Time Inconsistency, Sophistication, and Commitment
An Experimental Study*

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Abstract

We experimentally study the relationship between time inconsistency, sophistication about time inconsistency, and self-commitment. Previous research has interpreted demand for commitment devices as evidence for the sophistication of a time-inconsistent decision-maker. In our laboratory experiment, we attempt to measure sophistication directly by way of a cognitive test. We then test the hypothesis that people who are both time-inconsistent and show high cognitive capacity take up commitment devices when offered in the strategic game between their current and their future self. For experimental laboratory commitment choices, we cannot detect a moderating effect of cognition on commitment demand of time-inconsistent subjects.

Keywords: time-inconsistency, sophistication, present bias, future bias

JEL Classification: C90, C91, D91

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I Introduction

Time-inconsistent preferences, i.e. that people exhibit different levels of patience over different time horizons, have been used to explain a wide range of behaviors, including addiction, excessive credit-card borrowing, or saving and borrowing at the same time. To counter her bias, a person may show demand for commitment devices (see Bryan et al., 2010, for a review). Commitment devices have been helpful to increase savings (e.g. Ashraf et al., 2006), stop smoking (e.g. Giné et al., 2010), reduce alcohol consumption (e.g. Schilbach, 2019), or reduce procrastination and increase work/study output (e.g. Ariely and Wertenbroch, 2002; Kaur et al., 2015).

However, it is important to note that in standard models of time-preferences, only *sophisticated* decision-makers, i.e. people who are *aware* of their own time-inconsistency, should demand commitment devices (Eliaz and Spiegler, 2006). In the studies cited above, the fact that a (biased) decision-maker takes up a commitment option is usually interpreted as evidence for sophistication.

Such indirect inference of sophistication may be problematic. Uncertainty about the future make even sophisticated decision-makers to retain flexibility and reject commitment (Laibson, 2015; Casari and Dragone, 2015). And naïve decision-makers may adopt commitment contracts when basing their decision on historical data and experienced utility (Laibson, 2018). Commitment take-up has often been found to be inconsistent and noisy.[1]

More recently, some papers aimed to assess the decision-maker's sophistication directly by asking them to predict their own future behavior. Acland and Levy (2015) and Augenblick and Rabin (2019) find wide-spread naivety about time-inconsistency, but do not relate this to commitment take-up. Carrera et al. (2019) increase awareness of own bias, but find that such increased sophistication *reduces* commitment contract take-up. Similarly, John (2020) finds an unpredicted *negative* correlation between sophistication and commitment take-up for biased subjects.

We complement this literature by measuring (potential for) sophistication by way of cognitive ability, and testing the hypothesis that cognitive ability of time-inconsistent subjects is positively correlated with the take-up of commitment devices. In our experiment, we detect present-bias or future-bias using Attema et al. (2010)'s time-tradeoff sequences (TTO), and loosely follow Casari (2009)'s experimental design in offering commitment contracts to subjects which are tailored to their time-inconsistency. We employ the "Automated Operation Span" (AOS) test (Unsworth et al., 2005), measuring working memory, which has been found to be correlated with many other higher-order cognitive capabilities and is thus considered a measure

[1] For example, Carrera et al. (2019) report that individual demand for commitment contracts for going to the gym more and going to the gym less is positively correlated.

of general cognitive ability (see Engle and Kane, 2004 for a review, and Rydval, 2007; Rydval et al., 2009 for evidence on suboptimal decisions in guessing games and forecasting tasks).

We find no relation between our proxy for sophistication (potential) and the take-up of commitment devices. Regression analysis does not detect an effect of time-inconsistency or cognitive performance on the demand for commitment, neither directly nor in interaction. However, we see some weak evidence for the (hypothetical) take-up of a commitment contract in a savings survey question. Thus, our paper contributes mixed evidence to the literature on commitment devices. Measured time preferences and cognitive performance as a proxy for sophistication appear not to be helpful in explaining real commitment choices in the laboratory.

II Experimental design and procedures

Our laboratory experiment consisted of four parts.[2]

Time preferences. Using a shortened two-step version of Attema et al. (2010)'s Time Trade-Off sequences, a participant stated her willingness-to-wait t in weeks for a larger-later payment \$L which makes her indifferent to a smaller-sooner payment \$S in FED weeks (FED= front-end delay), $(\$S, FED) \sim (\$L, FED + t)$. Subsequently, the participant stated her willingness-to-wait t' (in weeks) for a larger-later payment \$L which makes her indifferent to a smaller-sooner payment \$S in $FED + t$ weeks, $(\$S, FED + t) \sim (\$L, FED + t + t')$.

An increasing willingness-to-wait over time ($t' > t$) indicates present-bias, while a decreasing willingness-to-wait ($t' < t$) represents future bias. We elicited choices for \$S=\$100, \$L=\$130, FED=1 week and \$S=\$200, \$L= \$240, FED=5 weeks, using a multiple price list with the willingness-to-wait t ranging from 1 to 26 weeks.

Table 2 below summarizes the four intertemporal choice questions presented to subjects, the average willingness-to-wait observed for these questions, and the distribution of time-preference types classified based on these two pairs of questions.For the first (second) set of parameters, 37% (33%) of subjects were classified as present-biased, 33% (29%) as future-biased, and 30% (38%) of subjects were either consistent or could not be classified.

Commitment choices. Adapting from Casari (2009), based on elicited t and t', we designed binary choices that imply a choice reversal for time-inconsistent subjects, i.e. a conflict between the current self, deciding now, and the future self, deciding later at time t. Specifically, subjects decided between (\$S, $t+FED$) and (\$L, $t+FED+d$), with delay d at the midpoint of the range of predicted choice reversals, $d = \frac{t+t'-1}{2}$. Then we offered subjects (that is: their current self) to leave the choice to their future self, or to commit their future self to one of the options. Subjects

[2]We provide a more detailed description in Appendix A.

with present-bias (future-bias) were assigned questions where commitment options lead to the choice of the larger-later (smaller-sooner) payment at the future date. Time-consistent subjects were randomly assigned commitment options correcting either present-bias or future-bias.

For each of the two parameter sets (\$S=\$100, \$L=\$130, FED=1 week and \$S=\$200, \$L=\$240, FED=5 weeks), we designed 8 commitment options that varied whether commitment was soft (costs added to the action that is to be avoided) or strict (restricting the future choice set), and in the cost/benefit of the commitment contract (in time or money).[3] These commitment options are listed in Table 1. Table 5 in Appendix A summarizes the raw results for the 16 commitment questions, and Appendix B includes the full text.

TABLE 1: Commitment options used in experiment

Strict commitment options		Soft commitment options	
1	No cost for committing	5	\$2/\$4 penalty on future tempting option
2	\$2/\$4 cost for committing	6	\$6/\$12 penalty on future tempting option
3	3 days cost for committing	7	1 week penalty on future tempting option
4	3 days benefit for committing	8	1 week penalty on future tempting option + 3 days benefit on now-preferred option

Notes: "Strict commitment" restricts the future choice set to the now preferred option. "Soft commitment" imposes a future penalty on the then tempting but now not preferred option.

While *sophisticated* biased subjects should accept a commitment option (if its direct costs are sufficiently low or its implicit costs sufficiently high), naïve biased subjects believe to be time-consistent and thus should accept a commitment option only if it comes with a benefit, just as truly time-consistent subjects.

Cognitive ability. We implemented the operation span test (Unsworth et al., 2005) in zTree (Fischbacher, 2007). Subjects solved math problems and at the same time remembered letters displayed on the screen under time pressure. Subjects were paid according to their performance. A subject's cognitive score is the number of correctly answered math and letter questions. Scores ranged from 81 to 149, with a mean of 129.4 and a standard deviation of 13.3 (see Figure 4 in the Appendix for the distribution).

Demographics. A final questionnaire collected subject's demographic information. It also contained three small vignette scenarios on real-life commitment behavior, for which we discuss results in Appendix E.

[3]Such commitment contract features have also been examined by Augenblick et al. (2015), Beshears et al. (forthcoming), Casari (2009), and Houser et al. (2018).

TABLE 2: Intertemporal choice questions in time preference elicitation

Seq	QNo. q	$\$S_q$	FED_q	$\$L_q$	Avg. WTW (StdDev)	Present-biased	Future-biased	Time-cons.	Un-class.
1	1	\$100	1 week	\$130	10.9 (9.9)	36.8%	33.3%	14.9%	14.9%
	2	\$100	1 week+t_1	\$130	10.3 (10.1)				
2	3	\$200	5 weeks	\$240	9.7 (9.8)	33.3%	28.7%	25.3%	12.6%
	4	\$200	5 week+t_2	\$240	10.2 (9.7)				

Notes: $\$S_q$, FED_q, and $\$L_q$ stand for the smaller-sooner amount, the front-end delay, and the larger-later amount in the time preference question, respectively. Avg. WTW indicates the average observed willingness to wait in weeks (and its standard deviation) for the question. The last 4 columns show the distribution of time-preference types classified based on the two questions in a sequence.

III Results

We collected commitment decisions from 87 subjects in 6 laboratory sessions. We observe wide variation in commitment take-up rates of biased subjects conditional on commitment contract features, ranging from 0-19% when commitment implies penalties over 16-31% when commitment comes at no costs to 44-55% when a strict commitment option has an additional benefit of 3 days less waiting time.[4]

To test our main hypothesis, we ran Probit regression models, reported in Table 3, that explore drivers of accepting a commitment option based on a subject's time-preferences and cognitive performance and features of the commitment device. "Time Inconsistency" indicates whether the subject was present/future-biased. "Cognitive Score" is the normalized score achieved in the Automated Operation Span test. Our main interest is the interaction effect "TI x CogScore" which estimates how the likelihood to commit changes for time-inconsistent people when cognitive performance is higher. As controls we include the "Patience level" (average willingness to wait), a dummy for a "Soft commitment" (rather than strict commitment) option, and the commitment device's actual costs and implicit costs (calculation detailed in Appendix C). We report separate estimations for correcting present bias or future bias, and parameter sets.[5]

We obtain a similar pattern of estimates for commitment decisions that correct either direction of bias. Most importantly, we do not find support for the hypothesis that commitment demand would be mainly driven by time-inconsistent but sophisticated people. As a matter of fact, neither time-consistency nor the cognitive score nor their interaction has a significant

[4]Table 5 in Appendix A gives details.

[5]A number of robustness checks are reported in Appendix D. None of them would change our conclusions here. We also note that we do not observe direct correlations between cognitive ability and patience levels (Pearson r=-0.08, p=0.45) or cognitive ability and the existence of present-bias (Point-Biserial r=-0.09, p=0.38), including when controlling for demographics.

TABLE 3: PROBIT ESTIMATIONS OF COMMITMENT OPTION ACCEPTANCE

	Correcting present-bias		Correcting future-bias	
	\$100, 1w	\$200, 5w	\$100, 1w	\$200, 5w
Model	(1)	(2)	(3)	(4)
Time-inconsistent (TI)	0.014	0.019	0.016	-0.018
	(0.060)	(0.056)	(0.055)	(0.048)
Cognitive Score	0.002	0.019	0.049*	0.057*
	(0.023)	(0.023)	(0.026)	(0.034)
TI × CogScore	0.036	-0.072	-0.031	0.046
	(0.040)	(0.054)	(0.048)	(0.067)
Patience level	0.001	-0.005	-0.001	-0.001
	(0.004)	(0.003)	(0.003)	(0.003)
Soft commitment	-0.125**	-0.105***	-0.127**	-0.040
	(0.063)	(0.041)	(0.063)	(0.054)
Actual cost	-7.146***	-8.704***	-6.031***	-11.194***
	(1.350)	(1.644)	(1.252)	(1.816)
Implicit cost	-1.198	-2.132**	0.519	-1.22
	(0.781)	(0.911)	(1.439)	(1.362)
#N observations	368	400	328	296
#N subjects	46	50	41	37
Log-Likelihood	-157.23	-168.26	-136.92	-94.97

Notes: We report average marginal effects. Robust standard errors are clustered at the subject level and given in parentheses.

impact on the likelihood of taking up a commitment device.[6] The main drivers of whether commitment is accepted or not seem to be the properties of the specific commitment option. Soft commitment options (penalties on giving in to temptation) are less preferred than strict commitment options (future choice restricted). The size of direct costs has a significant negative effect on commitment take-up. The effect of implicit costs is also negative in most cases, but not significantly so.

IV Conclusion

In this paper, we used a cognitive test to measure (potential for) sophistication of time-inconsistent decision-makers, in order to explore the relation between sophistication and demand for tailor-made commitment options. Contrary to the theoretical prediction, we find no relation between cognitive performance and take-up of commitment contracts for time-inconsistent people. We note, however, that cognitive ability has some predictive power for

[6]The weakly positive effect of a higher cognitive score on the take-up rate that correct future-bias disappears when we include demographic controls.

subjects' hypothetical demand for a savings commitment product in a survey vignette question. As we discuss in Appendix E, we do not consider this result to be reliable.

We thus contribute to a growing literature that finds individual commitment choices to be noisy and often inconsistent. However, we also document and replicate reasonable reactions to features of commitment devices, such as preference for strict vs. soft commitment options, and sensitivity to costs.

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Online Appendix

A Additional details on experimental design and procedures

Our laboratory experiment consisted of four parts, conducted in the order as described here.

Time preferences. Using a shortened two-step version of Attema et al. (2010)'s Time Trade-Off sequences.[7] In a first question, a participant stated her willingness-to-wait t in weeks for a larger-later payment \$L which makes her indifferent to a smaller-sooner payment \$S in FED weeks (FED stands for "front-end delay").

$$(\$S, FED) \sim (\$L, FED + t)$$

In a second question, the participant stated her willingness-to-wait t' (in weeks) for a larger-later payment \$L which makes her indifferent to a smaller-sooner payment \$S in $FED{+}t$ weeks.

$$(\$S, FED + t) \sim (\$L, FED + t + t')$$

An increasing willingness-to-wait over time ($t' > t$) indicates present-bias, while a decreasing willingness-to-wait ($t' < t$) represents future-bias. We vary the base stake size and the initial front-end delay (\$S=\$100, \$L=\$130, FED=1 week vs. \$S= \$200, \$L= \$240, FED=5 weeks). We elicited each question using a multiple price list of 26 binary choices between $\$S$ in FED weeks and $\$L$ in $FED + t$, with the willingness-to-wait t ranging from 1 to 26 weeks. We enforced consistency through a unique (or no) switching point between $\$S$ and $\$L$. Table 4 summarizes the intertemporal choice questions presented to subjects, and Figure 1 displays a screenshot of the multiple price list.

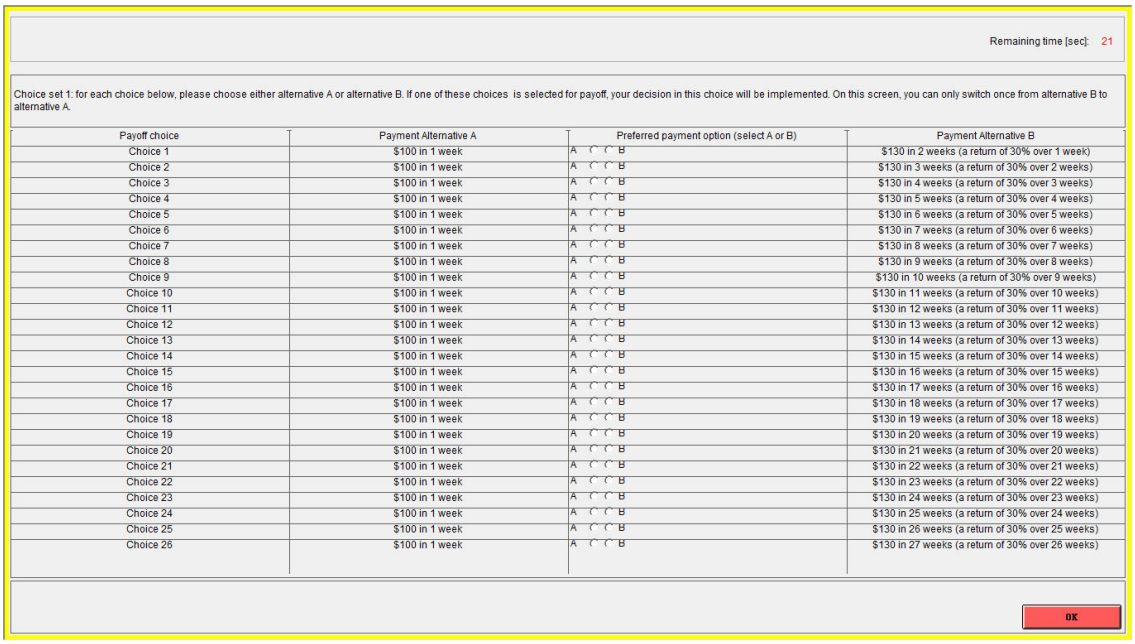
TABLE 4: Intertemporal choice questions in time preference elicitation

Seq	QNo. q	Smaller-sooner payment $\$S_q$	Front-end delay FED_q	Larger-later payment $\$L_q$	Elicited willingness to wait t_q
1	1	\$100	1 week	\$130	t_1
	2	\$100	1 week+t_1	\$130	t_1'
2	3	\$200	5 weeks	\$240	t_2
	4	\$200	5 week+t_2	\$240	t_2'

Commitment choices. Adapting from Casari (2009), we created situations in which, given (time-inconsistent) elicited t and t', a subject should show a choice reversal. Assume the subject

[7] The first part of our experiment featured additional choices in order to compare different methods to classify time inconsistency. We report these results in our paper Greiner and Zhang (2021).

FIGURE 1: Screenshot of an example intertemporal choice question



Remaining time [sec]: 21

Choice set 1: for each choice below, please choose either alternative A or alternative B. If one of these choices is selected for payoff, your decision in this choice will be implemented. On this screen, you can only switch once from alternative B to alternative A.

Payoff choice	Payment Alternative A	Preferred payment option (select A or B)	Payment Alternative B
Choice 1	$100 in 1 week	A ( ) ( ) B	$130 in 2 weeks (a return of 30% over 1 week)
Choice 2	$100 in 1 week	A ( ) ( ) B	$130 in 3 weeks (a return of 30% over 2 weeks)
Choice 3	$100 in 1 week	A ( ) ( ) B	$130 in 4 weeks (a return of 30% over 3 weeks)
Choice 4	$100 in 1 week	A ( ) ( ) B	$130 in 5 weeks (a return of 30% over 4 weeks)
Choice 5	$100 in 1 week	A ( ) ( ) B	$130 in 6 weeks (a return of 30% over 5 weeks)
Choice 6	$100 in 1 week	A ( ) ( ) B	$130 in 7 weeks (a return of 30% over 6 weeks)
Choice 7	$100 in 1 week	A ( ) ( ) B	$130 in 8 weeks (a return of 30% over 7 weeks)
Choice 8	$100 in 1 week	A ( ) ( ) B	$130 in 9 weeks (a return of 30% over 8 weeks)
Choice 9	$100 in 1 week	A ( ) ( ) B	$130 in 10 weeks (a return of 30% over 9 weeks)
Choice 10	$100 in 1 week	A ( ) ( ) B	$130 in 11 weeks (a return of 30% over 10 weeks)
Choice 11	$100 in 1 week	A ( ) ( ) B	$130 in 12 weeks (a return of 30% over 11 weeks)
Choice 12	$100 in 1 week	A ( ) ( ) B	$130 in 13 weeks (a return of 30% over 12 weeks)
Choice 13	$100 in 1 week	A ( ) ( ) B	$130 in 14 weeks (a return of 30% over 13 weeks)
Choice 14	$100 in 1 week	A ( ) ( ) B	$130 in 15 weeks (a return of 30% over 14 weeks)
Choice 15	$100 in 1 week	A ( ) ( ) B	$130 in 16 weeks (a return of 30% over 15 weeks)
Choice 16	$100 in 1 week	A ( ) ( ) B	$130 in 17 weeks (a return of 30% over 16 weeks)
Choice 17	$100 in 1 week	A ( ) ( ) B	$130 in 18 weeks (a return of 30% over 17 weeks)
Choice 18	$100 in 1 week	A ( ) ( ) B	$130 in 19 weeks (a return of 30% over 18 weeks)
Choice 19	$100 in 1 week	A ( ) ( ) B	$130 in 20 weeks (a return of 30% over 19 weeks)
Choice 20	$100 in 1 week	A ( ) ( ) B	$130 in 21 weeks (a return of 30% over 20 weeks)
Choice 21	$100 in 1 week	A ( ) ( ) B	$130 in 22 weeks (a return of 30% over 21 weeks)
Choice 22	$100 in 1 week	A ( ) ( ) B	$130 in 23 weeks (a return of 30% over 22 weeks)
Choice 23	$100 in 1 week	A ( ) ( ) B	$130 in 24 weeks (a return of 30% over 23 weeks)
Choice 24	$100 in 1 week	A ( ) ( ) B	$130 in 25 weeks (a return of 30% over 24 weeks)
Choice 25	$100 in 1 week	A ( ) ( ) B	$130 in 26 weeks (a return of 30% over 25 weeks)
Choice 26	$100 in 1 week	A ( ) ( ) B	$130 in 27 weeks (a return of 30% over 26 weeks)

OK

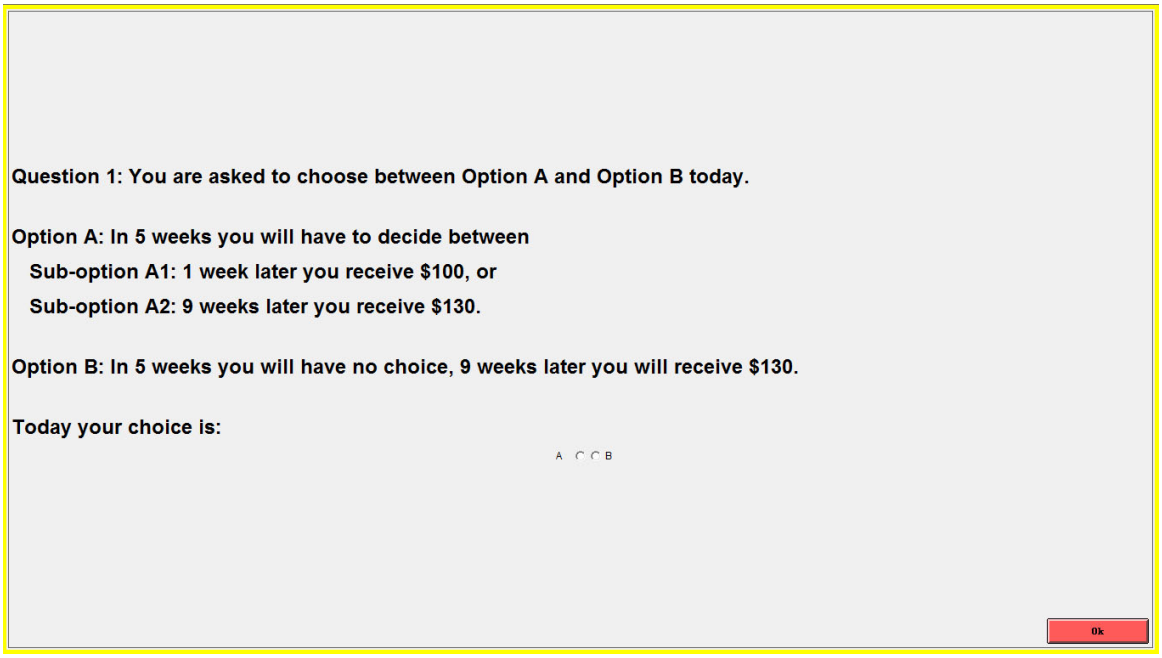
has a decision to make in the future, at time t, between a smaller-sooner payment that is paid at time t plus a front-end delay FED, (\$S, $t + FED$), and a larger-later payment that is paid with some further delay d, (\$L, $t + FED + d$). The subject's future self, who's "now" is at time t, will have a willingness to wait t for the larger payment. The subject's current self, who thinks now about that future choice at time t, will have a willingness to wait of t'. If t and t' differ, and if $t \leq d \leq t' - 1$ (in case of present bias) or $t' \leq d \leq t - 1$ (in case of future bias), then we should observe a choice reversal, in that the current self would decide differently than the future self.

Thus, we design binary choices between (\$S, $t+FED$) and (\$L, $t+FED+d$), and in order to maximize the differences between preferences of current and future self, we choose a delay d at the midpoint of the range of predicted choice reversals, $d = \frac{t+t'-1}{2}$.[8] Given these two options, we offered subjects (that is: their current self) the possibility to commit their future self to one of these options. In particular, subjects could decide between leaving the choice to their future self, or committing their future self to one of the options. If a subject exhibited present-bias, she was assigned questions where commitment options lead to the choice of the larger-later payment at a future date; if future-bias was detected, the subject was assigned questions where choosing the smaller-sooner payment is induced by commitment. Time-consistent subjects were randomly assigned commitment options correcting either present-bias or future-bias.

[8] If the mid-point was not an integer number, we rounded down for present-biased and up for future-biased people.

For each of the two parameter sets, we designed 8 commitment options that varied whether commitment was soft (costs added to the action that is supposed to be avoided) or strict (restricting the future choice set), and in the cost/benefit of the commitment contract (in time or money). Table 5 summarizes the altogether 16 commitment questions, Appendix B exemplarily lists the full text of commitment questions (for a present-biased decision-maker and parameters \$S=\$100, \$L=\$130, FED=1 week), and Figures 2 and 3 display screenshots.

FIGURE 2: SCREENSHOT OF EXAMPLE COMMITMENT QUESTION
(\$100 STAKES, PRESENT BIAS, STRICT COMMITMENT)



Measurement of cognitive ability. We used an automated version of the operation span test (Turner and Engle, 1989; Unsworth et al., 2005), implemented in zTree (Fischbacher, 2007), to measure subjects' working memory. After a practice trial, 75 math problems and 75 letter recalling questions were randomly ordered and organized into 12 task sets of 3 to 7 pairs each. Each task set repeatedly asked the subjects to solve math problems and at the same time remember letters displayed on the screen under time pressure. At the end of a task set, a recall screen asked for the sequence of letters in the correct order. We calculate a subject's cognitive score as the sum of the number of correctly answered math problems and correctly recalled letters. Subjects were paid according to their performance in the test. Cognitive scores ranged from 81 to 149, with a mean of 129.4 and a standard deviation of 13.3 (see Figure 4 for the distribution).

Survey and vignette. A questionnaire collected subject's demographic information and

FIGURE 3: Screenshot of example commitment question
($200 stakes, future bias, soft commitment)

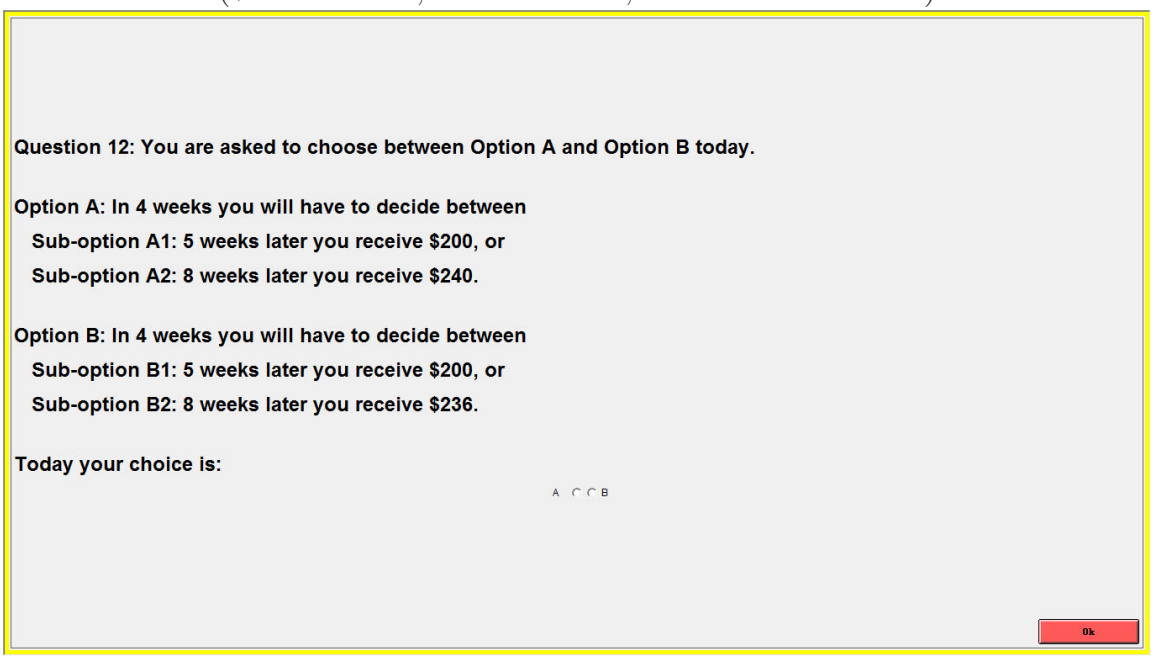
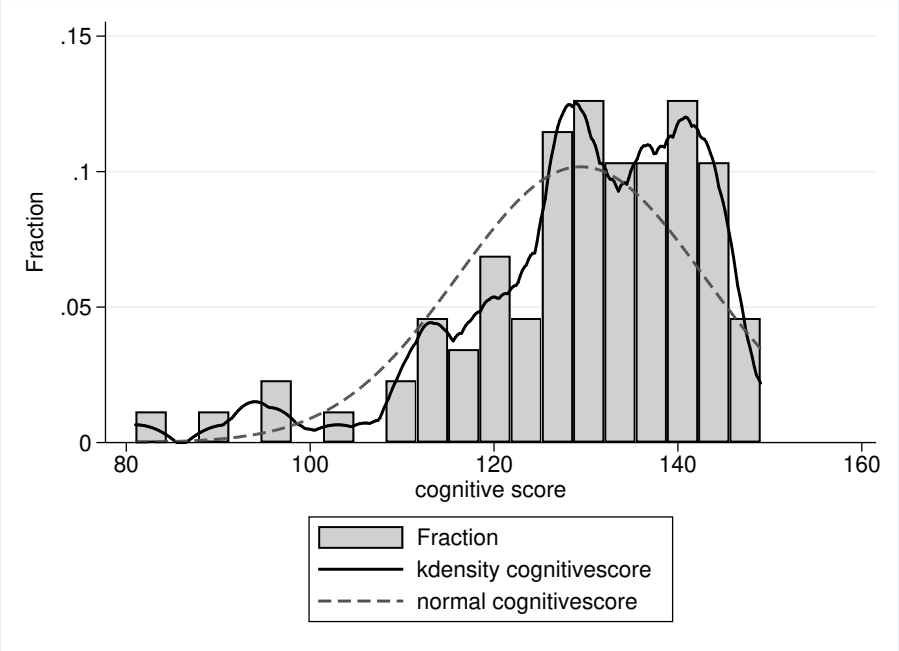


FIGURE 4: Distribution of cognitive scores



information on their real-world financial situations. We incentivized proper attention to the questions by including four control questions with obvious answers, where wrong answers (due to inattention) would attract a financial penalty.[9]

[9]Seven subjects answered 1 out of 4 control questions wrongly, no subject made more mistakes. In Appendix D we report whether excluding these seven subjects would affect the results of our analysis. It generally does

TABLE 5: Take-up rates of commitment options

Commitment question	Q	Pred for sophisticated biased subjects	Pred for naïve biased subjects	Take-up present-biased subjects	Take-up future-biased subjects
\$100 stakes, 1 week FED					
Strict commitment					
No cost for C	1	100%	indiff.	28.1%	31.0%
\$2 cost for C	2	dep. on tradeoff	0%	6.3%	6.9%
3 days cost for C	3	dep. on tradeoff	0%	18.8%	17.2%
3 days benefit for C	4	100%	100%	53.1%	55.2%
Soft commitment					
\$2 penalty on T	5	dep. on tradeoff	indiff.	0.0%	0.0%
\$6 penalty on T	6	dep. on tradeoff	indiff.	0.0%	0.0%
1 week penalty on T	7	dep. on tradeoff	indiff.	3.1%	0.0%
1 week penalty on T +3 days benefit for P	8	dep. on tradeoff	100%	50.0%	48.3%
\$200 stakes, 5 weeks FED					
Strict commitment					
No cost for C	9	100%	indiff.	31.0%	16.0%
\$4 cost for C	10	dep. on tradeoff	0%	3.4%	4.0%
3 days cost for C	11	dep. on tradeoff	0%	17.2%	8.0%
3 days benefit for C	12	100%	100%	51.7%	44.0%
Soft commitment					
\$4 penalty on T	13	dep. on tradeoff	indiff.	6.9%	4.0%
\$12 penalty on T	14	dep. on tradeoff	indiff.	3.4%	4.0%
1 week penalty on T	15	dep. on tradeoff	indiff.	3.4%	4.0%
1 week penalty on T +3 days benefit for P	16	dep. on tradeoff	100%	51.7%	32.0%

Notes: "C" stands for "deciding for the commitment option now", "T" refers to "choosing the tempting option in the future", and "P" refers to "choosing the (now) preferred option in the future." "Q" refers to the commitment question number.

The questionnaire also contained three binary questions in small vignette scenarios on real-life commitment behavior. One asked about the willingness to accept a commitment savings product, another about accepting a mutual bet to quit smoking, and a third one about a mutual bet to go to the gym regularly. We discuss details and results in Appendix E.

Experimental procedures. The experiment was conducted at the BizLab of the University of New South Wales with 87 subjects in 6 sessions, each lasting about 90 minutes. Subjects were recruited using ORSEE (Greiner, 2015). All parts of the experiment were programmed in zTree (Fischbacher, 2007) except for the questionnaire that was implemented in Qualtrics. Appendix F includes the experimental instructions.

not.

Experimental payoffs had three components. First, all subjects received a show-up fee of AU$5 and questionnaire fee of AU$5 (less any penalties for wrong answers to attention checks). Second, subjects received cash conditional on their performance in the cognitive test, on average AU$12.94. And third, 6 subjects were randomly selected for payoff of their time preference and commitment choices (they received AU$220 in 1 week, 2 x AU$200 in 7 and 12 weeks, and 3 x AU$240 in 11, 25, and 58 weeks, respectively).

Gift cards were chosen for the latter component in order to prevent potential arbitrage behaviors through investment of earned payoffs outside of the experiment (thus replacing endogenous waiting options). The gift cards from the Coles and Myer group, which run thousands of supermarkets and department stores in Australia, could also be partially used and thus functioned like cash earmarked for consumption. At the beginning of each session, we displayed the gift cards to all subjects, and declared that the Business School of the University of New South Wales guaranteed their experimental income, in particular delayed payments. The gift card payments were sent by Australian Express Post Platinum service to ensure arrival on the promised date.

B Commitment questions used in the experiment

Across each set of 8 questions we altered the design and cost of commitment. Four commitment questions C1, C2, C3, and C4 imposed a **strict commitment**, by limiting future choices to the now preferred alternative (based on elicited preferences), so there is no chance for temptation later. This option could be chosen for free (C1), come at a cost of \$2 (C2) or a (further) time cost of 3 days (C3), or could even carry a time benefit of 3 days (C4). A typical strict question (with a cost of \$2) would read:

> You are asked to choose between Option A and Option B today.
>
> Option A: *In 10 weeks you will have to decide between*
>
> *Sub-option A1: 1 week later you receive \$100 or*
>
> *Sub-option A2: 6 weeks later you receive \$130*
>
> Option B: *In 10 weeks you will have no choice, 6 weeks later your will receive* ***\$128****.*

To equalize transaction costs between options A and B, subjects who chose option B were also asked to send a confirmation message (no choice could be made) via email on the designated date.

The other four commitment questions C5, C6, C7, and C8 offered a form of **soft commitment**, which retained the choice flexibility but imposed a penalty on the tempting sub-option for the future self, making it less attractive. The costs are implicit, since they do not have to be incurred if commitment is successful and the current self's option is chosen in the future. The penalty imposed on choosing the tempting sub-option could be monetary costs of \$2 (C5) or \$6 (C6), a time cost of one week (C7), or the time cost of one week for choosing the tempting option combined with a reward of 3 days for choosing the option preferred by the current self (C8). A typical soft commitment option with a \$6 implicit cost would read:

> You are asked to choose between Option A and Option B today.
>
> Option A: *In 10 weeks you will have to decide between*
>
> *Sub-option A1: 1 week later you receive \$100 or*
>
> *Sub-option A2: 6 weeks later you receive \$130*
>
> Option B: *In 10 weeks you will have to decide between*
>
> *Sub-option B1: 1 week later you receive* ***\$94*** *or*
>
> *Sub-option B2: 6 weeks later you receive \$130.*

Assume a present-biased decision-maker who answered, when asked about her willingness to wait for \$130 vs. \$100 with a 1 week initial front-end delay, "7 weeks" for t and then "11 weeks" for t'. Then, we would use a $d = \lfloor \frac{t+t'-1}{2} \rfloor = \lfloor \frac{7+11-1}{2} \rfloor = 8$ weeks, such that the decision situation for which the participant is offered commitment contracts takes place in 7 weeks and is between \$100 in 7+1 weeks and \$130 in 7+1+8 weeks. The 8 different commitment questions presented to the participant were then:

C1 (strict commitment, no cost):
You are asked to choose between Option A and Option B today.
Option A: *In 7 weeks you will have to decide between*
Sub-option A1: 1 week later you receive \$100 or
Sub-option A2: 9 weeks later you receive \$130
Option B: *In 7 weeks you will have no choice, 9 weeks later your will receive \$130.*

C2 (strict commitment, \$2 cost):
You are asked to choose between Option A and Option B today.
Option A: *In 7 weeks you will have to decide between*
Sub-option A1: 1 week later you receive \$100 or
Sub-option A2: 9 weeks later you receive \$130
Option B: *In 7 weeks you will have no choice, 9 weeks later your will receive \$128.*

C3 (strict commitment, 3 days cost):
You are asked to choose between Option A and Option B today.
Option A: *In 7 weeks you will have to decide between*
Sub-option A1: 1 week later you receive \$100 or
Sub-option A2: 9 weeks later you receive \$130
Option B: *In 7 weeks you will have no choice, 9 weeks and 3 days later your will receive \$130.*

C4 (strict commitment, 3 days benefit):
You are asked to choose between Option A and Option B today.
Option A: *In 7 weeks you will have to decide between*
Sub-option A1: 1 week later you receive \$100 or
Sub-option A2: 9 weeks later you receive \$130
Option B: *In 7 weeks you will have no choice, 8 weeks and 4 days later your will receive \$130.*

C5 (soft commitment, $2 implicit costs):

You are asked to choose between Option A and Option B today.

Option A: *In 7 weeks you will have to decide between*

Sub-option A1: 1 week later you receive $100 or

Sub-option A2: 9 weeks later you receive $130

Option B: *In 7 weeks you will have to decide between*

Sub-option B1: 1 week later you receive $98 or

Sub-option B2: 9 weeks later you receive $130.

C6 (soft commitment, $6 implicit costs):

You are asked to choose between Option A and Option B today.

Option A: *In 7 weeks you will have to decide between*

Sub-option A1: 1 week later you receive $100 or

Sub-option A2: 9 weeks later you receive $130

Option B: *In 7 weeks you will have to decide between*

Sub-option B1: 1 week later you receive $94 or

Sub-option B2: 9 weeks later you receive $130.

C7 (soft commitment, 1 week implicit costs):

You are asked to choose between Option A and Option B today.

Option A: *In 7 weeks you will have to decide between*

Sub-option A1: 1 week later you receive $100 or

Sub-option A2: 9 weeks later you receive $130

Option B: *In 7 weeks you will have to decide between*

Sub-option B1: 2 weeks later you receive $100 or

Sub-option B2: 9 weeks later you receive $130.

C8 (soft commitment, 1 week implicit costs and 3 days benefit):

You are asked to choose between Option A and Option B today.

Option A: *In 7 weeks you will have to decide between*

Sub-option A1: 1 week later you receive $100 or

Sub-option A2: 9 weeks later you receive $130

Option B: *In 7 weeks you will have to decide between*

Sub-option B1: 2 weeks later you receive $100 or

Sub-option B2: 8 weeks and 4 days later you receive $130.

C Calculation of direct and implicit commitment costs

We calculate the size of direct and implicit costs of a (strict or soft) commitment option following Casari (2009)'s approach. We employ the simple interest rule under the assumption that utility is linear in money to compute the net present value of a commitment cost.

The "actual cost" of a (strict or soft) commitment option is the amount directly paid for being able to commit the future choice according to current preferences (i.e. to the larger-later payment for present-biased people or to the smaller-sooner payment for future-biased people, respectively). We express it as the relative loss in option B compared to option A in terms of net present value (NPV) on the preferred payment, calculated based on the observed impatience level in the relevant time preference sequence,

$\frac{NPV(L_A)-NPV(L_B)}{NPV(L_A)}$ for correcting present-bias, and

$\frac{NPV(S_A)-NPV(S_B)}{NPV(S_A)}$ for correcting future-bias.

The "implicit cost" of a (soft) commitment option is the penalty which is only imposed when the tempting choice is chosen in the future. That is, the "implicit cost" does not have to be paid if the commitment device works properly. We express it as the relative loss for the tempting payment alternative in option B compared to the tempting payment alternative in option A in terms of net present values, calculated based on the observed impatience level in the relevant time preference sequence,

$\frac{NPV(S_A)-NPV(S_B)}{NPV(S_A)}$ for correcting present-bias, and

$\frac{NPV(L_A)-NPV(L_B)}{NPV(L_A)}$ for correcting future-bias.

D Robustness checks for main regressions

Table 7 reports results from regressions similar to the ones reported in Table 3 in the main text, but which additionally control for subjects' demographic information.

As demographics controls we use "Liquidity-constrained" and "Has a credit card" as dummies indicating whether the subject would have difficulty to borrow $1000 within two weeks and uses a credit card, respectively, a gender indicator "Male" and a variable for "Age", whether the subject was born as an "Australian" or not, whether they have achieved a "Bachelor degree" or a "Master degree" (baseline is a High School degree), whether they study in a "Business/Economics major" or not, whether they are currently "Employed" or not, and a standardized score from a self-control assessment in the questionnaire (original scores range from 77 to 147, with a mean of 112.6 and a standard deviation of 15.5). Table 6 gives an overview over these variables.

TABLE 6: Means and standard deviations of demographic variables

Variable	Sample Mean	Standard Deviation
Age	21.7	2.8
Male (0/1)	0.529	
Australian (0/1)	0.299	
Employment (0/1)	0.356	
Bachelor (0/1)	0.172	
Master (0/1)	0.046	
Business major (0/1)	0.448	
Liquidity-constrained (0/1)	0.138	
Has a credit card (0/1)	0.448	
Self-control score	112.6	15.5

Including individual characteristics as independents does not change the interpretation of our main effects of interest, but demographics also contribute to explaining commitment decisions. Being liquidity-constrained is negatively related to commitment that allows to correct present-bias and positively related to commitment that allows to correct future-bias (significant only for higher stakes). Subjects who have achieved a bachelor's degree, compared to those with a high school degree, are less likely to commit. Older people are more likely commit to a present-bias correction (but keep in mind that the average age of our subjects is 21.7 with a standard deviation of only 2.8). Being an Australian and having obtained a Master degree are also detected as significant influences, but these seem not to be consistent across models.

We did several further robustness checks of our results. For example, we also ran a larger model that comprises data from all four cases and adds the independents "Commitment question type" (correcting present bias or future bias) and "Stake size". The results are basically

the same, with the only difference being that the coefficient for "Implicit costs" becomes significant, and that some coefficients on demographics (where they are inconsistently estimated across the four groups) become insignificant.

When we exclude seven subjects who made errors in control questions from our estimations reported in Table 3 and Table 7, then the interaction effects "TI × CogScore" in Models (2) are -0.111 and -0.129, and significant at the 5% and the 10% level, respectively. This, however, goes even contrary to our initial hypothesis of a positive interaction effect of time-inconsistency and cognitive performance.

TABLE 7: PROBIT ESTIMATIONS OF COMMITMENT OPTION ACCEPTANCE, INCLUDING DEMOGRAPHICS

	Correcting present-bias		Correcting future-bias	
	\$100, 1w	\$200, 5w	\$100, 1w	\$200, 5w
Model	(1)	(2)	(3)	(4)
Time-inconsistent (TI)	0.057	0.053	-0.013	0.017
	(0.052)	(0.058)	(0.061)	(0.048)
Cognitive Score	-0.018	0.024	0.06	0.036
	(0.027)	(0.028)	(0.044)	(0.028)
TI × CogScore	-0.019	-0.092	-0.027	0.015
	(0.048)	(0.060)	(0.060)	(0.052)
Patience level	0.004	-0.005	-0.001	-0.002
	(0.004)	(0.004)	(0.003)	(0.005)
Soft commitment	-0.131**	-0.109***	-0.132**	-0.047
	(0.061)	(0.039)	(0.064)	(0.052)
Actual cost	-7.112***	-8.694***	-5.973***	-11.682***
	(1.359)	(1.540)	(1.200)	(1.661)
Implicit cost	-0.972	-1.948**	0.729	-1.029
	(0.807)	(0.835)	(1.379)	(1.249)
Liquidity-	-0.068	-0.116**	-0.059	0.134*
constrained	(0.068)	(0.057)	(0.084)	(0.069)
Has credit card	0.038	-0.039	-0.041	-0.000
	(0.058)	(0.082)	(0.060)	(0.053)
Male	-0.046	-0.023	-0.002	-0.031
	(0.053)	(0.059)	(0.050)	(0.050)
Age	0.020**	0.019*	-0.017	-0.006
	(0.008)	(0.010)	(0.017)	(0.025)
Australian	-0.067	0.037	-0.096*	-0.001
	(0.057)	(0.087)	(0.058)	(0.089)
Bachelor degree	-0.112*	-0.103*	-0.001	-0.259*
	(0.062)	(0.057)	(0.068)	(0.142)
Master degree	-0.125***	-0.000	0.510**	omitted
	(0.046)	(0.106)	(0.231)	
Business/Ec major	0.066	0.065	-0.055	0.013
	(0.060)	(0.061)	(0.049)	(0.070)
Employed	-0.012	-0.045	0.074	0.077
	(0.053)	(0.056)	(0.051)	(0.047)
Self-control score	0.035	-0.010	-0.005	0.042
	(0.029)	(0.036)	(0.028)	(0.027)
#N observations	368	400	328	296
#N subjects	46	50	41	37
Log-Likelihood	-146.83	-160.86	-127.04	-83.10

Notes: We report average marginal effects. Robust standard errors are clustered at the subject level and given in parentheses.

E Analysis of survey vignette questions on real-life commitment behavior

Our post-experimental questionnaire also contained three binary questions in small vignette scenarios on real-life commitment behavior. One asked about the willingness to accept a commitment savings product, another about accepting a mutual bet to quit smoking, and a third one about a mutual bet to go to the gym regularly.

The first vignette question referred to the finance domain and was motivated by the field study conducted by Ashraf et al. (2006). It asked:

> If you were offered a saving product which does not allow you to withdraw funds until the funds on your account reach a goal date or target amount. Would you sign up for this?

The other two vignette questions addressed behavior in the health domain. One of them asked:

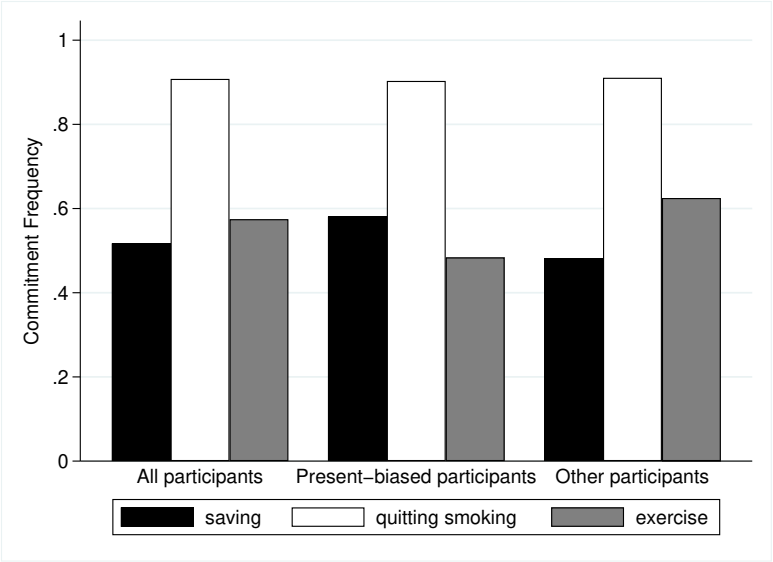
> Assume you are a smoker. You desperately want to quit smoking for better health. At the same time, a friend of yours also wants to quit smoking. Both of you plan to reduce nicotine intake over time and believe that in 10 weeks (a date agreed on by both of you) you will be smoke-free. Now, your friend offers you a bet: whoever is still smoking after the designated time will have to pay the other party $200. Would you take this bet?

The other question asked:

> Assume you intend to attend gym sessions regularly, but fail to do so due to discomfort after exercising. A friend of yours, experiencing the same situation, is willing to work out 3 times a week with you for the next month (on a date agreed on by both of you). S/He offers you a bet: whoever fails to stick to the plan will have to pay the other party $20 upon each time s/he does not go to the gym. Would you take this bet?

In the survey, 52% of subjects expressed interest towards the saving product, 57% would commit to do regular exercise, and 91% agreed to commit to quit smoking. Since the three commitment devices are targeted towards present-biased people, Figure 5 compares the commitment rates for the three questions between subjects identified to have present-bias and other people. We do not observe differences in commitment rates between present-biased and other people (Fisher's exact tests; $p = 0.502$, $p = 1.000$, and $p = 0.259$ for the savings, smoking, and exercise vignette question, respectively).

FIGURE 5: Commitment rates to questions



We use Probit regression models to analyze the interaction between being present-bias and having a high cognitive performance in explaining commitment take-up in the vignette questions. The independent "Present-biased" is an indicator whether the subject was classified as present-biased, or not. The "Patience level" here is the average waiting time across all 8 timed payment choices from Part 1 of the experiment.

Table 8 presents the results, separately for each of the three vignette questions. As before, our main interest is in the interaction effect "Present-biased × Cognitive Score". While for the contexts of quitting smoking and exercising the detected bias and measured cognitive performance cannot explain the take-up of a commitment device, for the decision to take-up a savings commitment product, our results are in line with the theoretical prediction. The interaction effect between present bias and cognitive score is positive and statistically significant while the two main effects are not different from zero.

We also ran a number of robustness tests for the Probit regressions reported in Table 8. Demographic characteristics only played a role for exercise commitment choices. In none of the three models their inclusion affected the estimates of the interaction effect. In addition, we explored the correlation between laboratory commitment behavior and answers to the vignette questions, and found no relation. When we exclude 7 subjects who made errors in control questions from the analysis, we find no changes for smoking and exercise commitment questions (other than the coefficient for *Patience level* for Exercising shifting significance level from 10% to 5%). For saving commitment decisions, the interaction term stays significant at the 1% level, but additionally the estimated marginal effect of *Present-biased* is positive and significant at the 10% level.

TABLE 8: Probit regression results on likelihood to take up commitment in the three vignette questions

Commitment context	Savings	Quitting smoking	Exercising
Present-biased	0.098	-0.049	-0.177
	(0.108)	(0.072)	(0.108)
Cognitive Score	-0.010	0.016	-0.033
	(0.051)	(0.028)	(0.054)
Present-biased × Cognitive Score	0.259***	-0.067	0.018
	(0.105)	(0.082)	(0.113)
Patience level	-0.006	-0.007**	-0.011*
	(0.006)	(0.003)	(0.006)
N	87	87	87
LL	-56.75	-22.93	-56.74

Note: Standard errors are given in parentheses.

However, we are very hesitant to interpret these results as evidence for our main hypothesis that cognitive ability of time-inconsistent subjects is positively correlated with the take-up of commitment devices. First of all, these are all hypothetical choices and not real choices as the ones we analyze in our main manuscript. Second, as Figure 5 shows, we do not observe different answers in these questions for present-biased and other participants. And third, the significant interaction effect is only found for one out of the three vignette questions. Thus, the observed effect might be a fluke of the data rather than a reliable result.

F Experimental instructions

F.A General Instructions

Welcome and thank you for participating in this experiment.

These instructions are the same for all the participants. From now on, please do not communicate with other participants. If you have a question please raise your hand. One of the experimenters will attend to you and answer your questions. Please switch your mobile phone off now. Please use the computer only for entering your decisions. Please only use the pen and forms provided. Don't start or end any programs, and do not change any settings. If you don't conform to these rules during the experiment we will have to exclude you from the any payoffs.

To ensure privacy of choices, each participant is seated in a cubicle. The experiment will be conducted by participants entering their choices via computers that are located in those cubicles.

This experiment consists of 4 different parts.

You are paid a show-up fee of $5, a reward conditional on your performance in part 3 of the experiment, and a $5 flat-fee for filling in a questionnaire in part 4.

Additionally, at the end of this experiment one participant will be randomly drawn. This participant is paid according to one of his/her choices in either part 1 or part 2, randomly selected, with payoffs ranging from $100 to $240. If you are the selected participant, your rewards will be paid with a Myers & Coles gift certificate. The ASBLab will send the gift certificate to you by post. "A payment in 1 week" means the certificate will be sent to you in 6 days and arrive at your address in 7 days (exactly one week). "A payment in t weeks and 2 days" means the certificate will be sent to you in t weeks and 1 day and arrive at your address in t weeks and 2 days. Please note that we send the gift certificates by Australian Post "Express Post Platinum" and thereby make sure that your gift certificate(s) will arrive at your address on the exact date.

F.B Instructions for Time Preferences Elicitation

In this part of the experiment, you will be asked to make a series of choices between alternatives concerning different valued gift certificates which you will receive at different points in time.

You will encounter 16 different choice sets (computer screens), each of which consists of 26 simple choices. Each choice asks you to make a decision between "Payment Alternative A" and "Payment Alternative B". "Payment Alternative A" is always a smaller-valued gift-certificate receivable in the near future while "Payment Alternative B" is always a larger-valued gift-certificate receivable some time later. On each screen (choice set), the amounts of gift cards A and B and the payoff time of gift card A are fixed, and the only thing which changes from one row to the next row is the time when you receive gift card B.

To enforce consistency among your choices on one screen, we will assume that if you prefer gift card A over gift card B when gift card B is paid in X weeks, then you also prefer A over B in X+1 weeks. In other words: Whenever you choose A over B, we will assume that in all rows below you also prefer A over B, and whenever you choose B over A we will assume that in all rows above you prefer B over A. The computer will correct this automatically on the screen whenever you make a choice.

At the end of the experiment one of your 16x26 choices will be selected for payoff. (We will first randomly select one out of 16 choice sets, and then randomly select one choice row out of the 26 choice rows in this set.) This choice will be implemented according to your decision. So, for example, if "choice set 8, choice row 14" is randomly selected, then we will look at your decision in set 8, choice 14. If you chose A, you will receive Payment Alternative A in that choice, if you chose B, you will receive Payment Alternative B in that choice.

As a result, each of your choices is equally likely to be selected for payoff. So you should carefully think about each choice, because it may be selected and your decision implemented exactly as described.

At the end of the experiment, one of the participants in this session will be randomly selected and paid out either for Part 1 according to the procedure described above, or for Part 2.

F.C Instructions for Commitment Questions

For this part of the experiment we will ask you to make choices on two separate days: one today during the experimental session, and the other at a specified later date.

Today you are asked to choose between Option A and Option B.

Some days later (the exact number of days will be displayed on the screen) we will contact

you by email. If you have chosen Option A today, we will later ask you to decide between Option A1 and Option A2. If you have chosen Option B today, we will later ask you to decide between Option B1 and B2 when they are available.

For example, the choice today could be:

Option A: *In 10 weeks you will have to decide between*
A1: right then you receive $100, or
A2: 13 weeks later you receive $130.

Option B: *In 10 weeks you will have no choices, 13 weeks later you will receive $130.*

Basically, choosing Option B means that you commit to getting a $130 certificate in 10 + 13 weeks. When you choose Option A you don't commit, and will choose in 10 weeks whether you take a $100 certificate right then or you wait a further 13 weeks to get a $130 certificate.

As another example, your choice today could be:

Option A: *In 3 weeks you will have to decide between*
A1: 5 weeks later you receive $200, or
A2: 20 weeks later you receive $240.

Option B: *In 3 weeks you will have to decide between*
B1: 5 weeks later you receive $196, or
B2: 20 weeks later you receive $240.

Here choosing Option B basically assigns a penalty of $4 to yourself in case in 3 weeks you choose to get the certificate of $200 in 5 weeks instead of waiting a further 20 weeks for the certificate of $240.

All your choices in this part will be similar to these two examples. Altogether you will make 16 choices.

After finishing the experiment, one of you will be randomly selected and paid out according to one of his/her choices in either Part 1 or Part 2. That is, if you are the selected participant to be paid out in Part 2, then we will check whether you chose Option A and Option B at the

selected choice. According to your choice, we will contact you in the specified number of weeks by email (asblabexperiment@gmail.com) and let you choose between Sub-options A1 and A2 (if you selected Option A today), or Sub-options B1 and B2 (if you selected Option B today).

Please note that what amount you will be rewarded and at which time point depends on what you choose in the experiment.

F.D Instruction for Test of Cognitive Ability

In this section, you need to try to remember a sequence of letters which appear on the computer screen and at the same time solve simple math problems. The better you are in this task, the more you will earn.

The specific instruction for this section will be presented on the screen. This section consists the practice part and the real trials. The practice part helps you get familiar with what to expect, and will not be paid. In the real trials, your payment will depend on your performance. Here is how you get paid in the real trials:

For the subtask of recalling letters, you will get 10 cents for each correctly remembered letter.

For the subtask of solving math problems, the benchmark is 50 percent. If you answer more than 50 percent of math questions correctly, then you will receive 20 cents for each correct answer above 50 percent. If you get less than 50 percent of math questions correctly, you will be deducted 10 cents for each wrong answer below 50 percent.

There are different versions of this section, so other participants will not be remembering the same letters and calculating the same math problems as you are.

Please complete this test quietly. You are not allowed to make any notes on paper, or to communicate with other participants.

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