumption guarantees that the threshold of the probability of $\beta = \beta_H$ is between 0 and 1. We note this threshold probability by ρ_2^*.

Definition. Define ρ_2^* with $\rho_2^*(-c) + (1-\rho_2^*)(-D) = \frac{-a}{\gamma}$. Since assumption 3, $0 < \rho_2^* < 1$ holds.

Assumption 4. $\frac{c}{\beta_H} < D < \frac{c}{\beta_L}$

This assumption means that for a high β case of satisfying self-control, an immediate cost c is acceptable compared to D a large cost, and in a poor self-control case (β_L), early practice (P) of immediate cost c is costly. Note that, this naive interpretation disregards reputational concerns over periods.

Having formulated the period game, we will now define the whole game. There are two periods $i = 1, 2$ in which the above period game is taken. For example, tidying up today and tomorrow, studying for a midterm exam and for a final exam, and shopping this month and next month. Payoffs over periods are discounted by δ as a usual assumption. In period 2 morning, agents have observed their past decision in period 1 and make current decision considered that. Thinking β (which is fixed over time) as a player's type, this is a Bayesian game. We take the belief ρ_1 in period 1 morning as a given value as the prior, and ρ_2 in period 2 morning as the posterior after observing P or G, which is calculated from ρ_1. For example, posterior observing P is as follows; if good self-control agents (β_H type) take a mixed strategy with $1-q$ on P and q on G, and another type of poor self-control (β_L type) always choose G, then $\rho_2 = \frac{q\rho_1}{q\rho_1 + (1-\rho_1)}$.

Finally we set two conditions on our equilibria. The first condition concerns natural equilibria. At the beginning of period 2, agents form some posterior (let ρ_2). Let the posterior after observing P in period 1 be ρ_2^+, and after observing G be ρ_2^-. We assume that in equilibria it holds that $\rho_2^- \leq \rho_1 \leq \rho_2^+$ (*monotonicity of belief*). Second condition is from the interest of analysis. We are interested in how period 1 agents' intention of signalling their willpower effects their whole behavior. In our model, $\beta = \beta_H$ agent may have an incentive to choose G of intentional lapse. And the necessary condition for patient type to choose G is $\frac{-c}{\beta_H} + \delta(-c) < (-D) + \delta(-a)$. Otherwise, the agents do not be concerned with future effects of their choice but this is not of interest to us. We call this condition *Maximal reputational change pays self-control*, or MRS[*1].

2.1 Results from the model

In this section, we discuss a basic result from the model.

Notation. We note the probability of choosing NW in period 2 if $\rho_2 = \rho_2^*$ by p_2, and note the frequency of β_H type in period 1 choosing G by q_1.

After all, the picture of the equilibrium behavior can be described by (q_1, p_2) except the initial choice in period 1 morning of no-willpower option or willpower option. Knowing this, we can move on to the results of the model. In the following discussion, terminology from signalling game is used, and q_1 is taken for the frequency of signaling. This is because if we restrict the game in only one period, then $q_1 = 0$. And note that every equilibrium we discuss is perfect Bayesian Nash equilibrium (PBE) of a Bayesian game.

Following Proposition 1 is on the configuration of equilibria.

Definition. Define q_1^* as q_1 which makes it indifferent the choice between NW and W for agents having observed G in period 2 morning, *i.e.* $\rho_2^- = \rho_2^*$. Additionally, define p_2^* as p_2 which makes it indifferent the choice between P and G for β_H type agent in period 1 afternoon, *i.e.* $\frac{1}{\beta_H}(-c) + \delta(-c) = -D + \delta(p_2^*(-a) + (1-p_2^*)(-c))$.

[*1] In this terminology, we use the term self-control in a broad sense of every inter-temporal strategic behavior. In narrow sense, I think, self-control refers to resisting some temptation such as avoiding snacks on a diet.

Proposition 1. Assume *monotonicity of belief* and MRS. There is a unique equilibrium path except when $\rho_1 = \rho_2^*$ and $\rho_1 = \tilde{\rho_1}$. $\tilde{\rho_1}$ is the lower bound of ρ_1 to take W option in period 1. If $\tilde{\rho_1} > \rho_2^*$ it works as the threshold of NW and W in period 1. But if $\tilde{\rho_1} \leq \rho_2^*$ then ρ_2^* is the alternate threshold. Equilibrium is then as follows: if $\rho_1 < \rho_2^*$, the path is NW-NW, if $\rho_2^* < \rho_1 < \tilde{\rho_1}$, NW-W and if $\rho_1 > \max\{\tilde{\rho_1}, \rho_2^*\}$, the path is W-$(q_1^*, p_2^*)$. There are at most two exceptional points in the prior at which there exist multi equilibrium paths. If $\rho_1 = \tilde{\rho_1} > \rho_2^*$, eq. path is any convex combination of W-(q_1^*, p_2^*) and NW-W. If $\rho_1 = \rho_2^*$, eq. path may be W-$(q_1 = 1, p_2 \geq p_2^*)$ or any convex combination of NW-NW and NW-W, and it may be the case that, any convex combination of W-$(q_1 = 1, p_2 \geq p_2^*)$, NW-NW and NW-W are equilibrium paths, depending on assumed parameters. When $\tilde{\rho_1} \leq \rho_2^*$, the only exceptional point is $\rho_1 = \rho_2^*$.

When $\rho_1 < \rho_2^*$, it is pooling equilibrium. However, then agents prefer the no-willpower option (or tidying up early) since probable procrastination, and then pretending behavior is off the path. For agents confident of her future willpower ($\rho_1 > \rho_2$), signaling of pretending low type would occur in equilibrium. As confidence ρ_1 increases, pretending frequency q_1 decreases because agents should set sufficiently low frequency of high type within selves taking G, in order to keep signals a valid sign of being low type.

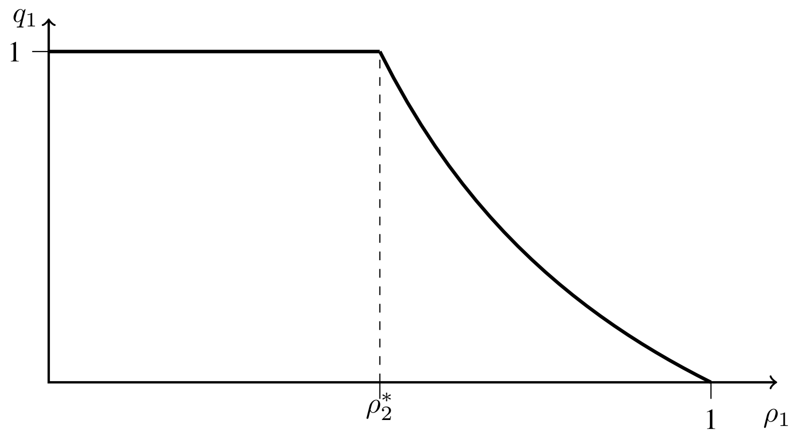

図 1: Frequency of patient (β_H) type to give up

To understand the signaling equilibrium, we consider the example of a university student taking a course. The course consists of two semesters in the Spring and Fall (which respectively correspond to period 1 and period 2) and in each semester, students are evaluated through an examination. The student wants to receive the credit for that course but regards work for exam as *costs*. A week before exam (period 1 morning), the student decide whether prepare (cost $a = 15$) for the exam or not. At this time, present bias $\gamma = 15/24 = 5/8$ works and the cost of preparation for the exam is increased to 24. If she procrastinates, they must study one day before the exam (let this be afternoon). An alternative P is studying all night. This is not good compared with preparation a week before, but not such a bad choice for credits, and the total cost is $c = 20$. The other choice is that she tries to study all night but gives up halfway. In this case, the possibility to get the credit is low and the total cost is $D = 25$. At this time, the present bias β works. Assume that the student's type of effort is intensive ($\beta_H = 20/24 = 5/6$) at 1/2 and not intensive ($\beta_L = .4$) at 1/2. For simplicity assume $\delta = 1$. Then we can calculate that $\rho_2^* = \frac{1}{5}$, $q_1 = 1/4$ $p_2^* = \frac{1}{5}$. Since $\rho_1 > \rho_2^*$, it is semi-separating equilibrium.

In the Spring semester, the student always procrastinate one day before exam. Then with $1/4 \times 1/2 + 1/2 = 5/8$ probability she gives up studying all night. In the Fall semester, she recalls that she has once yielded to temptation and prepares for exam with a probability of $1/5$. If she does not experience her lapse, then she procrastinates in the Fall semester again.

3 Simple welfare analysis and some interpretations

Naive welfare interpretation of the model is derived by comparing the result of whole game with that of *duplicated* period games. We define duplicated period games as follows: agents have a prior ρ_1 which is an expectation of the probability $\beta = \beta_H$ in commonly $i = 1$ and $i = 2$. But agents do not notice β is constant over the periods and play the whole game as if β in $i = 1, 2$ are independently distributed. If $\rho_1 \neq \rho_2^*$, then agents have no indifference situation both in period 2 morning and afternoon. Then agents in period 1 play the game without consideration of period 2 outcome and agents play whole game as if they play two independent games. Let us call agents in our model *strategic* and agents in duplicated period game *non-strategic*. And we define agents' welfare as their utility without bias β, γ in line with Rabin's discussion about present bias (O'Donoghue and Rabin (2006)).

Then we can analyze the difference of the welfare. If $\rho_1 < \rho_2^*$, both of strategic and non-strategic agents play the same equilibrium path of NW-NW and there are no difference in above defined welfare.

If $\rho_2^* < \rho_1 < \tilde{\rho_1}$, then the strategic player dominates since only strategic agents choose NW in period 1 and both of strategic and non-strategic agents choose W in period 2. Thus consider the case in which $\rho_1 > \tilde{\rho_1}$. Then non-strategic agents play W-W path but strategic agents play W-NW path with a positive probability.

The difference of welfare (strategic compared to non-strategic) if $\rho_1 > \tilde{\rho_1}$ and $\delta = 1$ is: $\rho_1 q_1^*(-D + c) + \delta[\rho_1 q_1^*\{p_2(-a+c)\} + (1-\rho_1)\{p_2(-a+D)\}] = (D-c)(D-a) \times (1-\rho_2^*) + \{(D-\frac{a}{\gamma}) - (D-a)\} \times (\frac{1}{\beta_H} - 1)c$

Thus, the adoption of a signaling strategy is on average beneficial for strategic agents if $\beta_H \approx 1$. We interpret this as agents' second-best strategy. The most desirable path for agents *ex ante* is clearly NW-NW of no procrastination. But if she has high confidence, she has incentive to procrastinate. Then she adopt secondly best strategy of switching efforts; at first period, fully procrastinate but at second period, do her job early.

As a quantitative model, there exists a threshold $\widetilde{\beta_H}$ above which low-pretending strategy is beneficial. And it is shown that this threshold $\widetilde{\beta_H}$ is the value irrelevant to the initial confidence ρ_1, therefore there exists a belief-independent value of required patience in a given game. In general, the following proposition holds.

Proposition 2. There exists welfare improving condition of $\widetilde{\beta_H}$ where if $\beta_H \geq \widetilde{\beta_H}$, welfare does not worsen in any initial belief ρ_1, and if $\beta_H < \widetilde{\beta_H}$, welfare may worsen, depending on ρ_1.

Note that discussion here is naive because we are comparing outcomes from different settings in the same way.

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