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Sophisticated and naïve procrastination: an experimental study*

Claudia Cerrone† Leonhard K. Lades‡

Abstract

The model of time-inconsistent procrastination by O'Donoughe and Rabin shows that individuals who are not aware of their present-bias (naïve) procrastinate more than individuals who are aware of it (sophisticated) or are not present-biased (time-consistent). This paper tests this prediction. We classify participants into types using a novel measure, and require them to perform a real-effort task on one out of three dates. We find that sophisticated participants perform the task significantly *later* than naïve participants. Our data suggest that this result may be explained by habit formation.

JEL classification: C70, C91, D03, D91.

Keywords: procrastination; present-bias; habit formation.

1. Introduction

Procrastination is pervasive in the workplace, in the household, in health care and finance management. People procrastinate writing reports, searching for a new job, returning defective items, starting a diet, exercising, scheduling medical check ups, saving for retirement, and several other onerous activities. According to O'Donoghue & Rabin (1999) (henceforth ODR), procrastinating an activity that is immediately onerous, but yields rewards in the future, is the result of a time-inconsistent taste for immediate gratification known as "present-bias". While time-consistent individuals complete onerous activities when it is optimal from an ex-ante perspective, present-biased individuals overvalue the immediate costs and hence may procrastinate. ORD call individuals who are fully aware of their tendency to overvalue the present "sophisticated", and individuals who are unaware of this tendency "naïve" (or, following ODR, "sophisticates" and "naifs"). ODR's model predicts that naïve individuals will perform onerous activities weakly later than sophisticated and time-consistent individuals. To our knowledge, this prediction has never been experimentally tested.

Testing whether naïve individuals procrastinate more than sophisticated and time-consistent individuals requires measuring naïvete, sophistication, and time-consistency (the independent

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variable) separately from individuals' observed procrastination behavior (the dependent variable). To the best of our knowledge, the literature has not yet agreed upon a measure of self-awareness about present bias that has the latter feature and maps onto the model of time-inconsistent procrastination, i.e. procrastination generated by present-bias. Acland & Levy (2015) elicit participants' predictions about future gym attendance by measuring their willingness to pay for a coupon that pays contingent on attending the gym.[1] Augenblick & Rabin (2016) incentivize participants' predictions of future work decisions given five randomly chosen wages. We did not use these measures as they involve the participants' behavior in the task used to observe their procrastination behavior. Ameriks et al. (2007) propose a survey instrument to measure perceived temptation and self-control. They offer people 10 restaurant vouchers to be used within two years and ask participants about their *ideal* allocation of vouchers, their allocation *if they gave in to temptation*, and their *expected* allocation. They then measure self-control as the difference between expected and ideal consumption, and temptation as the difference between tempted and ideal consumption. We did not use this measures as it maps onto the self-control model by Gul & Pesendorfer (2001), rather than onto a model of time-inconsistent discounting. Building on Ameriks at al., John (2016) proposes a measure of sophistication based on the interaction between time inconsistency (as measured by Multiple Price Lists) and predictions about ideal versus tempted behavior (as measured by Ameriks et al.). This measure is the closest measure to ours. Finally, discriminating naiveté from sophistication by observing people's demand for commitment has recently been shown to be problematic.[2]

This paper proposes a simple and novel way to classify people as naïve, sophisticated, or time-consistent – without using their completion behavior in the task used to measure their procrastination. Our measure combines an incentivized delay discounting task that classifies participants as present-biased or time-consistent with a one-item survey measure that elicits whether present-biased participants are aware of their time-inconsistency. The delay discounting task is the Convex Time Budget (CTB) method by Andreoni et al. (2013), which requires participants to allocate monetary payments between two points in time. The overall payoff increases if more money is allocated to the later point in time. The one-item survey measure asks participants whether they perceive themselves as people who delay activities that should be done sooner. We then ask participants to complete a real-effort task – stuffing letters into envelopes – on one out of three possible dates. The later they do the task, the more letters they have to stuff into envelopes. We test whether our measure of naïvete, sophistication, and time-consistency predicts participants' completion behavior in the real effort task. To our knowledge,

[1] As the authors observe, incentivizing beliefs may also incentivize changes in the behavior which is being predicted, thereby producing a biased prediction of future behavior.

[2] Firstly, a growing literature shows that only a minority of experimental subjects demand commitment. Secondly, Laibson (2015) shows that commitment is not a robust implication of present-bias – present-biased people will often choose not to commit as the perceived benefit from committing does not exceed the perceived cost from reduced flexibility. Finally, the demand for a commitment cannot separate sophistication from a possible taste for commitment, nor from the possibility that people demand commitment by mistake.

ours is the first test of ODR's procrastination model.

We find that naïve participants complete the task significantly *earlier* than sophisticated participants. This is surprising, as ODR's model predicts the opposite. Our data suggest that this result may be explained by a procrastination habit. In particular, participants who are aware of their tendency to procrastinate report having procrastinated in the past significantly more than participants who are not aware of it. This suggests that sophisticated individuals may procrastinate the real-effort task more than naïve ones because they have developed a stronger procrastination habit. In fact, a procrastination habit would have two effects: it would increase the individuals' awareness of their tendency to procrastinate and make them more likely to procrastinate again – so that sophisticates would procrastinate more than naifs.

The remainder of the paper is structured as follows. Section 2 reviews and expands ODR's theoretical model. Section 3 describes the study's design. Section 4 describes the data and the methodology, and presents the results. Section 5 presents some robustness checks. Section 6 discusses habit formation as a potential explanation for our results. Section 7 concludes.

2. The model

In this section, we introduce the model of time-inconsistent procrastination by ODR. Suppose that a person must perform an onerous task by a final period $T < \infty$. The reward schedule and cost schedule are respectively denoted by $\mathbf{v} \equiv (v_1, v_2, ..., v_T)$ and $\mathbf{c} \equiv (c_1, c_2, ..., c_T)$, where $v_t \geq 0$ and $c_t \geq 0$ for $t \in \{1, 2, ..., T\}$. In each period $t < T$, the person decides either to perform the task or to wait. If she does it, she incurs an immediate cost, c_t, and makes no further decision. The reward will be obtained in the future. If she waits, she will face the same decision in the following period. If she waits until the final period, she must perform the task then.[3] Below, we will relax the latter assumption to make the model more suited for experimental implementation. Letting $\beta \in [0, 1]$ denote the present bias factor and τ the period in which the agent performs the task, the agent's intertemporal utility in period $t \leq \tau$ is[4]

$$U^t(\tau) \equiv \begin{cases} \beta v_\tau - c_\tau, & \text{if } \tau = t; \\ \beta v_\tau - \beta c_\tau, & \text{if } \tau > t. \end{cases} \tag{1}$$

A person with $\beta = 1$ is defined as "time-consistent", whereas a person with $\beta < 1$ is present-biased and can be classified as either "sophisticated" or "naïve", depending on whether she is able to predict her future time preferences (and thus behavior). A sophisticated individual, like a time-consistent one, has correct perceptions about her future time preferences: she can predict when her future selves would perform the task, if she does not perform it today. In contrast, a

[3] Cerrone (2016) extends this individual model of procrastination to a strategic setting where the task feels less onerous if performed when someone else does.

[4] Without loss of generality, it is assumed that the exponential discount factor, δ, equals 1.

naïve individual has incorrect perceptions: she mistakenly believes that if she does not perform the task today, she will behave like a time-consistent individual in the future.

A person's strategy is denoted by $\mathbf{s} \equiv (s_1, s_2, ..., s_T)$, where $s_t \in \{Y, N\}$ specifies for period $t < T$ whether or not to perform the task in t, given that it has not been performed yet (Y stands for yes and N stands for no). The strategy $\mathbf{s}$ specifies performing it in period t if $s_t = Y$, and waiting if $s_t = N$. In addition to specifying when the individual will actually perform the task, a strategy also specifies what she "would" perform in periods after she has already performed it. As the task must be performed in the final period, if it has not been performed yet, it is required that $s_T = Y$.

ODR's solution concept, "perception-perfect strategy", requires that an individual chooses optimally given her current preferences and her perceptions of her future behavior.

Definition 1. [ODR] A perception-perfect strategy for *time-consistent* and *naïve* individuals is a strategy $\mathbf{s}^j \equiv (s_1^j, s_2^j, ..., s_T^j)$ that satisfies for all $t < T$ $s_t^j = Y$ if and only if $U^t(t) \geq U^t(\tau)$ for all $\tau > t$ and $j \in \{tc, n\}$.

Definition 2. [ODR] A perception-perfect strategy for *sophisticated* individuals is a strategy $\mathbf{s}^s \equiv (s_1^s, s_2^s, ..., s_T^s)$ that satisfies for all $t < T$ $s_t^s = Y$ if and only if $U^t(t) \geq U^t(\tau')$, where $\tau' \equiv \min_{\tau > t}\{\tau | s_\tau = 1\}$.

A perception-perfect strategy maps onto the timing of completion, i.e., for $j = \{tc, n, s\}$ $\tau_j \equiv \min_t\{t | s_t^j = Y\}$. ODR show that naïve individuals will perform an onerous task later than sophisticated and than time-consistent ones.[5]

Proposition 1. [ODR] (i) $\tau_{tc} \leq \tau_n$. (ii) $\tau_s \leq \tau_n$.

We will now relax one of the assumptions of the model – we will allow for the possibility that the task is never performed. Allowing for the latter is realistic, as most onerous tasks can be left undone. For example, smokers might never get themselves to quit smoking, overweight people might never start a diet or join the gym, and students might fail to hand in an assignment. Moreover, once this assumption is removed, the model lends itself more naturally to the implementation, as no ethical experimental study can force participants to perform a task. Their participation in the study will always ultimately be their own choice, and they can retain the right to drop out at any point. Proposition 2 states that Proposition 1 holds also when the task can be left undone.

Proposition 2. Suppose that $s_T \in \{Y, N\}$. Then Proposition 1 still holds.

[5]The comparison between time-consistent and sophisticated individuals does not allow for a general result. Due to her perfect foresight, a sophisticate might decide to do the task even earlier than she would want to, so as to avoid doing it later than she would want to. The sophistication effect can outweigh the present bias effect, so that a sophisticate may perform the task earlier than she would if she was not present-biased.

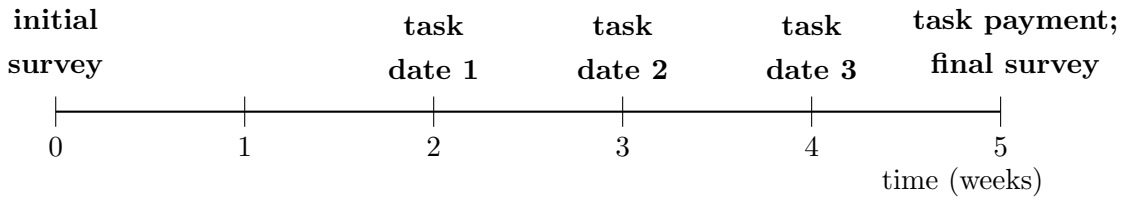
Proof: See Appendix A.

A sophisticated individual procrastinates less than a naif with the same preferences because she can correctly foresee her future tendency to procrastinate. Her perfect foresight prevents her from underestimating the cost of procrastinating now, thereby mitigating her tendency to delay. The hypothesis that we will test follows straight from Proposition 2.

Hypothesis. Suppose that a real-effort task can be performed on one out of three possible dates or never. The later the task is performed, the more effort it takes. The reward for completion is delayed and fixed. Then naïve participants will perform the task weakly later than sophisticated and time-consistent participants.

3. Design

All the sessions were run on Tuesdays in the experimental laboratory at the Economics Department of Royal Holloway University. The study was first conducted in February 2015, and then repeated in November 2015 to increase sample size. None of these months are directly affected by exams, as the main exam period at Royal Holloway is May/June. The participants were students and there were no restrictions imposed regarding their field of study or demographic characteristics. The software used was z-Tree (Fishbacher 2007). The timeline is illustrated by the following figure.



3.1. Invitation and initial survey

In the invitation, potential participants were told that they would have to be available on three consecutive Tuesdays at 6 pm in order to be eligible to participate in the study – although they would have been required to show up only on one of these three dates. This restriction and the fact that students do not have lectures or seminars after 6 pm ensured that each of the three dates was a feasible option for them. Using the same day of the week ensured that participants valued the three dates equally. We are not aware of any special events that took place on the relevant Tuesdays and that could have prevented participants from performing the task.

On the first day of the study, participants were invited to the lab to complete a brief initial survey (see Appendix B), at the end of which each of them was paid £2 cash. First, we asked them four questions – one generic and three domain-specific – about whether they thought they

would delay activities that should have been done earlier. We used the general-domain question to distinguish naïve and sophisticated individuals, as described in subsection 3.4. We then asked them four questions – again, one generic and three domain-specific – about their procrastination experiences in the past four months (see Section 6). In between these two sets of questions, we asked participants about their demographic characteristics. Both the general and the domain-specific questions allowed for a binary answer (yes/no), as ODR's model – and thus this study – only considers the extreme cases of full sophistication and full naiveté.[6] As a robustness check, Section 5 identifies naifs and sophisticates by using the domain-specific questions.

The initial survey also included instructions for the rest of the study. We informed participants that they had to complete a real-effort task on *one* out of the three consecutive Tuesdays at 6 pm, and that the task would become increasingly onerous over the three possible dates, as described in subsection 3.2. We also told them that they would receive £8 for completing the task, exactly one week after the last possible date to perform the task, independently of when they performed the task. At the end, we asked when they thought they would complete the task, with no obligation to actually adhere to the reported date.

3.2. Real-effort task

The real-effort task consisted of filling letters into envelopes (Falk & Ichino 2006). Participants performing the task on the first Tuesday were required to put 20 letters into envelopes, which took about 10 minutes. Participants doing the task on the second Tuesday were required to put 35 letters into envelopes, which took about 17-18 minutes. Participants choosing the last Tuesday were asked to put 60 letters into envelopes, which took about 30 minutes. While Falk & Ichino were interested in assessing productivity, i.e., the number of letters stuffed into envelopes, we were interested in whether and when the task was performed. Therefore, the participants were required to stuff all letters into envelopes in as much time as they needed.[7] As the letters were real invitations to referee papers for an upcoming economics conference, it is reasonable to expect that the participants thought that the stuffed letters would have been used by the Economics Department.

3.3. Final survey

On the last day of the study, participants came to the experimental lab to collect their payment for performing the task and complete a final survey, which gave them the possibility to earn additional money. The final survey aimed to measure participants' time-preferences – their

[6] An alternative option would have been to use a 5-point scale. We have decided against it because translating a 5-point measure into a binary one would have required an arbitrary decision on which values of the scale correspond to a "yes", and which to a "no".

[7] The envelope task was chosen because it does not involve the use of a computer and hence could take place in a lecture theater, thus avoiding possible space constraints in the experimental lab.

present-bias factor β and discount factor δ – using the Convex Time Budget (CTB) by Andreoni et al. (2013). This method requires subjects to allocate monetary payments to two points in time. The more money is allocated to the later point in time, the higher is the overall payment. Unlike in the Multiple Price List method, where the monetary payments must be fully allocated to either the earlier or the later point in time, the CTB method allows for interior choices in addition to corner solutions, and thus for convex budgets. It is then not necessary to assume linear utility when estimating discount rates from the observed allocations.

The survey included instructions, an example, and the actual 24 decisions from Andreoni et al. (2013), where the amounts were converted from dollars to pounds. Once the survey was complete, one third of the participants was randomly selected and received the payments associated with one randomly selected decision out of the 24 decisions they made.[8] As by completing this survey participants could earn additional money – and potentially *more* money than by completing the real-effort task – we ran this survey at the end of the study so as not to alter the participants' incentives to perform the real-effort task. This, however, reduced our sample, as not all the participants took the final survey.

3.4. The classification into types

In order to classify participants into time-consistent, sophisticated, and naïve types, we combined their present-bias factor β, as elicited by the CTB method, and their answer about their perceived procrastination. More specifically, participants were classified as "present-biased" if β was below 0.95, as "time-consistent" if β was between 0.95 and 1.05, and as "future-biased" if β was above 1.05. Present-biased participants were then further classified as "sophisticated" if they answered the general question about perceived procrastination in the affirmative, and as "naïve" otherwise. The question was phrased as "Are you a person who delays things that should be done in a timely manner?". We further discuss this measure and possible alternatives in Section 5 and in Appendix C. Future-bias is a time-inconsistent preference towards the future. While ODR's model does not account for this category, evidence shows that a substantial fraction of individuals hold future-biased preferences. Note that in a setting with increasing costs like ours, theory predicts that time-consistent and future-biased individuals will behave in the same way and that the awareness of the future-bias will not affect behavior.

4. Results

4.1. Descriptive results

The original sample consists of 162 students from Royal Holloway University. As our classification into types uses the participants' present bias factors and some participants did not com-

[8] At the end of the study, after completing the CTB survey, these participants were asked whether they preferred cash payments or bank transfers.

plete the time preferences survey, or did not provide usable time preferences data, the remaining sample consisted of 125 individuals.[9] 9 of these individuals did not complete the real-effort task, but nonetheless completed the final survey. Table 1 presents the descriptive statistics – overall and broken down by type. The mean completion of naïve individuals is lower than that of sophisticated and time-consistent individuals. The t-test shows that the difference between the completion of naïve and sophisticated individuals is significant, whereas the difference between naïve and time-consistent individuals is not. Table 1 also shows that 39.2% of the participants (i.e., 49 individuals) are present-biased, 19.2% (24 individuals) are time-consistent and 41.6% (52 individuals) are future-biased. Among the present-biased individuals, 31 are sophisticated and 18 are naïve. The distribution of participants across types is comparable to those in previous studies.[10] In the last row, called "Completion (1-4)", not performing the task is interpreted as performing it on a fictitious fourth period. Hence this row includes the 9 individuals who did not perform the real-effort task, but nevertheless completed the final survey. This interpretation does not change the mean completion date of naïve individuals, as all of them completed the task (between 7 and 10 percent of each of the other types did not).

Figure 1 shows the percentage of each type performing the task on the first date, second date, third date, or never: naifs perform the task earlier than sophisticates. The numbers in brackets in the legend indicate the number of participants for each type. The Z-test for differences in proportions shows that the fraction of naifs who performed the task on the first date versus later or never is significantly larger than the respective fraction of sophisticates ($p < 0.05$), time-consistent agents ($p < 0.1$) and future-biased agents ($p < 0.1$). Moreover, the two-sided Mann-Whitney U-test and the Kruskal Wallis test show that naifs' completion behavior is significantly different from sophisticates' completion behavior ($p = 0.02$), whereas the difference between naifs and time-consistent individuals is not significant. The difference in completion behavior between naifs and sophisticates is significant even when we exclude people who did not do the task ($p = 0.08$).

Finally, it can also be observed that, compared to sophisticates, naifs plan to do the task earlier (Mann-Whitney U-test and Kruskal Wallis test: $p = 0.03$), are less likely to have procrastinated in the past (Mann-Whitney U-test and Kruskal Wallis test: $p = 0.0004$) and have a higher present-bias factor β (Mann-Whitney U-test and Kruskal Wallis test: $p = 0.09$). This will be further discussed in Section 6.[11]

[9] 65% of the individuals who did not complete the time preferences survey did not perform the task either.

[10] Using the MPL method, Ashraf et al. (2006) and Meier & Sprenger (2010) find around 30-35 percent of subjects to be present-biased and a smaller percentage to be future-biased. Like us, John (2016) finds the fractions of future-biased and present-biased to be close to each other – although smaller than ours. Using the CTB method in a field experiment, Giné et al. (2017) find about the same amount of future-bias and present-bias.

[11] In line with theory's prediction, the completion behavior of time-consistent and future-biased individuals is not significantly different – in fact, it is almost identical.

Table 1: Summary Statistics by type

	PB Naïve		**PB Soph**		**TC**		**FB**		**All**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Female	0.78	0.43	0.58	0.50	0.71	0.46	0.73	0.45	0.70	0.46
Mother's education	2.39	0.61	2.29	0.53	2.17	0.82	2.54	0.50	2.39	0.61
Age	20.44	1.34	20.90	2.56	21.50	2.45	20.85	1.89	20.93	2.13
Father's education	2.50	0.71	2.45	0.62	2.17	0.82	2.40	0.60	2.39	0.70
Exp. date (1-3)*	1.39	0.70	1.89	0.88	1.46	0.60	1.46	0.77	1.55	0.77
Exp. date	1.39	0.70	1.90	0.87	1.46	0.59	1.46	0.78	1.56	0.78
Past Procrastination	0.56	0.51	0.97	0.18	0.71	0.46	0.67	0.47	0.74	0.44
β	0.75	0.22	0.65	0.27	1.00	0.03	1.35	0.37	1.02	0.41
δ	0.99	0.03	1.01	0.02	1.00	0.01	1.02	0.03	1.01	0.03
Completion (1-3)*	1.44	0.78	1.86	0.85	1.59	0.73	1.65	0.84	1.66	0.81
Completion (1-4)	1.44	0.78	2.07	1.03	1.79	0.98	1.83	1.02	1.82	0.99
Observations	18/18		31/28		24/22		52/48		125/116	

PB = Present-biased, Soph = Sophisticated, TC = Time-consistent, FB = Future-biased.

*s indicate that the rows are based on the sample of 116 participants who completed the real-effort task.

4.2. OLS and probit

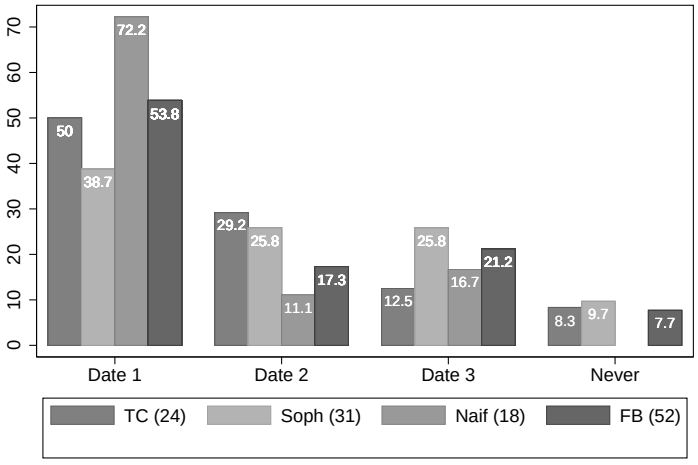
As O'Donoghue & Rabin's results hold all other things being equal, we also present a "finer" analysis that allows controls for the participants' characteristics. First, we run probit and OLS regressions, as described

$$\mathbf{Y}_i = b_0 + b_1 Type_i + b_2 \delta + \mathbf{b}\mathbf{X}_i + \epsilon_i, \tag{2}$$

where the vector $\mathbf{Y}$ indicates the respective outcome variable ("Delay", "Completion (1-3)", or "Completion (1-4)") of individual i, and the categorical variable $Type_i$ indicates whether individual i is time-consistent, sophisticated, naïve, or future-biased. In all the regressions, we set naifs as the baseline category. The variable δ is the exponential discount factor elicited by the CTB. We do not include the present-bias factor β as it is used in $Type$. The vector $\mathbf{X}$ denotes the control variables gender, age, and mother's and father's education. ODR's model predicts that b_1 is significantly negative for sophisticated and time-consistent participants (compared to naïve ones) in all three regressions.

Table 2 summarizes the results of our first three regression models. Column (1) presents the results of a probit regression; the dependent variable takes value 1 in case of completion later than on the first date, and 0 otherwise. Compared to naifs, sophisticated and future-biased individuals are more likely to delay the task. The predicted probabilities for delaying the task are as follows: time-consistent 46.11%, sophisticated 61.88%, naïve 24.82%, and future-biased 48.65% (see Figure 2, Panel A). Column (2) presents the results of an OLS model regressing the date at which the task is completed on the types. It shows that sophisticated participants completed

Figure 1: Completion by type



the task significantly later than naïve participants. The predicted times for completing the tasks are as follows: time-consistent 1.57, sophisticated 1.91, naïve 1.38, and future-biased 1.65 (see Figure 2, Panel B). In column (3), we treat the 9 participants who did not complete the task as participants who did it on a fictitious fourth date later than the third date. Column (3) presents the results of an OLS model regressing the completion variable ranging from 1 to 4 on the time preference types. It shows that sophisticated and future-biased participants completed the task significantly later than naïve participants (or never). The predicted times for completing the tasks are as follows: time-consistent 1.72, sophisticated 2.09, naïve 1.37, and future-biased 1.88 (see Figure 2, Panel C).

In all the regressions, the discount factor δ is not significant. However, its sign is always negative, suggesting that impatient individuals (i.e. individuals with a low δ) complete the task later than patient ones. Table 2 shows that females complete the task later than males and that mother's education increases the probability of completing the task early. As the demographics coefficients and significance levels are almost the same in all of the following regressions, we will not report them.

4.3. Ordered probit

To refine our analysis and isolate the impact of naïvete on each of the possible completion dates, we use an ordered probit model. This model estimates the average marginal effects of being sophisticated, time-consistent and future-biased versus naïve, on the probability of performing the task on each date. The basic model is given by:

$$\tau_i^* = b_1 Soph_i + b_2 TC_i + b_3 FB_i + \mathbf{b}\mathbf{X}_i + \epsilon_i, \tag{3}$$

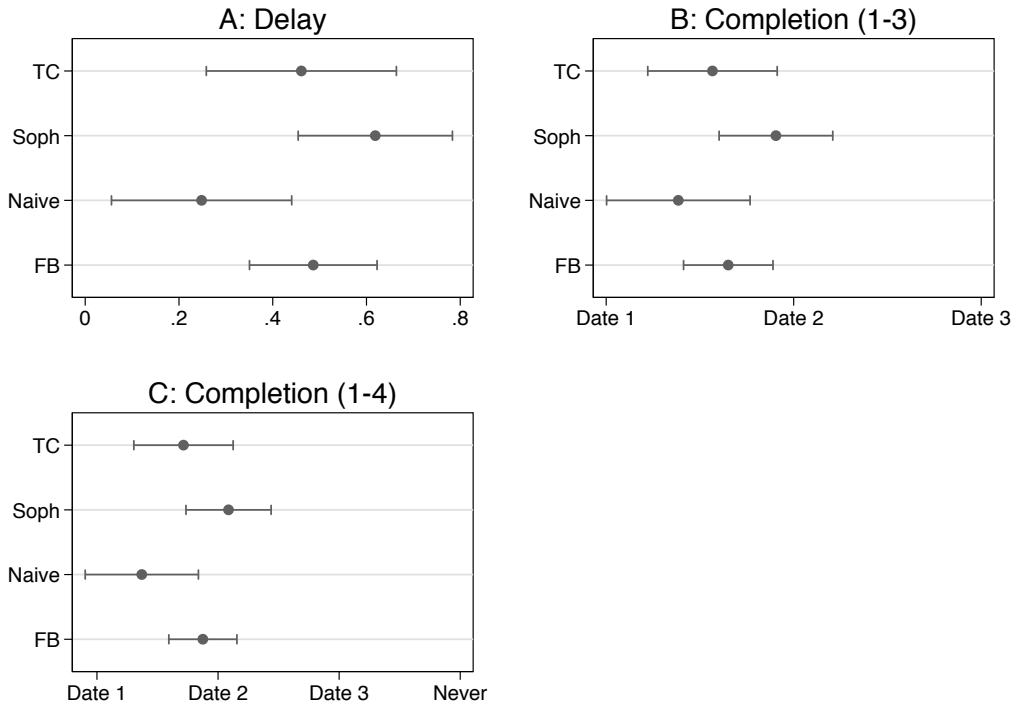
Table 2: Completion behavior by type (probit and OLS)

Variables	(1) Delay	(2) Completion (1-3)	(3) Completion (1-4)
Types with base category Naïve			
Time consistent	0.622	0.182	0.344
	(0.429)	(0.257)	(0.311)
Sophisticated	1.050**	0.521**	0.716**
	(0.411)	(0.246)	(0.295)
Future-biased	0.690*	0.266	0.504*
	(0.389)	(0.233)	(0.281)
δ (Standardized)	-0.0857	-0.0384	-0.0758
	(0.125)	(0.0787)	(0.0939)
Female	0.633**	0.508***	0.448**
	(0.270)	(0.169)	(0.196)
Age	0.0202	0.00738	0.0249
	(0.0591)	(0.0351)	(0.0425)
Mother's education	-0.379*	-0.128	-0.223
	(0.213)	(0.136)	(0.157)
Father's education	0.0902	0.000836	0.0753
	(0.188)	(0.120)	(0.141)
Constant	-0.903	1.181	0.891
	(1.377)	(0.823)	(0.997)
Observations	125	116	125

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Column 1: probit. Columns 2-3: OLS.

Figure 2: Predicted margins for completion behavior by type (probit and OLS)



where τ_i^* denotes the latent completion variable for individual i, X_i includes a set of controls, $Soph_i$ is a dummy variable that equals 1 if the individual is classified as sophisticated, and 0 otherwise, TC_i is a dummy variable that equals 1 if the individual is classified as time-consistent, and 0 otherwise, FB_i is a dummy variable that equals 1 if the individual is classified as future-biased, and 0 otherwise, and ϵ_i is the error term. The observed variable τ_i can take values 1, 2, 3 or 4.

Table 3 shows the average marginal effects of being sophisticated, time consistent and future biased versus being naïve, on the probability of completing the task on each of the possible dates (or not at all). All the specifications include controls for the demographic characteristics and for the estimated discount factor δ. Column (1) treats those who did not complete the task as participants who completed it on a fictitious fourth date later than the third one, hence the dependent variable can take 4 possible values. Column (2) excludes those who did not perform the task and restricts the dependant variable to the three possible dates. We find that sophisticates are significantly less likely than naifs to perform the task on the first date, and significantly more likely to do it on the second date, on the third date, or never.

Table 3: Completion behavior by type (ordered probit)

	(1)				(2)		
Variables	Date 1	Date 2	Date 3	Never	Date 1	Date 2	Date 3
Types with base category Naïve							
Time consistent	-0.179	0.058	0.084	0.037	-0.123	0.047	0.076
	(0.132)	(0.046)	(0.063)	(0.030)	(0.136)	(0.053)	(0.085)
Sophisticated	-0.348***	0.079*	0.166***	0.103**	-0.315**	0.083*	0.233**
	(0.120)	(0.042)	(0.061)	(0.045)	(0.127)	(0.047)	(0.094)
Future biased	-0.250**	0.071*	0.119**	0.060**	-0.162	0.058	0.104
	(0.116)	(0.043)	(0.056)	(0.030)	(0.121)	(0.050)	(0.075)
δ	1.193	-0.202	-0.571	-0.420	0.670	-0.171	-0.499
	(1.512)	(0.262)	(0.729)	(0.544)	(1.562)	(0.401)	(1.164)
Demographics	Yes				Yes		
Observations	125				116		

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

5. Robustness checks

Our classification into types combines the participants' present-bias factor and a survey question measuring whether the participants self-identify as people who tend to procrastinate. Our data show that those who identify themselves as procrastinators do indeed delay the real-effort task more. One could then wonder whether the survey question alone drives our result and

Table 4: Procrastination awareness predicting date of completion behavior by types

	(1)	(2)	(3)	(4)
Variables	Date (1-4)	Date (1-4)	Date (1-4)	Date (1-4)
Group	All	Present biased	Time consistent	Future biased
Procr. awareness	0.0971	0.773**	-0.226	-0.230
	(0.181)	(0.306)	(0.400)	(0.304)
δ (standardized)	-0.0323	-0.0787	-0.301	-0.0478
	(0.0895)	(0.176)	(0.749)	(0.125)
Constant	1.313	0.660	2.480	-0.216
	(0.998)	(1.471)	(1.989)	(1.950)
Demographics	Yes	Yes	Yes	Yes
Observations	125	49	24	52

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

predicts procrastination in the real-effort task independently of participants' time preferences. To test whether this is the case, we regress completion behavior on the survey question about perceived procrastination, in the full sample and in the sub-samples of present-biased, time-consistent and future-biased individuals. Table 4 shows that the survey question alone does not predict procrastination in the task in the full sample. Among the sub-samples, it predicts procrastination only for present-biased individuals. This suggests that the combination of the participants' time preferences with our simple survey measure of procrastination awareness does indeed provide sensible information about people's procrastination behavior.

To explore further the validity of our classification into types, we use the survey question about the expected completion date. One might imagine that naifs expect to complete the task earlier than sophisticates. Indeed, Table 1 shows that the mean expected completion date of the participants classified as naïve is 1.39 and that of those classified as sophisticated is 1.90 (t-test: $p < 0.05$). The expected date's distribution of naifs is significantly different from that of sophisticates (Mann-Whitney U-test: $p < 0.05$).[12]

An alternative classification into types can be provided by the domain-specific survey questions about health checks, borrowing books from the library, and working on an assignment. The questions were phrased as: "Would you ever postpone a health check, even if you have not had one in a long time?", "Would you ever return an item to the library late, even if you may have to pay a fine?", and "Would you ever submit a piece of work past its deadline?". Table 5 shows completion behavior by type, using the three classifications provided by the three

[12]Note that, once combined with the actual completion date, the expected completion date can serve as a behavior-based measure of sophistication. However, as discussed in Section 1, we cannot use such measure of sophistication to test ODR's model.

Table 5: Completion by type using domain-specific classifications

	(1)	(2)	(3)
Variables	Date (1-4)	Date (1-4)	Date (1-4)
Domain of TP Group	Health	Books	Assignment
Types with base category Naïve			
Time-consistent	0.0600	0.118	0.0180
	(0.279)	(0.282)	(0.261)
Sophisticated	0.415	0.511*	0.659*
	(0.291)	(0.287)	(0.353)
Future-biased	0.216	0.283	0.170
	(0.243)	(0.249)	(0.220)
δ (standardized)	-0.0531	-0.0659	-0.0510
	(0.0947)	(0.0949)	(0.0940)
Constant	1.332	1.133	1.156
	(0.996)	(0.998)	(0.995)
Demographics	Yes	Yes	Yes
Observations	125	125	125

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The independent type variables are domain-specific and differ across columns.

domain-specific questions. The assignment-specific classification and the book-specific classification produce the same main result as our preferred classification based on the general-domain question: sophisticates perform the task later than naifs. The health-specific classification has a similar coefficient, but it is not significant. This may be due to the fact that the health domain is farther away from completing a real-effort task than the book domain and the assignment domain. While specific questions may help subjects recognize a certain behavior by linking it to a real-life situation they can easily relate to,[13] they pose the concern that some subjects may be misclassified as people who do not (or would not) delay a given activity simply because it is an activity they are not familiar with. In light of this, we have used the general-domain question in our main classification into types.

6. Habitual procrastination

In our study, naïve participants performed an onerous real-effort task sooner than sophisticated participants. This contradicts ODR's prediction. Our data suggest that this result could be explained by habit formation. According to habit-formation theory, habits increase the

[13] Dohmen (2005) uses a generic question that asks about willingness to take risks on a 11-point scale and five questions about willingness to take risks in specific domains such as car driving and financial matters.

marginal utility of engaging in an activity in the future.[14] We argue that individuals who are aware of their tendency to procrastinate may procrastinate more than individuals who are unaware of it because they have developed a (stronger) procrastination habit. The negative effect of a procrastination habit may outweigh the positive effect of awareness. In other words, individuals' awareness of their present-bias may not be enough to avoid future procrastination when they have a procrastination habit, especially in the absence of binding commitment devices.

While we are unable to test directly whether sophisticates procrastinate more than naifs due to a stronger procrastination habit, our data are consistent with this possible explanation. Firstly, as mentioned in subsection 4.1, the survey question about past procrastination shows that significantly more sophisticated participants (over 97%) than naïve participants (56%) reported past procrastination experiences (Mann-Whitney U-test and Kruskal Wallis test are significant: $p = 0.0004$; Z-test for differences in proportions: $p = 0.0003$). In line with Ali (2011), this suggests that individuals' awareness of their present-bias may be driven by their past procrastination; past procrastination may in turn be associated with a procrastination habit. Secondly, sophisticated participants have a significantly stronger present-bias than naïve ones. This is consistent with the habit-formation explanation: individuals with a procrastination habit are expected to be relatively more present-biased and aware of it. Finally, sophisticated participants expect to complete the real-effort task significantly later than naïve ones (and this prediction is fairly accurate). This is consistent with the habit-formation explanation as well: habitual procrastinators will expect to perform onerous tasks later than individuals who do not have a procrastination habit and are unaware of their present-bias.

7. Conclusion

Naïve participants performed the real-effort task significantly *earlier* than sophisticated ones. A potential explanation for this counterintuitive finding is habit-formation. Sophisticated participants reported past procrastination significantly more than naïve participants. Thus, they may be relatively more aware of their present-biased *and* have procrastinated the real-effort task more because they have developed a (stronger) procrastination habit.

References

Acland, D. & Levy, M. R. (2015), 'Naivete, projection bias, and habit formation in gym attendance', *Management Science* **61**(1), 146–160.

Ali, N. S. (2011), 'Learning self-control', *Quarterly Journal of Economics* **126**(2), 857–893.

Ameriks, J., Caplin, A., Leahy, J. & Tyler, T. (2007), 'Measuring self-control problems', *The American Economic Review* **97**(3), 966–972.

[14] Habit formation was formalized by Pollak (1970) and later applied to negative habits such as addiction (Becker & Murphy 1988), and positive habits such as physical exercise (Charness & Gneezy 2009; Acland & Levy 2015).

Andreoni, J., Kuhn, M. A. & Sprenger, C. (2013), 'On measuring time preferences', NBER Working Paper No. 19392.

Ashraf, N., Karlan, D. & Yin, W. (2006), 'Tying odysseus to the mast: evidence from a commitment savings product in the philippines', *Quarterly Journal of Economics* **121**(2), 635–672.

Augenblick, N. & Rabin, M. (2016), 'An experiment on time preferences and misprediction in unpleasant tasks', Working Paper.

Becker, G. S. & Murphy, K. M. (1988), 'A theory of rational addiction', *Journal of Political Economy* **96**(1), 675–700.

Cerrone, C. (2016), 'Doing it when others do: a strategic model of procrastination', Max Planck Institute for Research on Collective Goods, Preprint No. 2016/10.

Charness, G. & Gneezy, U. (2009), 'Incentives to exercise', *Econometrica* **77**(3), 517–529.

Dohmen, T. (2005), 'Individual risk attitudes: new evidence from a large, representative, experimentally-validated survey', IZA Discussion Papers No. 1730.

Falk, A. & Ichino, A. (2006), 'Clean evidence on peer effects', *Journal of Labor Economics* **24**(1), 39–57.

Fishbacher, U. (2007), 'z-tree: Zurich toolbox for ready-made economic experiments', *Experimental Economics* **10**(5), 171–178.

Giné, X., Goldberg, J., Silverman, D. & Yang, D. (2017), 'Revising commitments: field evidence on the adjustment of prior choices', *The Economic Journal,* doi: 10.1111/ecoj.12378 .

Gul, F. & Pesendorfer, W. (2001), 'Temptation and self-control', *Econometrica* **69**, 1403–1436.

John, A. (2016), 'When commitment fails: evidence from a field experiment', EOPP Discussion Paper 55, London School of Economics.

Laibson, D. (2015), 'Why don't present-biased agents make commitments?', *American Economic Review: Papers & Proceedings* **105**(5), 267–272.

Meier, S. & Sprenger, C. (2010), 'Present-biased preferences and credit card borrowing', *American Economic Journal: Applied Economics* **1**, 193–210.

O'Donoghue, T. & Rabin, M. (1999), 'Doing it now or later', *American Economic Review* **89**(1), 103–124.

Pollak, R. A. (1970), 'Habit formation and dynamic demand functions', *Journal of Political Economy* **78**, 745–763.

Appendix

A. Proofs

Proof of Proposition 2

Case (i). Time-consistent vs naïve. For any $t < T$, the proof of Proposition 1(i) applies. For $t = T$, both time-consistent and naïve individuals will perform the task in t if and only if $\beta v_T - c_T \geq 0$. It follows that, even when the individuals have the option not to perform the task in $t = T$, if naifs perform it, then time-consistent agents do it.

Case (ii). Sophisticated vs naïve. For any $t < T$, a naif will perform the task in t if and only if $U^t(t) \geq U^t(\tau)$, where $\tau > t$ (ODR). Suppose that a sophisticate knows that, if she does not perform the task today, she will do it in $\tau' \equiv \min_{\tau > t}\{\tau | \tilde{s}^s_\tau = Y\}$. Then she will perform the task today if and only if $U^t(t) \geq U^t(\tau')$. Suppose that a sophisticate knows that, if she does not perform the task today, she will never do it. Then she will perform the task today if and only if $U^t(t) > 0$. For $t = T$, both sophisticates and naifs will perform the task in t if and only if $U^T(T) \geq 0$. It follows that, even when the agents have the option not to perform the task in $t = T$, if naifs do it, then sophisticates do it.

B. Surveys and instructions

B.1. Initial survey

Screen 1

Please answer the following questions.

1. Are you a person who delays things that should be done in a timely manner? *(y/n)*
2. Would you ever postpone a health check, even if you have not had one in a long time? *(y/n)*
3. Would you ever return an item to the library late, even if you may have to pay a fine? *(y/n)*
4. Would you ever submit a piece of work past its deadline? *(y/n)*

Screen 2

5. What is your gender?
6. In which year were you born?
7. Which year of study are you in?
8. What is the highest level of education your mother has completed?
9. What is the highest level of education your father has completed?

Screen 3

10. In the past 4 months, have you submitted any coursework past its deadline? *(y/n)*
11. In the past 4 months, have you returned a book to the library late? *(y/n)*
12. In the past 4 months, have you delayed any activity which would have been better done earlier? *(y/n)*
13. In the past 4 months, have you planned to do a health check and then postponed it? *(y/n)*
14. In the past 6 months, have you done any of the following things?[15]

[15] This question was not used in the analysis, as there was an error in the coding.

- Taken only a fixed amount of cash when heading out to party for a night.
- Bought small quantities of junk food rather than buying in bulk.
- Not kept alcohol in the house.
- Brushed your teeth earlier in the evening in order to avoid late night snacking.

Screen 4

As part of this experiment, you have to complete **one task on one out of these three possible Tuesdays**: – Tuesday the 10th of November at 6 pm, OR
– Tuesday the 17th of November at 6 pm, OR
– Tuesday the 24th of November at 6 pm.
The task will take place in the Horton Lecture Theatre 1 (HLT1), and will consist of putting letters into envelopes.

If you do the task on Tuesday the 10th of November, you will have to put 20 letters into envelopes (it will take about 10 minutes)
If you do the task on Tuesday the 17th of November, you will have to put 35 letters into envelopes (it will take about 17-18 minutes)
If you do the task on Tuesday the 24th of November, you will have to put 60 letters into envelopes (it will take about 30 minutes)
If you do the task you will be paid £8 on the 1st of December.
Your payment does **not** depend on **when** you do the task.
You will also have the possibility to earn additional money by filling in a brief survey (5 minutes long).

15. On which day do you think you will do the task? (Note that you are not obliged to stick to this date: we only want to know when you **think** you will do the task.)

Screen 5

Thank you for participating today!
Please wait to be given your payment.
Tonight you will receive an email with a summary of the information about the rest of the experiment.

B.2. Final survey

This survey is not presented here in full, as it is a slightly adapted version of the survey in Andreoni et al. (2013). While in their setting all the participants were paid for one randomly selected decision, in ours – as well as in other papers using this survey – only one third of the participants were randomly selected and paid according to one randomly selected decision. The survey was run in the experimental lab. The first screen presented the instructions, the second screen presented an example to show how the survey questions worked, and the following four screens presented the four sets of 6 decisions that the participants faced. The first set of decisions is illustrated by Figure 3.

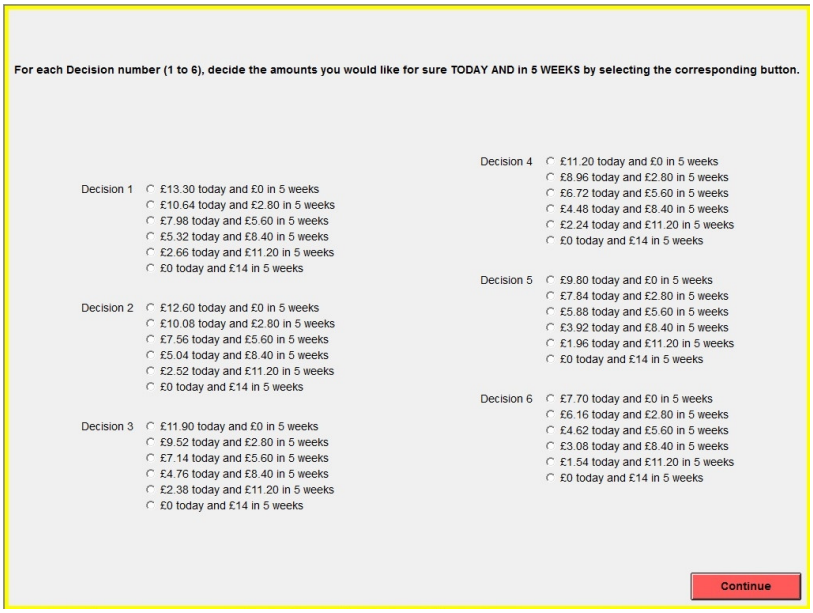


Figure 3: Sample decisions from the time-preferences survey

C. An alternative classification into types

An alternative classification can be obtained by simply combining the survey questions about past procrastination and procrastination awareness. In fact, the questions about past procrastination could be used in substitution for elicited time preferences in order to split participants into time-consistent and present-biased individuals. This can be done by using either the general question or any of the three specific questions. In the former case, participants who answered "Yes" to the question "In the past 4 months, have you delayed any activity which would have been better done earlier?" can be classified as present-biased, and participants who answered "No" can be classified as time-consistent. We can then classify present-biased individuals as sophisticated if they are aware of their procrastination tendencies and as naïve if they are not.

This measure allows for a bigger sample, but presents several disadvantages. Firstly, naïve individuals might not be able to identify their past behavior as procrastination, or may view their past behavior as consistent with their expected behavior so as to reduce cognitive dissonance. This would lead to an underestimate of the fraction of present-biased individuals. Secondly, some participants may have not procrastinated in the past 4 months, but have procrastinated in the more distant past. This would lead to to a misclassification of present-biased individuals as time consistent. Thirdly, participants were asked about past procrastination after being asked about perceived procrastination. Even if we tried to reduce anchoring effects by asking demographic questions in between and by displaying the second set of questions on a different screen and in a different order, yet participants' answers about past procrastination may have been anchored to their previous answers. Finally, this measure does not allow us to identify future-biased individuals (who are, according to previous studies, a substantial fraction of the population), but provides a fourth type which both theory and evidence are silent about: individuals who do not report past procrastination, but are aware of their procrastination tendencies. It is not obvious how this type should be treated (e.g., as a subcategory of time-consistent individuals, or as a non-classifiable category).

Table 6: Completion behavior by type using an alternative measure (probit in column (1) and OLS regressions in columns (2) and (3))

Variables	(1) Delay	(2) Completion (1-3)	(3) Date (1-4)
Types with base category Naïve			
Time-consistent	-0.121	-0.0748	-0.203
	(0.293)	(0.208)	(0.282)
Sophisticated	0.134	0.113	-0.0382
	(0.245)	(0.174)	(0.234)
Non-classified	-0.105	0.0546	-0.195
	(0.559)	(0.384)	(0.531)
Constant	0.365	1.664**	2.438**
	(1.173)	(0.779)	(1.114)
Demographics	yes	yes	yes
Observations	162	129	162

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 6 shows our main regressions using this classification – using the general survey questions, and keeping the fourth type in the sample as a separate category. There is no significant difference in the completion behavior of time consistent, sophisticated, naïve, and "non-classifiable" individuals. The same is obtained by using the specific questions.[16] In these regressions we included δ in order to control for impatience, but did not control for β, as the past procrastination question proxies β.

[16]There is an exception. When using the specific question about returning books to the library, we find that sophisticates do it significantly later than naifs, but only when using the completion variable (1-4).