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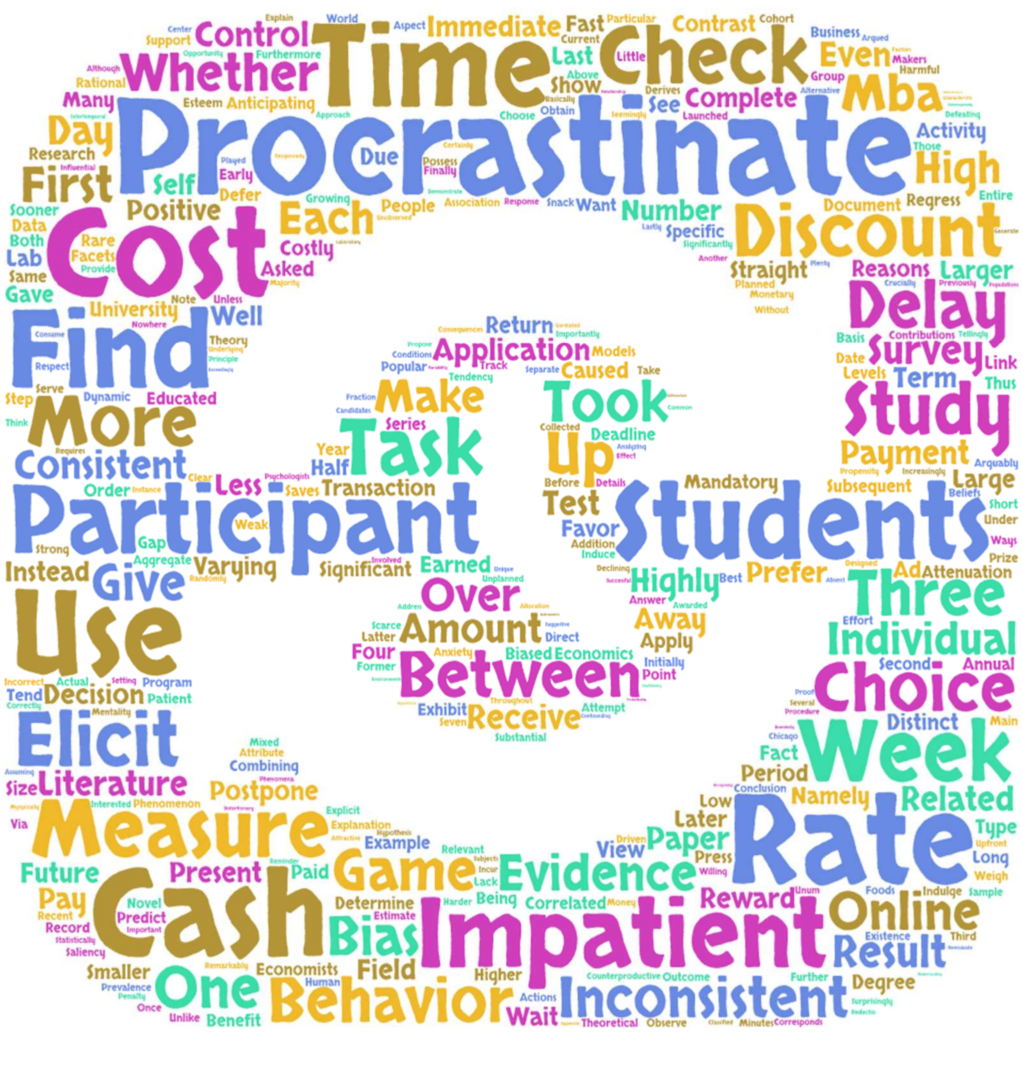

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Abstract

We use a combination of lab and field evidence to study whether highly-impatient individuals are more likely to procrastinate. To measure impatience, we elicit individual discount rates by giving participants choices between smaller-sooner and larger-later rewards. To measure procrastination, we record how fast participants complete three tasks: an online game, their application to the university, and a mandatory survey. We find that, consistent with the theory, impatient individuals procrastinate more, but only in tasks where there are costs to delay (the online game and university application). Since we paid participants by check to control for transaction costs, we are also able to determine whether the participants' cashing behavior is consistent with the timing of their payment choice. We find substantial evidence of time inconsistency. Namely, more than half of the participants who received their check straight away instead of waiting two weeks for a reasonably larger amount, subsequently took more than two weeks to cash it.

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Keywords: procrastination, impatience, hyperbolic discounting, discount rates, time inconsistency

JEL Classification: D01, D03, D90.

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1 Introduction

Many studies document the prevalence of two arguably harmful behaviors: procrastination and impatience. The tendency for people to give up large future rewards in favor of smaller immediate ones is well documented (for a review see Frederick et al., 2002). In addition, a growing number of studies show that people tend to procrastinate, that is, to defer actions or tasks to a later time with counterproductive consequences (Ariely and Wertenbroch, 2002; DellaVigna and Malmendier, 2006; Choi et al., 2006; Burger et al., 2011). Most economists view these behaviors as two facets of the same phenomenon. Highly impatient individuals weigh immediate costs more and delayed benefits less and thus postpone activities where costs are upfront and indulge in activities where costs are delayed (O'Donoghue and Rabin, 1999a,b, 2001).[1] While this view is increasingly popular (e.g. see, Frederick et al., 2002; Bernheim and Rangel, 2005; Loewenstein and O'Donoghue, 2005; Steel, 2007), there is no direct behavioral evidence supporting it. In this paper we use data collected under controlled conditions to test the existence of a link between procrastination and impatience.[2] Furthermore, we do so for a group of highly-educated and relevant decision makers in the world of business, namely, University of Chicago MBA students.

To elicit the degree of impatience, we asked an entire cohort of MBA students, who previously earned between $0 and $300, whether they wanted to receive a check with their earnings immediately or with a higher amount in two weeks time. By varying the size of the delayed amount we get an estimate of each participant's (short-term) discount rate. Like many other studies, we find that participants in our sample exhibit high degrees of impatience: 64.8% of them give up a 2% return over two weeks, which in annual terms corresponds to a discount rate of 67%, in order to receive their earnings without delay. Remarkably, 13.4% of them are not willing to wait even for a 12% two-week return (corresponding to an annual discount rate of 1,804%).

We measure the participants' propensity to procrastinate in three ways. First, we launched an online game that lasted 20 minutes and gave students four weeks to participate in it. Crucially, for

[1] By contrast, a large number of psychologists and the popular press attribute procrastination to anxiety, low self-esteem, and a self-defeating mentality (see e.g., Chissom and Iran-Nejad, 1992; Schouwenburg, 1992; Bandura, 1997; Sapadin and Maguire, 1997; Burka and Yuen, 2008). For an alternative explanation in the economics literature, see Akerlof (1991) who derives procrastination from the saliency of current costs.

[2] Some economists make a further distinction between 'procrastination' and 'delay'. The former being unplanned postponement of an activity caused by incorrect beliefs, and the latter being a planned decision to postpone correctly anticipating future behavior. Throughout the paper, we do not make this distinction and use the term procrastination for both types of postponements.

each of the first three weeks of the game, a prize was randomly awarded to one of the students who had participated up to that point. The declining benefit of participation was designed to induce an explicit cost to procrastination. As a second measure, we use the date students applied to the MBA program. Each year, students have three separate time periods, each with a specific deadline, in which to apply to the program. Procrastinating on one's application is costly in that an early response saves candidates the cost of other applications. Finally, as the third measure, we use the number of days students took to answer a mandatory survey. Unlike the first two measures of procrastination, students had to complete the survey before the deadline but there was no penalty for completing it on the last day, which makes procrastinating less costly.

When we use the online game or the application period to measure procrastination, we find a strong and positive relation between impatience and procrastination. By contrast, the relation between impatience and the survey measure of procrastination, although positive, is weak and is not statistically significant. These results give support the conclusion of O'Donoghue and Rabin (1999a) that procrastination is the result of high levels of impatience and costs of delay.

A novel characteristic of this study is that instead of paying participants in cash, we choose to pay them by check. This procedure gives us the opportunity to observe yet another aspect of the participants' behavior, namely how long they take to cash the check. In particular, we are interested in analyzing whether the participants' cashing behavior is consistent with their choices in the discount rate elicitation task. Evidence of dynamically inconsistent choices is rare (Dohmen et al., 2012).[3] In fact, recent research using monetary payments in controlled environments finds little to no aggregate evidence of time inconsistency (e.g., Andreoni and Sprenger, 2012; Sutter et al., 2013; Halevy, 2015). By contrast, we find a large fraction of students who make seemingly inconsistent choices. Specifically, among students who gave up an attractive rate of return (above 2% over two weeks) and received their check straight away, a majority of them (57.8%) took more than two weeks to cash it; some of them (31.4%) even took more than four weeks.

In order to determine whether the surprisingly high amount of inconsistent behavior is due to impatient individuals who procrastinate in cashing their checks, we regress the number of days students took to cash their check on their elicited discount rate as well as each of the three measures of procrastination. We initially obtain mixed results. While the measures of procrastination are significantly correlated with the students' cashing behavior, the elicited discount rate is not. However, as

[3]The two best examples are Read and van Leeuwen (1998) who find inconsistent choices over time with respect to snack foods and Augenblick et al. (2015) who find evidence of inconsistency in the allocation of effort over a seven week-period.

we demonstrate by modeling the students' choices assuming they possess present-biased preferences (Strotz, 1956; Laibson, 1994), this lack of significance could be due to the attenuation bias caused by unobserved heterogeneity in the costs of cashing the check. Consistent with this hypothesis, a two-step regression approach where we first regress the discount rate on the three measures of procrastination and then reevaluate the relation between the discount rate and the days to cash the check results in a positive and significant association between the two.

The rest of the paper proceeds as follows: Section 2 describes the data used; Section 3 evaluates the association between the three measures of procrastination and impatience; Section 4 analyzes the students' cashing behavior and its relationship with our measures of impatience and procrastination; and Section 5 concludes.

2 Data

In this paper, we utilize data from the Templeton-Chicago MBA longitudinal study (TCMLS). As part of a long-term research project on individual characteristics and economic success, the TCMLS collects data from the 2008 MBA cohort at the University of Chicago Graduate School of Business (see Reuben et al., 2008). In the paper, we restrict our analysis to the 284 students who participated in all the activities related to this study. In Appendix B, we evaluate whether there was selection into the different parts of the study by comparing the observable characteristics of students who completed all activities and those who did not.[4] By and large, we do not find differences between the two samples.

2.1 Measuring impatience

As our measure of impatience, we use the participants' short-term discount rate, which was elicited in a laboratory experiment run in October 2006. The experiment consisted of two lotteries, five games, and a task designed to measure short-term discount rates. The games were played in the following order: lottery with losses, asset market game, trust game, competition game, chocolate auction, social dilemma game, and lottery without losses. The games were programmed in z-Tree (Fischbacher, 2007) and played in four groups in four large classrooms. In order to give students an incentive to take their decisions seriously, they were paid according to their performance. One of the games was randomly drawn and participants were paid according to their earnings in that

[4]Out of 475 participants who consented to the use of their admissions data, 432 completed the discount rate elicitation task, and 284 participated in the online game.

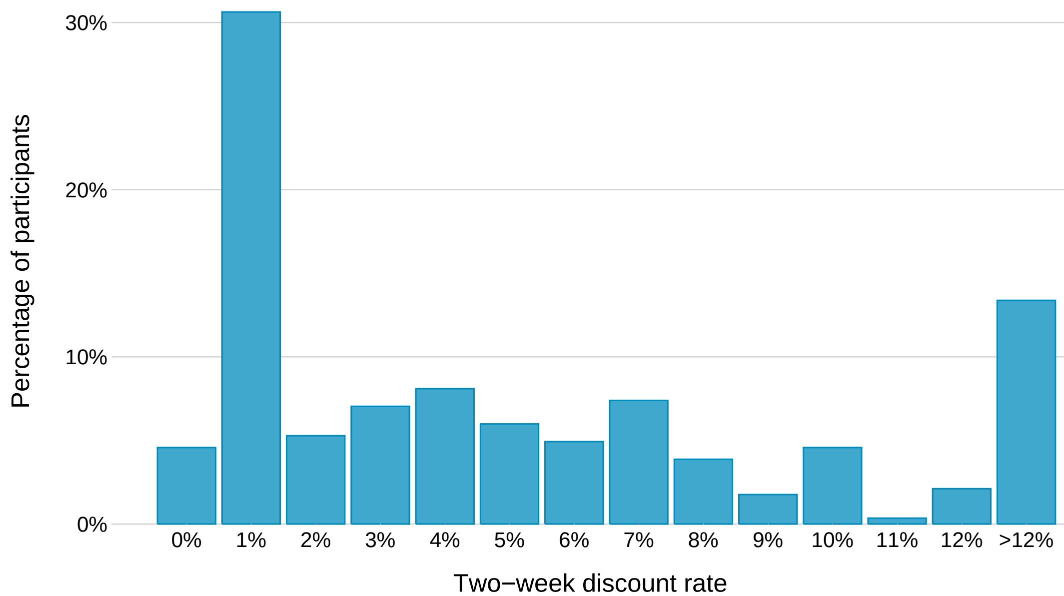

Figure 1: Distribution of the the participants' elicited two-week discount rate

game. Students who participated in the experiment earned on average \$78.32 in addition to a \$20 show-up fee, which was paid in cash at the beginning of the session. In this paper we concentrate on the task designed to measure short-term discount rates. A short summary of the procedures and the instructions of this task are available in Appendix C. For a description of the other games see Reuben et al. (2008).

We elicit short-term discount rates by giving participants a series of simple choices of the following type: receive x dollars today or receive $(1 + r)x$ dollars in two weeks, where x equaled each participant's earnings in the abovementioned experiment. Each participant answered thirteen questions, with r varying from 0 to 0.12 in steps of 0.01. At the end, one of the questions was randomly selected and implemented. If, for a given r and x, a participant prefers x dollars today, we can infer that she is willing to sacrifice $r\%$ of earnings in order to receive the payment today instead of in two weeks. Thus, by varying r and observing the point where participants switch from payment today to payment in two weeks, we get a small interval (of 0.01 width) that contains each individual's short-term discount rate. Throughout the paper, we refer to the switching value of r as an individuals discount rate, although it should be understood that the actual discount rate lies in the interval $[r - 0.01, r]$. We chose this procedure because it is incentive compatible and simple to understand. In this sense, it is encouraging that, even though we did not restrict the participants' choices, none switched in the "wrong" direction (from late to early delivery).

Figure 1 plots the discount rate (over two weeks) at which students switched towards the late delivery. Roughly one third of the students switch at 1%, which, in the absence of other considerations, is the level a rational exponential discounter is expected to choose. However, two thirds exhibit a larger discount rate, with almost 15% of the students not switching even at the 12% rate, which in annual terms corresponds to a discount rate of 1,804%. Table 1 reports the summary statistics for this variable, where we impose a discount rate equal to 13% on all the students who did not switch (even for $r = 12\%$).

The use of monetary rewards to elicit discount rates has been criticized (Cubitt and Read, 2007) because access to credit may disassociate money from consumption, and thus rational individuals who can borrow should discount monetary rewards at the borrowing rate, independently of their own time preference. Recent studies, however, do suggest that money can be used to observe time preferences. In particular, recent neurological data shows that, when making intertemporal choices, individuals display activation in the same limbic areas of the brain irrespective of whether the choice involves monetary (McClure et al., 2004) or primary rewards (McClure et al., 2007)—in particular, the ventral striatum, the medial prefrontal cortex and the posterior cingulate cortex (Kable and Glimcher, 2007).

Taken together, this evidence suggests that, regardless of the time of actual consumption, participants enjoy receiving the carrier of reward (Knutson et al., 2001), and hence, they can show impatience toward the carrier itself. We corroborated this hypothesis in a separate experiment where we find a positive and statistically significant correlation between the discount rate for a monetary reward and the discount rate for a primary reward (chocolate) (Reuben et al., 2010).[5] Lastly, discount rates elicited in the laboratory have been found to be correlated with behavior in the field (e.g., Chabris et al., 2008; Meier and Sprenger, 2010).

2.2 Measuring procrastination

We use three measures of procrastination, each derived from actual behavior in a task where participants face a short-term cost that delivers a long-term benefit. In the first two measures, the benefit of completing the task clearly decreases with delay. By contrast, in the third measure, the benefit of completing the task is unaffected by the time of completion. Each variable is described below.

[5] The correlation is not present for participants who are not hungry and/or do not like chocolate. This evidence suggests that money is not only suitable for the study of time preferences, but might be more reliable than primary rewards given the confounding effects associated with the use of primary rewards (e.g., differences in taste, hunger, satiation, and divisibility problems).

Table 1: Summary statistics

	Mean	**Median**	**Std. Dev.**	**Min**	**Max**
Measures of Impatience					
Two-week discount rate	5.018	4.000	4.335	0.000	13.000
Two-week discount rate ≤ 1	0.352	0.000	0.478	0.000	1.000
Measures of Procrastination					
Days before the application deadline	86.128	71.861	44.266	0.078	160.525
Deadline used for the application	1.803	2.000	0.632	1.000	3.000
Days before the online game deadline	20.731	20.833	7.283	-0.104	28.479
Week of participation in the online game	1.704	2.000	0.835	1.000	4.000
Days before the survey deadline	7.604	7.621	5.139	0.000	16.669
Other variables					
Money at stake	82.861	80.000	54.274	2.000	260.000
Female	0.327	0.000	0.470	0.000	1.000
CRT score	2.472	3.000	1.290	0.000	4.000
Trust	0.539	1.000	0.499	0.000	1.000

The online game

As our first measure of procrastination, we utilize the time it took participants to complete an online game. In March 2008, an online game with the same cohort of students was launched. Participants had to guess, by looking at old facebook pictures, who were the most successful alumni of the University of Chicago MBA program. The participant with the highest number of correct answers received a $1500 prize. Participants had four weeks to complete the 20-minute game. More importantly for this paper, at the end of each of the first three weeks of the game, an additional prize (a free iPhone worth $500) was randomly awarded to one of the participants who had completed the game up to that date (each participant had an equal chance of winning and winners were not excluded from future draws). Thus, participants who completed the game in the first week took part in three draws, those who completed it in the second week took part in two draws, and those who completed it in the third week took part in one. This declining benefit of participation was designed to separate, to some degree, participants who procrastinate from participants who do not.

As we can see from Figure 2, a disproportionate number of those who participated (86.27%) completed the game in the first two weeks: 48.59% in the first week and another 37.68% in the

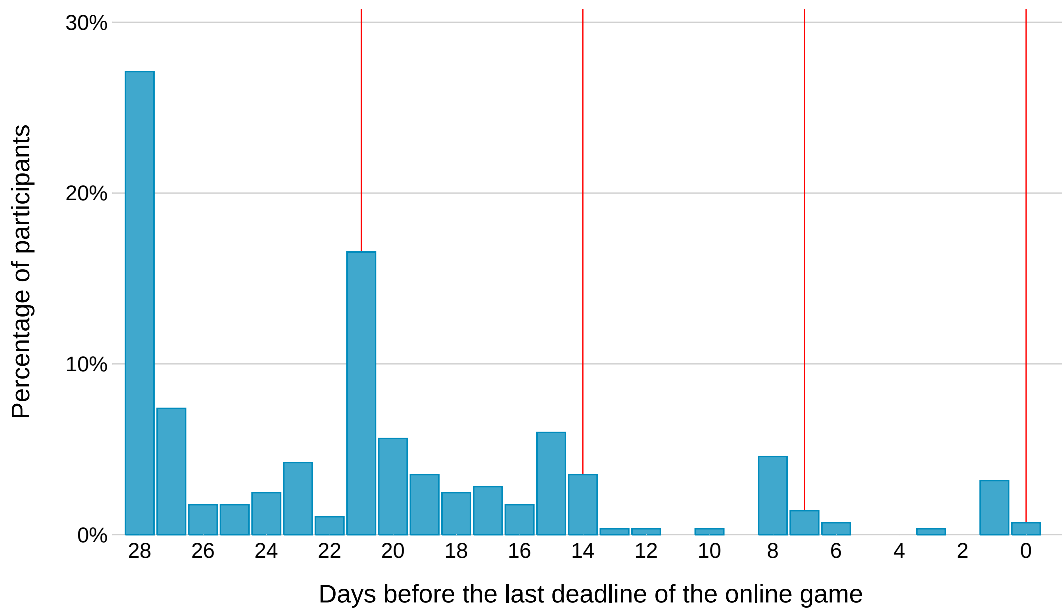

Figure 2: Distribution of the day in which participants completed the online game

Note: Days are measured from the last deadline (May 14th 2008). The red vertical lines indicate the four deadlines.

second one. If the cost of participation is constant over time, there is no reason for a participant who did not participate in week one to participate in week two. Even allowing for variation in the cost of participating, compared to first-week participants, later-week participants are more likely to have suboptimally postponed taking part in the game.

This task has the advantage that we have a measure of the long-term benefit (i.e., the chance of winning $1500 and iPhones) and the disadvantage that we do not know the value of the short-term cost (i.e., the cost of taking part in the game). However, in this case, we do have a clear indication of how much the benefit decreases with delay, and importantly, we know that the decrease is the same for all participants. The problem with this variable is that we do not know whether students who did not take part in the game were simply not interested, or if they were people who procrastinated to the point that they missed the last deadline.

Application timing

As in many other schools, prospective students to the University of Chicago MBA program have three separate time periods to apply to the program. Each period has a specific deadline: one in the middle of October, the second at the beginning of January, and the third in the middle of March. The advantage of an early application is an early response. Most students who apply at the earlier

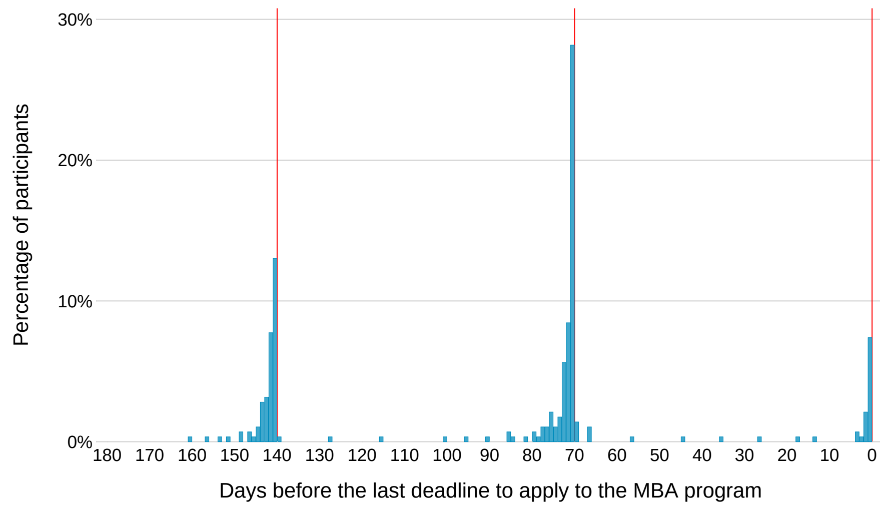

Figure 3: Distribution of the day in which participants applied to the MBA program

Note: Days are measured from the last deadline (March 15th 2006). The red vertical lines indicate the three deadlines.

deadlines receive an answer before the next deadline. This gives them the opportunity to adjust their application strategy and save application costs. As Figure 3 shows, 30.32% of the applicants adhere to the first deadline, 57.64% to the second, and 12.04% adhere to the last.

The MBA application is an attractive measure as it constitutes a very important decision in the life of these students. However, it has the disadvantage that we have a lot less control concerning the costs and benefits. For example, some students might have applied to other schools first and might have been waiting to hear from them before applying to the University of Chicago. Furthermore, we have no way of knowing whether missing the first deadline has the same cost as missing the second deadline. Lastly, students admitted at different deadlines might differ in important ways. For instance, students that apply to the last deadline might be doing so because they are less qualified and need more time to prepare a strong application. Using other variables described below, we do find that students admitted at different deadlines significantly differ in their gender (χ^2 tests, $p = 0.034$) and almost do so in the CRT score (Kruskal-Wallis rank test, $p = 0.114$). Hence, we control for these variables in our subsequent analysis.

2.3 The survey

The last measure of procrastination is the time participants took to complete an online survey. The survey was made available in mid August 2006 and students were given 18 days to complete it. The survey was a requirement for a course, so students where obliged to complete it. However, there

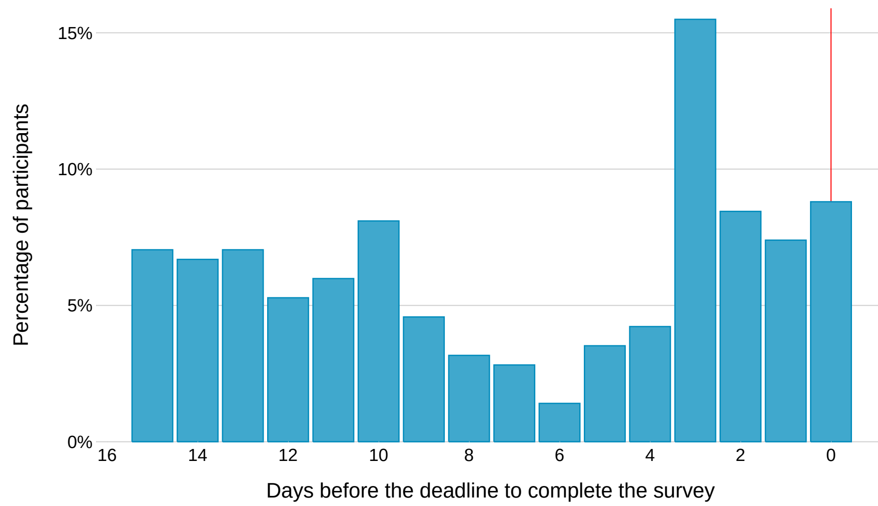

Figure 4: Distribution of the day in which participants completed the survey

Note: Days are measured from the deadline (October15$^{\text{th}}$ 2006). The red vertical line indicates the deadline.

was no penalty for waiting until the last minute to finish it. A cost to delay is a crucial element of the theories that predict procrastination as a consequence of high levels of impatience (O'Donoghue and Rabin, 1999a,b), hence having a measure of procrastination that is not affected by costs to delay allows us to test whether the absence of such costs weakens the link between procrastination and impatience.

As we can see in Figure 4, 47.89% of the participants completed the survey in the first nine days while the remaining 52.11% completed it in the last nice days with 40.14% doing it in the last four. This pattern is strikingly different from the online game, where most students (86.27%) completed it early on. However, the difference is consistent with students understanding that there is a cost to delay in the latter but not in the former.

2.4 Other variables

The remaining data was collected in the abovementioned online survey. The survey was designed to acquire demographic data and measure various personality traits (the questions used are available in Reuben et al., 2008). In this paper we concentrate on three variables: trust, cognitive ability, and gender.

We want to control for trust because it is possible that distrustful individuals will trust the experimenters less and therefore will be less willing to wait two weeks for payment. Trust was measured using the standard question from the World Values Survey: the answer "Most people can be trusted" to the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?"[6] Table 1 shows sample statistics for this variable: 54.40% of the students responded that most people can be trusted.

Frederick (2005) and Benjamin et al. (2013) show that cognitive reflection is related to discount rates. Consequently, in our analysis, we also control for cognitive reflection. Following Frederick (2005), we measure cognitive abilities using the Cognitive Reflection Test (CRT). To simplify the test, we conducted a pilot study using University of Chicago MBAs and PhDs and selected the four most challenging questions of the ten suggested by Frederick (2005). These four questions were then administered to our entire sample.[7] Sample statistics for the CRT scores are in Table 1: the average student answered 2.47 out of 4 questions correctly.

Lastly, we also control for gender as there is some evidence that women exhibit lower degrees of impatience in tasks such as the one used in this paper (e.g., Kirby and Maraković, 1996; Coller and Williams, 1999; McLeish and Oxoby, 2007). As seen in Table 1, 32.75% of our sample are women.

3 Procrastination and impatience

Is there a correlation between the rate of impatience inferred from the time a student chooses to receive her earnings and our measures of procrastination? Table 2 answers this question by regressing each student's two-week discount rate on the measures of procrastination.[8] Since each value of the discount rate falls within a range of values (e.g., between 4% and 5%) and, at the extremes, is censored from below at $r \leq 1\%$ and above at $r \geq 13\%$, we estimate these regressions with an interval regression (robust standard errors are reported in parentheses).

In column A, the measure of procrastination is the week in which students participated in the online game. As expected, students who participated in the online game in later weeks have a higher discount rate. The effect is economically meaningful: each week of delay in participation is

[6] The other answers are "Can't be too careful" and "Don't know".

[7] The questions are "1. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?"; "2. If you flipped a fair coin 3 times, what is the probability that it would land heads at least once?"; "3. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?"; "4. Two cars are on a collision course, traveling towards each other in the same lane. Car A is traveling 70 miles an hour. Car B is traveling 80 miles an hour. How far apart are the cars one minute before they collide?"

[8] We use the discount rate as the dependent variable as this is more in line with the way the model is constructed. However, all the results in the paper hold if instead we run the regressions with the measures of procrastination as dependent variables.

Table 2: Impatience and procrastination

Note: The dependent variable is the participants' two-week discount rate. The table presents interval regressions censoring at $r \leq 1$ and $r \geq 13$. All regressions contain 284 observations. Robust standard errors are in parentheses. *,**,*** indicate statistical significance at the 10, 5, and 1 percent level.

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Week of participation in the online game	0.604				1.082**			
	(0.518)				(0.487)			
Applied on the 2^{nd} deadline		1.071				0.531		
		(0.981)				(0.893)		
Applied on the 3^{rd} deadline		3.536**				2.997**		
		(1.461)				(1.432)		
Days to complete the survey			0.096				0.099	
			(0.089)				(0.081)	
Common procrastination factor				0.968**				1.115***
				(0.439)				(0.414)
Money at stake					-2.621***	-2.411***	-2.476***	-2.547***
					(0.497)	(0.504)	(0.498)	(0.499)
Female					-0.424	-0.765	-0.391	-0.353
					(0.839)	(0.858)	(0.848)	(0.835)
CRT score					-0.428	-0.518*	-0.446	-0.415
					(0.308)	(0.309)	(0.312)	(0.307)
Trust					-1.650**	-1.716**	-1.598*	-1.685**
					(0.836)	(0.839)	(0.838)	(0.832)
Constant	2.341**	2.352***	2.468***	3.371***	14.489***	14.865***	15.119***	15.988***
	(1.011)	(0.767)	(0.961)	(0.451)	(2.507)	(2.577)	(2.577)	(2.444)
Wald χ^2	1.360	5.870	1.167	4.869	37.153	31.853	31.207	36.633

associated to an increase in the discount rate of 0.60 percentage points. The coefficient, however, is not statistically significant ($p = 0.243$).

In column B, the measure of procrastination is the deadline the students adhered to when they applied to the MBA program. As discussed in Section 2, since we do not know whether missing the first deadline has the same cost as missing the second deadline, we inserted two dummy variables, one for students who adhered to the second deadline and another for those who adhered to the third (i.e., the omitted category corresponds to students who complied with the first deadline). We can see that later applicants have higher discount rates. For students who adhered to the second deadline, this effect is again economically meaningful but not significantly different from zero ($p = 0.275$). However, for students who adhered to the last deadline, the effect is both large and statically significant: they exhibit a discount rate that is 3.54 percentage points higher than students who adhered to the first deadline ($p = 0.016$).

Column C presents the results of using the third measure of procrastination: the number of days to complete the survey. The coefficient is positive, indicating that students who completed the survey closer to the deadline have higher discount rates. However, the effect is modest—a one standard deviation increase in the number of days implies an increase in the discount rate of around 0.50 percentage points—and is not statistically significant ($p = 0.280$). The fact that we find a weaker effect for the survey measure of procrastination compared to the other two measures suggests that costs to delay are necessary for impatience to have a noticeable impact on procrastination, as modeled by O'Donoghue and Rabin (1999a,b).

As an alternative approach, instead of using separately our measures of procrastination, we use factor analysis to extract a primary common factor from our three measures of procrastination. The results of running an interval regression with this common factor (normalized to have a mean of zero and a standard deviation of one) is seen in column D. It shows a positive and statistically significant relationship between procrastination and impatience ($p = 0.027$).

In columns E through H, we control for other potential determinants of the intertemporal trade-off. The first variable is the amount of money at stake, which we include because numerous studies that varied the size of the reward find that bigger rewards are discounted less than smaller ones (see references in Frederick et al., 2002). Consistent with these studies, we find a significant effect for the money at stake—in fact we use the logarithm of the money at stake as this gives a better fit. A one standard deviation increase in the amount of money at stake (which equals approximately $55) is associated with a significant decrease of about 2.50 percentage points in the elicited discount rate ($p < 0.001$).[9] The second variable is gender: women appear to be more patient than men but this effect is not statistically significant ($p > 0.372$). The third variable is cognitive ability. In experimental research, measures of IQ have been linked to patience and delayed gratification (Mischel, 1974; Shoda et al., 1990; Benjamin et al., 2013). It is possible that individuals with higher cognitive abilities understand the question (implied interest rates) better than individuals with lower cognitive abilities. Alternatively, the causality could be reversed, as Mischel (1974) and Shoda et al. (1990) seem to suggest: patient individuals may work harder at answering test questions and achieve higher grades. Consistent with Frederick (2005), we find that students with higher cognitive ability tend to have lower discount rates ($p < 0.176$). We also control for the World Values Survey measure of trust. We hoped that by equating the reward's delivery method at both delivery dates would eliminate any trust considerations. Nevertheless, we find that more trustful participants have lower discount rates ($p < 0.059$). Since distrustful individuals will see the later reward as more uncertain, this effect is consistent with models that predict high short-term discount rates as a consequence of uncertainty in the future (Keren and Roelofsma, 1995).

Adding these controls does not change the positive relation between procrastination and impatience. In fact, the most noticeable change is that the coefficient for participation in the online game is now bigger and statistically significant ($p = 0.026$). Overall, these results provide support to the link between procrastination and impatience when there as costs to delay, as hypothesized in O'Donoghue and Rabin (1999a,b, 2001).[10]

[9] Since the amount of money at stake is determined by events in the experiment, one might worry that its effect is driven by the ability of participants to play the experimental games. We think this is unlikely as the payment method introduces a very large random component. Nevertheless, in order to test whether this conjecture is true, we calculated the students' expected earnings—that is, their earnings if they played against the average actions of others and faced the expected value of the random draws. When we introduce this variable into our regression (not reported), it does not affect the statistical significance of the other variables.

[10] We checked whether this result is robust to selection into the whole study by rerunning the regressions in columns B and F including the students who completed the discount rate elicitation task but not the online game (148 students). Including these students does weaken the coefficient of adhering to the last deadline ($p > 0.426$). Interestingly, the effect reemerges if we look at when students apply within each deadline. In particular, whether students applied in the last day before a given deadline (about half of the students at each deadline). We find that the most impatient students in our sample are those who applied on the last day of the last deadline ($p < 0.097$). Further analysis using the whole sample is available in Reuben et al. (2007).

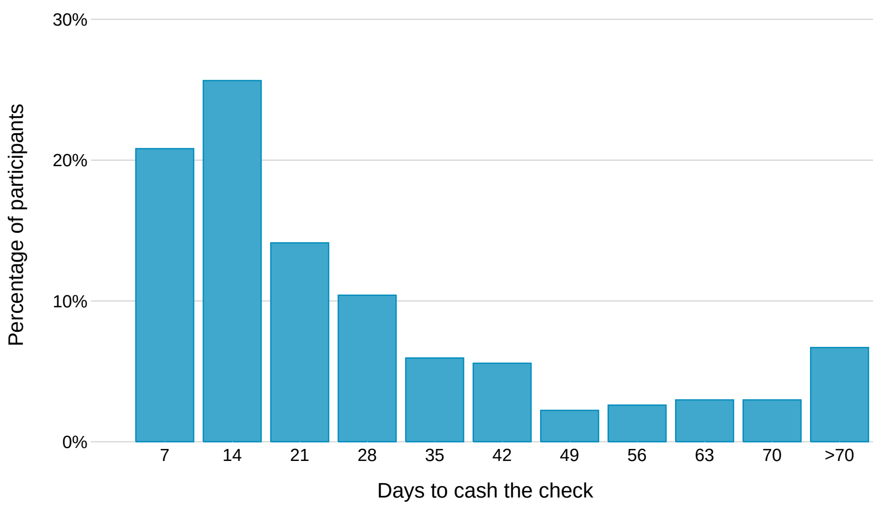

Figure 5: Distribution of the number of days taken to cash the check

4 Check cashing

As mentioned earlier, we paid participants with a check instead of cash, the traditional method in laboratory experiments. Checks were distributed either the day of the experiment or two weeks later at the same time of day. Check delivery was always done on days in which participants attended a mandatory class and thus had to be present on campus. In order to keep the transaction costs constant over both delivery times, we delivered the check in their mailbox. Student mailboxes are easily accessed and are checked regularly. One of the advantages of this payment method is that it allows us to observe yet another aspect of the participants' behavior, namely how long they take to cash the check.

Is the participants' cashing behavior consistent with their choices in the discount rate elicitation task? At first glace, it is appears that is is not. The distribution of the number of days participants took to cash the check (from the day they received it) is reported in Figure 5. On average, it takes participants 27 days (3.86 weeks) to cash the check and only 46.50% of them cashed it within two weeks. Some participants took a long time to cash their check with the last check being cashed after 206 days and 15 students (5.28%) did not cash the check at all. These figures suggest that a large fraction of the students gave up attractive rate of return to receive their check right away but then took considerably more than two weeks to cash it.

Next we look at the relation between impatience and check cashing. Are impatient students more likely to cash the check earlier, or do they also procrastinate on this task and end up cashing the check later? Table 3 takes a first look at answering this question. It presents summary statistics

Table 3: Check cashing depending on the discount rate

	Discount rate		
	All	$r \leq 1$	$r \geq 2$
Fraction paid two weeks after experiment	0.620	0.940	0.446
Paid the day of the experiment			
Days to cash the check	29.314	24.500	29.615
Cashed within one week	0.167	0.167	0.167
Cashed within two weeks	0.407	0.167	0.422
Never cashed	0.056	0.000	0.059
Paid two weeks after the experiment			
Days to cash the check	25.593	24.811	26.506
Cashed within one week	0.216	0.245	0.183
Cashed within two weeks	0.460	0.500	0.415
Never cashed	0.051	0.043	0.061

of the students' cashing behavior depending on their elicited discount rate and the day they received their check . Specifically, we divide students into those who where behave as an exponential discounter ($r \leq 1$) and those who display a high degree of impatience ($r \geq 2$). Table 3 confirms that many participants exhibit substantial inconsistency. In particular, of the 102 students who indicated they did not want to wait two-weeks for a return of at least 2% and who got paid the day of the experiment, only 42.2% actually cashed their check within those two weeks. The table also suggests that impatient participants have a slight tendency to cash their checks later, consistent with them procrastinating more. Next, we further explore the relation between check cashing, impatience, and procrastination using regressions analysis, which allows us to control for other variables.

Table 4 presents regressions with the number of days each student took to cash their check as the dependent variable. Given the survival-time nature of check cashing, we estimate Cox proportional hazards models. In all regressions, we use the same control variables as in the previous section: the logarithm of the money at stake, the students' gender, their cognitive ability, and the World Values Survey measure of trust. In addition, we also control whether students were paid the day of the experiment or two weeks later, which depended on their choice in the discount rate elicitation task and the randomly realization of the interest rate. The table reports the estimated coefficients and their corresponding robust standard errors in parenthesis.

Table 4: Check cashing

Note: The dependent variable is the number of days participants took to cash their check. The table presents Cox proportional hazards regressions. All regressions contain 284 observations. Robust standard errors are in parentheses. *,**,*** indicate statistical significance at the 10, 5, and 1 percent level.

	A	**B**	**C**	**D**	**E**
Discount rate	-0.001				-0.226***
	(0.018)				(0.086)
Week of participation in the online game		-0.161**			
		(0.076)			
Applied on the 2^{nd} deadline			-0.213*		
			(0.126)		
Applied on the 3^{rd} deadline			-0.287		
			(0.203)		
Days to complete the survey				-0.031***	
				(0.011)	
Money at stake	0.178***	0.201***	0.169***	0.187***	0.183***
	(0.062)	(0.060)	(0.062)	(0.062)	(0.062)
Female	-0.214	-0.241*	-0.227	-0.265*	-0.202
	(0.140)	(0.137)	(0.142)	(0.139)	(0.142)
CRT score	-0.040	-0.054	-0.029	-0.052	-0.035
	(0.050)	(0.048)	(0.050)	(0.049)	(0.049)
Trust	-0.389***	-0.398***	-0.405***	-0.384***	-0.385***
	(0.128)	(0.126)	(0.127)	(0.126)	(0.126)
Paid two weeks after experiment	-0.001	-0.011	0.005	0.041	-0.018
	(0.154)	(0.126)	(0.127)	(0.127)	(0.126)
Wald χ^2	17.485	28.771	21.980	32.089	28.847

In column A, we test the relation between check cashing and impatience by including the elicited discount rate as an independent variable. We do not find a strong relation between the students' discount rate and the rate at which they cash their check. The sign and magnitude of the coefficient indicate that once we add controls, a one standard deviation increase in the discount rate implies only a 0.6% decrease in the rate at which participants cash their checks ($p = 0.936$). By contrast, we find a strong positive effect for the money at stake: an increase of $55 in the amount of money at stake (one standard deviation) increases the rate at which checks are cashed by 19.6% ($p = 0.004$).

This effect is quite intuitive, if individuals fear losing the check the more time they take to cash it, then they should cash larger checks faster since they imply a larger loss. This effect also explains the apparent relation between check cashing and the discount rate seen in Table 3 since money at stake is significantly associated to both. In addition, we find that the rate at which women cash their checks is around 20% slower than men's and the rate at which distrustful participants cash their checks is around 32% faster than that of trustful participants, which again is quite intuitive. We do not find a significant relation between the rate of check cashing and cognitive abilities or the date the check was delivered.

In columns B, C, and D, we test the relation between check cashing and our three measures of procrastination by successively including each measure in a separate regression. Unlike with the discount rate, we do find a substantial relation between check cashing and procrastination. For example, *ceteris paribus*, a student who participated in the online game in the first week has a 38.3% lower check-cashing rate than one who participated in the last week. The coefficients for the online game and the days to answer the survey are both clearly statistically significant ($p < 0.034$). The coefficients for the application deadlines to the MBA program are large but do not reach statistical significance at conventional levels ($p = 0.091$ for the second deadline and $p = 0.158$ for the third). Overall, however, there is strong support for thinking of delay in check cashing as a manifestation of a general tendency to procrastinate.

Puzzlingly, we find an economic and statistically significant relationship between measures of procrastination and both the elicited discount rate (Table 2) and the number of days it takes to cash a check (Table 4). However, we do not find a relation between discount rates and check cashing. We conjecture that this apparently contradictory result might be due to the interdependence of the choices in the discount rate elicitation task and the decision of when to cash the check. In particular, unobserved heterogeneity in the costs of cashing the check can induce an attenuation bias in our estimated correlation between impatience and check cashing, a problem that the other measures of procrastination do not suffer from. To illustrate how the attenuation bias might arise, we develop a theoretical model of the participants' cashing choice as a manifestation of present-biased preferences (in the spirit of Carroll et al., 2009) and then analyze how anticipation of their cashing behavior affects their choices in the discount rate elicitation task. Below we simply describe the model's insights and leave the description of the full model to Appendix A.

We model the participants decision of when to cash the check as a dynamic problem in which participants choose in every time period whether to incur an immediate transaction cost (e.g., walking to the closest bank) in order to cash the check or delaying their cashing decision to the next period and incur the risk of losing the check.[11] The model's intuition is straightforward. On average, impatient individuals are predicted to cash the check later than patient individuals because they discount more their future costs of cashing the check.

The novel aspect of the model is that anticipating their cashing strategy affects the participants' initial trade-off between receiving the check today or in two weeks. In particular, participants have two reasons to give up an attractive rate of return in order to receive an immediate payment. The first reason is that they are impatient and therefore prefer the immediate enjoyment of receiving the check today to the delayed enjoyment of receiving it in two weeks. The second reason is that individuals might face a low cost of cashing the check today and therefore prefer an immediate payment rather than waiting two weeks when their expected cashing costs are higher. For example, a participant who is going to the bank today for an unrelated reason might prefer to get the check straight away and cash it even though she knows that she can receive a larger amount in two weeks. In other words, variability in the costs of cashing the check may generate the appearance of impatience among patient individuals and that of patience among impatient individuals, causing an attenuation bias in the estimated relationship between impatience and cashing behavior.

If it is true that the reason we do not find a relationship between the discount rate and cashing behavior is because of unobserved differences in the costs of cashing the check, then a two-step regression could solve the problem. This is the approach we use in column E in Table 4. Specifically, we first regress the discount rate on the three measures of procrastination, which are in all likelihood unaffected by time-varying costs of check cashing. Thereafter, we use the predicted discount rate from that regression to re-estimate the specification of column A in Table 4. The results show a positive and significant relationship between check cashing and impatience. Consistent with the attenuation bias hypothesis, the effect of the discount rate is quantitatively much bigger. A one standard deviation increase in the discount rate is associated with a 62.5% decrease in the rate at which participants cash their checks ($p = 0.009$).

In summary, we find considerable inconsistency between the students' choice of when to receive a check with their payment and the time they take to cash their check. We also find compelling evidence that this is due to impatient participants who are more likely to both accept an early payment and to procrastinate on cashing the check.

[11] Since participants have access to credit and hence do not need to cash the check to consume their earnings, we assume that cashing the check has no immediate reward.

5 Conclusions

One of the main contributions of behavioral economics to the understanding of human behavior is its *reductio ad unum*—its attempt to explain several phenomena that has been classified as distinct on the basis of a common underlying principle. Nowhere has this attempt been more successful than in the study of present-biased time preferences (Strotz, 1956; Laibson, 1994). We make two important contributions to this literature. First, we test the relationship between impatience and procrastination by asking MBA students whether they prefer a check with a specific amount of money immediately or with a higher amount in two weeks time and then observing whether their payment choice correlates with the degree to which they procrastinate completing three unrelated tasks (an online game, their MBA application, and a mandatory survey). Second, we provide suggestive evidence of intertemporal inconsistency between the subjects payment choice and their decision of when to cash their check.

A series of influential theoretical papers propose that procrastination is the outcome of high levels of impatience (O'Donoghue and Rabin, 1999a,b, 2001). The relation between the two, however, had not been tested using actual behavior. In this paper, we address this gap in the literature by combining a laboratory measure of impatience—the students' elicited discounted rate—with field measures of procrastination. Like in other populations, we find that our highly-educated business students exhibit exceedingly high discount rates. More importantly, we find a positive association between the students' elicited discounted rates and two of our measures of procrastination: the online game and their MBA application. Tellingly, we do not find a significant correlation between discount rates and the completion of the survey, which is the only measure of procrastination that does not have a clear cost of delay. These results are consistent with the theoretical literature, which predicts that individuals who are impatient will procrastinate more than those who are patient when delay is costly (O'Donoghue and Rabin, 1999a).

One of the reasons that models of procrastination are at the center of the literature on present-bias is that they predict time inconsistent behavior. Surprisingly, finding evidence of time inconsistency in choices is harder than one might initially think. As argued by Dohmen et al. (2012), evidence in favor of time inconsistency is not only scarce but might even be driven by methodological details. For example, once confounding factors are controlled for, aggregate evidence of present-bias and time inconsistent choices over monetary payments is basically absent (e.g., see Andreoni and Sprenger, 2012; Sutter et al., 2013; Halevy, 2015).

By paying participants with a check, we are able to track whether the participants' cashing behavior is consistent with their choices in the discount rate elicitation task. We find plenty of evidence of inconsistency. In particular, 57.8% of the students who received their check straight away instead of a reasonably larger amount in two weeks, subsequently took more than two weeks to cash it. Certainly, this behavior is not conclusive proof that our participants have time-inconsistent preferences. For instance, this type of dynamic inconsistently can also be the outcome of boundedly rational individuals who make the payment decision myopically disregarding the subsequent transaction costs involved in cashing the check. Future research could differentiate between these explanations by, for example, exogenously varying the costs of cashing the check.

Lastly, the results of this study serve as a cautionary reminder of the potentially distortionary effect played by the anticipation of transaction costs. As we show in Appendix A, the fact that the elicited discount rates are not significantly related to cashing behavior unless we use the other measures of procrastination as instruments is consistent with an attenuation bias caused by the anticipation of time-varying cashing costs. Importantly, note that the attenuation bias is not unique to our setting. It applies as long as discount rates are elicited via a task that requires participants to incur a time-varying cost if they want to consume their reward. The time series variability in this cost may generate the appearance of impatience, even among rational and patient individuals.

A Modeling check cashing

Approximately two out of three students gave up a very attractive rate of return to receive their check right away, and at the same time, they took an average of 3.71 weeks to cash their check. In order to try to explain this paradoxical behavior, we model the participants' cashing choice assuming they possess present-biased preferences (O'Donoghue and Rabin, 1999a).[12] The novel implication of our model is that the equilibrium cashing strategy has an effect on the initial decision of when to receive the payment (and thus on the measured impatience). Anticipating when they will cash the check, rational individuals will alter their trade-off between the check today and the check in two weeks. This aspect provides additional empirical implications, which we test thereafter.

To model the participant's behavior, we distinguish between the immediately rewarding sensation of receiving a check and the delayed need to cash it. Specifically, we assume that the check itself is the carrier of reward and therefore, independent of the utility from consuming their earnings, participants enjoy receiving the check itself (Knutson et al., 2001; Kable and Glimcher, 2007).

[12]Theoretical analysis of nonstandard discounting functions date back to Strotz (1956), Chung and Herrnstein (1967), Phelps and Pollak (1968), Ainslie (1975), and more recently Laibson (1994).

Once participants have received their check, they are confronted with the decision of when to cash it. Given the near-zero return on checking accounts and the fact that participants do not need to cash the check to consume their earnings (e.g., they all have a credit card), we assume that cashing the check has no immediate reward. It has, however, an immediate *cost*: participants had to walk to the closest bank or ATM and complete the process of cashing a check. The benefit of cashing the check is only long term: once the check has been cashed it cannot be lost and the money is readily available.

Solving the model by backward induction, we first analyze the decision to cash the check (Section A.1), and subsequently, we analyze the decision of when to receive the check (Section A.2).

A.1 Cashing the check

Building on the model of 401(k) enrollment of Carroll et al. (2009), we model the decision of when to cash the check as the result of a dynamic optimization problem in which the individual decides whether to incur the cost of cashing the check today or at some future date.

As in Laibson (1994), we assume individuals have quasi-hyperbolic preferences so that their discount function is $D(t) = 1$ if $t = 0$ and $D(t) = \beta\delta^t$ if $t \geq 1$. We further assume that $\delta = 1$ for two reasons. First, long-term discounting ought to be negligible in the timeframe considered here. Second, at the time of the experiment, bank interest rates were extremely low (less than 1% per annum for a checking account), making the cost of the interest forgone trivial.[13]

Given the absence of a significant interest forgone, we model the cost of not cashing the check as the probability $0 < p < 1$ of losing it. We believe this modeling choice is very realistic given that 6.25% of the checks were never cashed.[14]

Finally, we assume that cashing the check has a cost c_t drawn at the beginning of each period t from a uniform distribution with support $[0, \bar{c}]$. As a result, when making her decision in period t, an individual knows the value of c_t, but not its future realizations. This assumption is meant to capture two characteristics of cashing checks. First, that there is some variability in the cost of cashing. For example, the day a participant has to go to the bank for other reasons or visit

[13]We think that modeling discounting through β instead of δ is more appropriate for our setting. If the elicited discount rates in Figure 1 measure δ then most of our participants would not forgo two years income in order to receive an MBA

[14]From a modeling perspective, the probability of (not) losing the check $(1 - p)$, plays a similar role to assuming that $\delta < 1$. However, as we argue in footnote 13, we think that setting $\delta = 1$ in our context is the more realistic assumption.

the bookstore (which is opposite a bank), her cost of cashing can be trivial. However, when she is studying for an exam or very busy in other social activities, her cost may be very high. Second, that the cost of cashing in the future is less certain than the cost of cashing in the present. Note that these costs can also be interpreted as the possibility that individuals forget to cash their check in a given day. In this case, for example, a very low c_t would correspond to an individual who wants to cash the check today because she knows there is a high chance that she will forget to do so in the future.

After receiving the check, in each period t, individuals decide between cashing the check that period, which implies incurring the immediate cost c_t, and delaying their decision to the next period, which implies incurring the risk of losing the check. In other words, after receiving the check for an amount $S > 0$, an individual minimizes the following current discounted loss function V:

$$V = \begin{cases} c_t & \text{if check is cashed} \\ \beta[pS + (1-p)L] & \text{if check is not cashed} \end{cases}$$

where L is the individual's undiscounted expected future costs of cashing the check if she does not cash it in period t, and p is the probability of losing the check.

This problem can be solved with a cutoff rule. An individual cashes the check in period t if the realized cost in that period is smaller than c^*; otherwise she postpones the decision until the next period.

Lemma 1 *The equilibrium cutoff rule is given by*[15]

$$c^*(\beta, p, S, \bar{c}) = \frac{\sqrt{(p\bar{c})^2 + 2(1-p)p(2-\beta)\beta S\bar{c}} - p\bar{c}}{(1-p)(2-\beta)}. \tag{1}$$

Proof. At the cutoff point c^* the individual is indifferent between cashing the check in the current period or delaying the decision:

$$c^* = \beta[pS + (1-p)L(c^*)].$$

Note that $c^* > 0$ otherwise the individual never cashes the check and eventually losses it incurring a cost $S > 0$. Since the probability that an individual cashes the check in a given period is $c^*/\bar{c}$, and if she does, she pays an average cost of $c^*/2$, we can write $L(c^*)$ as

$$L(c^*) = \sum_{k=0}^{\infty} \left(1-p\right)^k \left(1 - \frac{c^*}{\bar{c}}\right)^k \left[\frac{c^*}{\bar{c}}\frac{c^*}{2} + \left(1 - \frac{c^*}{\bar{c}}\right) pS\right] = \frac{(c^*)^2 + 2p(\bar{c} - c^*)S}{2c^* + 2p(\bar{c} - c^*)}.$$

[15] We do not attempt to identify all solutions to the problem. We are concentrating on the unique solution in the space of stationary pure strategies.

Note that β does not appear in L as the individual is evaluating trade-offs between future periods only. Combining the preceding two expressions gives a quadratic equation. (1) is obtained by solving the equation for c^* using the upper root such that $c^* > 0$. ■

Given $c^* \leq \bar{c}$ we can calculate the expected number of periods τ that the individual takes to cash a check received in $t = 0$ conditional on the fact that only checks that are not lost are cashed

$$\tau^* = \frac{\bar{c} - c^*}{c^* + p(\bar{c} - c^*)}. \tag{2}$$

The following proposition follows:

Proposition 1 *If the check is not too big, the lower β is (i.e, the more impatient the individual is) and the smaller the size of the check S, the more time an individual takes to cash the check.*

Proof. The time to cash the check is positive as long as $c^* < \bar{c}$, which holds if

$$S < \frac{2 - (1-p)\beta}{2p\beta}\bar{c}. \tag{3}$$

Since the right hand side of the expression is decreasing in β, it means that more impatient individuals satisfy (3) more easily and thus are less likely to always cash the check in period 0. Given that we observe positive cashing times and a negative relation between the cashing time and the size of the check, it appears that (3) is satisfied by most of our sample. Furthermore, since the partial derivative of τ with respect to c^*, which is

$$\frac{\partial \tau}{\partial c^*} = -\frac{\bar{c}}{(c^* + p(\bar{c} - c^*))^2},$$

is always negative, and the partial derivatives of $c^*(.)$ with respect to S and β, which equal

$$\frac{\partial c^*}{\partial S} = \frac{p\beta\bar{c}}{\sqrt{(p\bar{c})^2 + 2(1-p)p(2-\beta)\beta S\bar{c}}} \tag{4}$$

$$\frac{\partial c^*}{\partial \beta} = \frac{p\bar{c}\left(p\bar{c} + 2(1-p)(2-\beta)S - \sqrt{(p\bar{c})^2 + 2(1-p)p(2-\beta)\beta S\bar{c}}\right)}{(1-p)(2-\beta)^2\sqrt{(p\bar{c})^2 + 2(1-p)p(2-\beta)\beta S\bar{c}}}, \tag{5}$$

are both positive for $0 < p < 1$, and $0 < \beta \leq 1$, we can confirm that if (3) is satisfied then both $\partial\tau/\partial\beta$ and $\partial\tau/\partial S$ are always negative ■

The main intuition is the same as in Carroll et al. (2009). When choosing between cashing today and cashing tomorrow, impatient individuals discount heavily the cost of cashing tomorrow.

Hence, they resort to cashing the check today only for very low realization of c. Consequently, on average, impatient individuals end up cashing the check later. In contrast, the higher the amount of the check, the higher is the cost of losing it. This risk will lead individuals to cash their check earlier. As seen in Table 4, there is strong support for Proposition 1 as participants with larger checks have significantly shorter cashing times in all regressions.

A.2 Getting the check

Having derived the optimal cashing behavior, we now analyze how participants choose the timing of the reward as a function of their present bias. We solve the model for the case in which participants are assumed to be sophisticated—that is, they are aware of the degree to which she will postpone the decision to cash the check in the future. However, as we demonstrate in Reuben et al. (2007), all of the models' predictions also apply to the naïve case.

At the end of the experiment, participants request either a check for S right away or a check for $S(1+r)$ the following period, where for simplicity, we assume each period lasts two weeks. Clearly, the value of receiving the check today versus a period from now depends upon the optimal cashing behavior. For the calculations below, it is useful to denote $L^*(S)$ as the undiscounted expected future costs of cashing the check if an individual does not cash it in a given period, given her optimal cutoff rule c^*.

If an individual takes the check and cashes it in $t = 0$, she receives $S - c_0$. If she takes the check in $t = 0$ but does not cash it right away, she receives $S - \beta L^*(S)$. Finally, if she takes the check in $t = 1$, she receives $\beta[S + rS - L^*(S + rS)]$. Therefore an individual will request a smaller check in period 0 rather than a larger check in period 1 if and only if

$$\beta < \frac{S}{S + rS - [L^*(S + rS) - L^*(S)]} \quad \text{or} \quad \beta < \frac{S - c_0}{S + rS - L^*(S + rS)}. \tag{6}$$

These conditions illustrate that there are two reasons to prefer a check today.

The first reason to prefer a check today is that the individual might have a very high bias toward the present (i.e., a very low β). The intuition is straightforward. A higher β makes the delayed delivery more valuable as does a higher r. More formally, the validity of our method to elicit the degree of present bias is confirmed from (6) which leads to the following proposition:

Proposition 2 *The lower the interest rate offered, r, and the lower β is (i.e, the more impatient an individual), the higher the probability that an individual will prefer a check now rather than in the next period.*

Proof. The probability that an individual prefers a check today is given by

$$\Pi = \begin{cases} 0 & \text{if } \beta > \bar{\beta} \\ \dfrac{S - \beta\left(S + rS - L^*(S + rS)\right)}{\bar{c}} & \text{if } \underline{\beta} < \beta < \bar{\beta} \\ 1 & \text{if } \beta < \underline{\beta} \end{cases} \tag{7}$$

$$\text{where } \bar{\beta} = \frac{S}{S + rS - L^*(S + rS)}$$

$$\text{and } \underline{\beta} = \max\left(\frac{S}{S + rS - [L^*(S + rS) - L^*(S)]}, \frac{S - \bar{c}}{S + rS - L^*(S + rS)}\right).$$

We first show that the probability of taking the check today is decreasing in r and β for the case $\underline{\beta} < \beta < \bar{\beta}$. The derivative of $L^*(S)$ with respect to c^* is given by

$$\frac{\partial L^*(S)}{\partial c^*} = \frac{\frac{1}{2}(1-p)c^{*2} - p\bar{c}(S - c^*)}{(c^* + p(\bar{c} - c^*))^2}. \tag{8}$$

Using (1) and solving for c^* indicates that (8) is negative if

$$c^* \leq \frac{\sqrt{(p\bar{c})^2 + 2(1-p)pS\bar{c}} - p\bar{c}}{(1-p)},$$

which holds as long as $\beta \leq 1$. Combining this with the positive sign of (4) and (5) ensures that $\partial\Pi/\partial r < 0$. Moreover, since it always the case that $S + rS > L^*(S + rS)$, it follows that $\partial\Pi/\partial\beta < 0$.

Next, we look at how r affects the threshold values $\bar{\beta}$ and $\underline{\beta}$. Note that, since (4) is positive and (8) is negative, $\bar{\beta}$ is decreasing in r. In other words, a high r makes it more likely that the individual never requests the check today irrespective of the value of c_0. Similarly, given the signs of (4) and (8), it follows that $\underline{\beta}$ is also decreasing in r. Correspondingly, a high r makes it less likely that the individual always requests the check today irrespective of the value of c_0.

Lastly, we look at how changes in β change the threshold values $\bar{\beta}$ and $\underline{\beta}$. In the case of $\bar{\beta}$, the fact that (5) is positive and (8) is negative immediately implies that $\partial\bar{\beta}/\partial\beta < 0$, and therefore an increase (decrease) in β makes it more (less) likely that the individual never requests the check today irrespective of the value of c_0. In the case of $\underline{\beta}$, we have to look separately at each possible maximum value. If the maximum value happens to be the right value in equation for $\underline{\beta}$ in (7), then it is easy to see that, given the signs of (4) and (8), $\partial\underline{\beta}/\partial\beta < 0$. In other words, once again, an increase (decrease) in β makes it less (more) likely that the individual always requests the check today irrespective of the value of c_0. The relative effect of β on $\underline{\beta}$ is not as straightforward if its maximum value is the left value in the equation for $\underline{\beta}$ in (7). In this case, β has the desired effect on the threshold if $\partial\underline{\beta}/\partial\beta < 1$. Unfortunately, it is not possible to find a manageable analytical solution for this inequality. Therefore, to show that this holds in this study we calculated $\partial\underline{\beta}/\partial\beta$

for cases in which the value of β is close to $\underline{\beta}$. Specifically, we calculated $\partial\underline{\beta}/\partial\beta$ for the following parameter values: $p \in [0.01, 0.99]$, $S \in [1, 300]$, $\bar{c} \in [1, 300]$, and $r \in [0, 0.15]$, when $\beta = \underline{\beta}$.[16] We find a maximum value for $\partial\underline{\beta}/\partial\beta$ of 0.126, which is less than 1. Consequently, if β is close to $\underline{\beta}$, we obtain once again that an increase (decrease) in β makes it less (more) likely that the individual always requests the check today ■

The second reason an individual might request the check right away is that today's realization of the cost c_0 is so low that she wants to get the check and cash it now when her cost is low, rather than wait to receive it in the future—where she expects the cost of cashing to be much higher and there is a risk of losing it. In other words, if a participant knows she has to go to the bank today, she will prefer to get the check today and cash it—even though she knows that by waiting two weeks she can receive a larger amount. This intuition is not unique to participants with a present bias, but it is common to rational exponential discounters. So we have

Corollary 1 *Even if offered a positive interest rate r, an individual with $\beta = 1$ will not necessarily delay receiving the check.*

Proof. As can be seen from (7), an individual with $\beta = 1$ has a positive probability of taking the check today as long as $rS < L^*(S + rS)$,[17] which is the true for all r that satisfy

$$r < \frac{c^*}{2S} + p\frac{\bar{c} - c^*}{c^*}.$$

It is not hard to find parameter values for which this inequality holds. For example, if $S = \$100$, $\bar{c} = \$50$, and $p = 0.01$, an individual with $\beta = 1$ has a positive probability of taking the check today as long as $r < 0.090$ ■

Corollary 1 is important since it is not unique to this setting. It applies to all situations where participants have to incur a cost to receive or consume the delayed reward, which includes most experiments designed to elicit discount rates. The time series variability in this cost may generate the appearance of impatience, even among patient individuals.

In fact, the impact of unobserved heterogeneity on the observed relationship between the elicited discount rate and cashing behavior might be stronger than simply adding noise. So far, we assumed that all individuals have the same risk of losing the check (p) and the same distribution of cashing

[16] Calculations were done in steps of 0.01 for p and r, and steps of 1 for S and $\bar{c}$. They are available upon request.

[17] For individuals with $\beta = 1$ it is always the case that $rS - (L^*(S + rS) - L^*(S)) > 0$, which implies that their only motivation to request a check today is due to a low value of c_0.

costs (uniform between 0 and $\bar{c}$). Relaxing this assumption would not only add noise, which would make the relationship between check cashing and impatience harder to detect, it can potentially generate a negative correlation between the elicited discount rate and the time to cash the check. In particular, whereas the model exhibits a positive relationship between the probability of choosing the check today (i.e., $\partial \Pi / \partial p > 0$), the relationship between the time to cash the check conditional on cashing it τ^* and p (i.e., $\partial \tau^* / \partial p$) is negative for some parameter values and positive for others. Hence, *ceteris paribus*, differences in p or a combination of differences in p and $\bar{c}$ can produce a negative relationship between Π and τ^*. In other words, the attenuation bias when evaluating a correlation between impatience and weeks to cash the check might be quite strong.

Lastly, we point out that the relationship between the delivery timing and the amount of money at stake is not so straightforward as the one with impatience. For high interest rates, the relationship is as expected. Higher amounts make delaying the reward more valuable (because it yields a higher interest) and so make the delayed choice more likely. This result is no longer true for small interest rates because the probability of losing the check becomes relatively more important than the interest accumulated on the check. In fact, we have:

Corollary 2 *For high interest rates r there is a negative relationship between the amount of money at stake S and the probability of accepting a check right away. For low interest rates, this relationship is positive.*

Proof. From (7) one can see that, as long as $\underline{\beta} < \beta < \bar{\beta}$, the relationship between S and the probability of taking the check today is given by

$$\frac{\partial \Pi}{\partial S} = \frac{1}{\bar{c}} \left(1 - \beta \frac{\partial (S + rS - L^*(S + rS))}{\partial S} \right)$$

To facilitate notation, we denote $\partial(S + rS - L^*(S + rS))/\partial S$ as λ^*. If $\beta\lambda^* < 1$ the relationship between Π and S is positive, otherwise it is negative. Writing $c^*(\beta, p, S + rS, \bar{c})$ as c^*, we get

$$\lambda^* = \frac{1 + r - \frac{1}{2} c^*_S}{c^* + p(\bar{c} - c^*)} c^* + \frac{(1 + r)S - \frac{1}{2} c^*}{(c^* + p(\bar{c} - c^*))^2} p\bar{c} c^*_S$$

$$\text{where } \; c^*_S = \frac{p\beta(1 + r)\bar{c}}{\sqrt{(p\bar{c})^2 + 2(1 - p)p(2 - \beta)\beta(1 + r)S\bar{c}}}$$

which is positive as $\frac{1}{2} c^*_S < (1 + r)$ and $\frac{1}{2} c^* < (1 + r)S$.

The derivative of λ^* with respect to r is

$$\frac{\partial \lambda^*}{\partial r} = \frac{2S(1 - p)(c^* - S c^*_S) + \left(2 - \frac{1}{1+r} c^*_S\right) pS\bar{c}}{(c^* + p(\bar{c} - c^*))^3} p\bar{c} c^*_S + \frac{(1 + r)S - \frac{1}{2} c^*}{(c^* + p(\bar{c} - c^*))^2} p\bar{c} c^*_{Sr} + \frac{1 - \frac{1}{2} c^*_{Sr}}{c^* + p(\bar{c} - c^*)} c^*$$

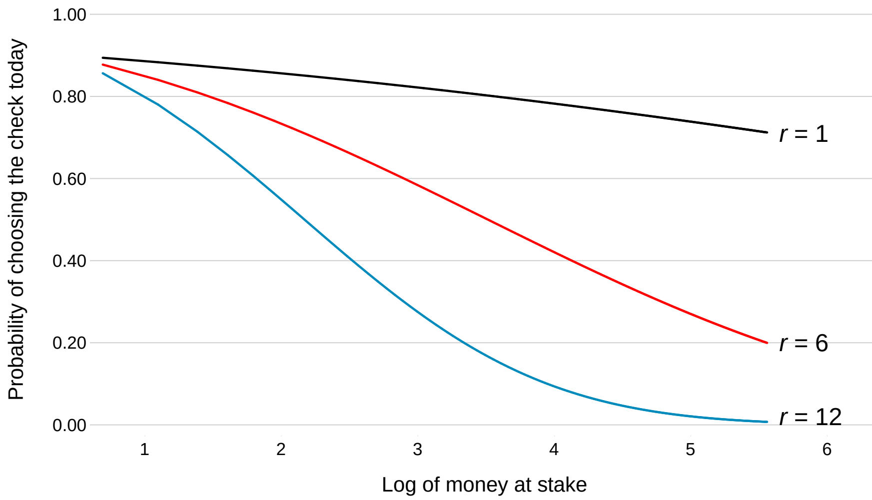

Figure 6: Interaction between the interest rate and the money at stake

Note: Probability that a participant requests the check today as a function of the money at stake and selected interest rates. Estimated with the regression in column B in footnote 19.

$$\text{where } c^*_{Sr} = \frac{p\bar{c} + (1-p)(2-\beta)\beta(1+r)S}{((p\bar{c})^2 + 2(1-p)p(2-\beta)\beta(1+r)S\bar{c})^{\frac{3}{2}}}\beta(p\bar{c})^2$$

which again is positive as $0 < c^*_{Sr} < 1$, as well as $S > c^* > Sc^*_S$ and $2(1+r) > c^*_S$. In other words, $\partial\Pi/\partial S$ switches from being (weakly) positive to (weakly) negative as r increases if for a low r it holds that $\beta\lambda^* < 1$. In this case, there is an r^* such that for $r > r^*$ it holds that $\partial\Pi/\partial S \leq 0$ and for $r < r^*$ it holds that $\partial\Pi/\partial S \geq 0$.[18] The precise value of r^* is given by the r that solves $\partial\Pi/\partial S = 0$. Although it is not possible to find an explicit expression for r^*, it is easy to calculate it for various parameter values. For example, if $S = \$80$, $\bar{c} = \$20$, $p = 0.03$, and $\beta = 1$, then $\underline{\beta} = 0.969$, $\bar{\beta} = 1.061$, and $r^* = 0.033$. Similarly, if $S = \$135$, $\bar{c} = \$35$, $p = 0.1$, and $\beta = 0.9$, then $\underline{\beta} = 0.889$, $\bar{\beta} = 1.002$, and $r^* = 0.127$ ■

Corollary 2 also applies more generally and implies a relationship between the size of the reward and the elicited discount rate. This is consistent with numerous studies that vary the size of the reward and find that bigger rewards are discounted less than smaller ones (see references in Frederick et al., 2002). In other words, this corollary suggests that the so-called "magnitude effect" could be due to transaction costs and is not a property of discount function per se. In fact, Corollary 2 goes further and makes a non-obvious prediction: the relationship between impatient behavior and the amount of money at stake varies with the offered interest rate r.

[18] Note that for very low and very high values of r, there might not be a relationship between Π and S as β can fall outside the thresholds $\underline{\beta}$ and $\bar{\beta}$. Thus, this corollary applies strictly only when comparing intermediate values of r.

This prediction cannot be tested with the regressions in the main body of the paper and therefore we ran an additional regression to test it. Specifically, we ran a Probit regression in which the dependent variable is a dummy variable indicating whether, for a given r, a participant takes the check today or in two weeks. Given that each participant makes 13 such decisions, in addition to controlling for the value of r, or more precisely $\ln(1 + r)$ since it gives a better fit, we allow for intragroup correlation in the standard errors by clustering on individual participants. We included the same control variables used in the regressions in Table 2 plus the interaction between the interest rate and the money at stake. In accordance with the model, the coefficient of the interaction variable is negative and statistically significant.[19] To visualize this interaction, Figure 6 plots the predicted effect of the interest rate on the relationship between the money at stake and the probability of choosing the immediate delivery of the check. In accordance with the model, for low interest rates the effect of the money at stake is close to zero whereas for high interest rates it is significantly negative.

B Selection

In Table 5, we check whether there was selection into the different parts of the study by comparing the observable characteristics of students who completed all activities and those who did not. Specifically, the first two columns of the table present the mean for all the variables used in this paper for the 284 students who participated in the online game as well as the 148 students who consented to study and completed the discount rate elicitation task. The third column, presents the p-value of a Mann-Whitney U-test comparing the two populations.

By and large, we do not find many differences between the two samples. Students who completed the online game complete the survey earlier than those who did not complete the online game. If we take the survey as a reliable measure of procrastination, this suggests that at least some students who failed to complete the online game might have done so because they procrastinated to the point that they missed the last deadline. Note, however, that if this is the case, excluding these students from the main analysis would make it harder to find a relationship between procrastination and impatience using the online game measure of procrastination. Since we find a positive relation with

[19]The estimated marginal effects along with their standard errors are: -0.024 (0.020) for money at stake; -0.034 (0.038) for female; -0.024 (0.014) for CRT score; -0.080 (0.037) for trust; 0.006 (0.009) for the interest rate; and -0.016 (0.002) for the interaction between the interest rate and money at stake. The regression's Wald test equals gives $\chi^2 = 301.138$.

Table 5: Means depending on completion of the online game

	Completed online game?		
	Yes	**No**	***p*-value**
Measures of Impatience			
Two-week discount rate	5.02	4.91	0.732
Two-week discount rate ≤ 1	0.35	0.378	0.590
Measures of Procrastination			
Days before the application deadline	86.13	83.60	0.331
Deadline used for the application	1.80	1.84	0.482
Days before the survey deadline	7.60	6.19	0.003
Other variables			
Money at stake	82.86	84.54	0.983
Female	0.33	0.25	0.096
CRT score	2.47	2.53	0.514
Trust	0.54	0.55	0.762
Days to cash the check	27.00	26.85	0.844
Failed to cash the check	0.05	0.08	0.250

the online game measure and not with the survey, we think that the number of students who were interested in the online game but failed to participate must be small.

C Instructions and Experimental Procedures

C.1 Experimental procedures

The experiment was run during Tuesday, October 3rd and Thursday, October 5th, 2006. Students were randomly assigned to participate in one of the two days. Two sessions were run each day in the afternoon, one starting at 1 pm and the other one at 3 pm. Due to scheduling conflicts with other activities, all national students (US citizens) participated in the 1 pm sessions and international students in the 3 pm sessions.

Upon arrival, students received a set of materials, which included their $20 show-up fee and a unique randomly assigned number that is used to identify each student. Once all students were seated, the experimenter reminded them not to communicate with one another and that their interaction with others would remain anonymous. Thereafter, students were asked to sign various consent forms. Consenting to the different aspects of the study was voluntary and participants have the option to opt out of the study at any time. The experiment was run with computers and programmed in zTree (Fischbacher, 2007). Each session lasted around one and a half hours.

C.2 Instructions for the payment choice

As your last choice, you decide when to receive your payment. For each row below, choose the amount and timing of your payment. If you choose to be paid *now*, a check will be delivered to your mailfolder by the *end of the day*. If you choose to be paid *later*, the check will be delivered to your mailfolder in *two weeks time*. One of the rows will be randomly selected by the computer and that choice will be implemented.

[Example with earnings of $80]

1. Receive $80.00 today or receive $80.00 in two weeks
2. Receive $80.00 today or receive $80.80 in two weeks
3. Receive $80.00 today or receive $81.60 in two weeks
4. Receive $80.00 today or receive $82.40 in two weeks
5. Receive $80.00 today or receive $83.20 in two weeks
6. Receive $80.00 today or receive $84.00 in two weeks
7. Receive $80.00 today or receive $84.80 in two weeks
8. Receive $80.00 today or receive $85.60 in two weeks
9. Receive $80.00 today or receive $86.40 in two weeks
10. Receive $80.00 today or receive $87.20 in two weeks
11. Receive $80.00 today or receive $88.00 in two weeks
12. Receive $80.00 today or receive $88.80 in two weeks
13. Receive $80.00 today or receive $89.60 in two weeks

C.3 Instructions for the online game

Complete the "Face of Success" survey and participate in a lottery to win an iPhone! Each week we will draw a winner from those of you who have completed the survey. The winner will receive a brand new 16GB iPhone. Note that, winning in a given week does not exclude you from participating in subsequent lotteries. Hence, if you complete the survey by noon Tuesday, April 23, you will take part in three lotteries and you can win up to three iPhones.

iPhone lotteries will take place the following days at noon:

- 1st lottery: April 23
- 2nd lottery: April 30
- Last lottery: May 7

In addition, if you are the best at spotting the true Face of Success you can win our grand prize: a $1,500 value that you can spend on either a dinner at Alinea restaurant, airplane tickets, or a Macbook Air. The contest ends on May 14. Log on and compete! To take the 20-minute survey click here.

References

Ainslie, G. (1975). Specious reward: A behavioral theory of impulsiveness and impulse control. *Psychological Bulletin*, 82:463–96.

Akerlof, G. (1991). Procrastination and obedience. *American Economic Review*, 81:1–19.

Andreoni, J. and Sprenger, C. (2012). Estimating time preferences from convex budgets. *American Economic Review*, 102:3333–3356.

Ariely, D. and Wertenbroch, K. (2002). Procrastination, deadlines, and performance: Self-control by precommitment. *Psychological Science*, 13:219–224.

Augenblick, N., Niederle, M., and Sprenger, C. (2015). Working over time: Dynamic inconsistency in real effort tasks. *The Quarterly Journal of Economics*, forthcoming.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. Freeman, New York.

Benjamin, D. J., Brown, S. A., and Shapiro, J. M. (2013). Who is "behavioral"? cognitive ability and anomalous preferences. *Journal of the European Economic Association*, 11:1231–1255.

Bernheim, B. D. and Rangel, A. (2005). Behavioral public economics: Welfare and policy analysis with fallible decision-makers. In Diamond, P. and Vartianen, H., editors, *Institutions and Behavioral Economics*. Princeton University Press, Princeton.

Burger, N., Charness, G., and Lynham, J. (2011). Field and online experiments on self-control. *Journal of Economic Behavior & Organization*, 77:393–404.

Burka, J. and Yuen, L. M. (2008). *Procrastination: Why You Do It, What to Do About It Now*. Da Capo Press, Cambridge.

Carroll, G. D., Choi, J. J., Laibson, D., Madrian, B. C., and Metrick, A. (2009). Optimal defaults and active decisions. *The Quarterly Journal of Economics*, 124:1639–1674.

Chabris, C. F., Laibson, D., Morris, C. L., Schuldt, J. P., , and Taubinsky, D. (2008). Individual laboratory-measured discount rates predict field behavior. *Journal of Risk and Uncertainty*, 37:237–269.

Chissom, B. and Iran-Nejad, A. (1992). Development of an instrument to assess learning strategies. *Psychological Reports*, 71:1001–1002.

Choi, J. J., Laibson, D., Madrian, B. C., and Metrick, A. (2006). Saving for retirement on the path of least resistance. In McCaffrey, E. and Slemrod, J., editors, *Behavioral Public Finance: Toward a New Agenda*, pages 304–351. Russell Sage Foundation, New York.

Chung, S.-H. and Herrnstein, R. J. (1967). Choice and delay of reinforcement. *Journal of the Experimental Analysis of Behavior*, 10:67–74.

Coller, M. and Williams, M. B. (1999). Eliciting individual discount rates. *Experimental Economics*, 2:107–127.

Cubitt, R. P. and Read, D. (2007). Can intertemporal choice experiments elicit time preferences for consumption? *Experimental Economics*, 10:369–389.

DellaVigna, S. and Malmendier, U. (2006). Paying not to go to the gym. *American Economics Review*, 96(3):694–719.

Dohmen, T., Falk, A., Huffman, D., and Sunde, U. (2012). Interpreting time horizon effects in intertemporal choice. Working paper series 3750, CESifo.

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

Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives*, 19:25–42.

Frederick, S., Loewenstein, G., and ODonoghue, T. (2002). Time discounting and time preference: A critical review. *Journal of Economic Literature*, 40:351–401.

Halevy, Y. (2015). Time consistency: Stationarity and time invariance. *Econometrica*, 83:335–352.

Kable, J. W. and Glimcher, P. W. (2007). The neural correlates of subjective value during intertemporal choice. *Nature Neuroscience*, 10:1625–1633.

Keren, G. and Roelofsma, P. (1995). Immediacy and certainty in intertemporal choice. *Organizational Behavior and Human Decision Processes*, 63:287–297.

Kirby, K. N. and Maraković, N. N. (1996). Delay-discounting probabilistic rewards: Rates decrease as amounts increase. *Psychonomic Bulletin & Review*, 3:100–104.

Knutson, B., Adams, C. M., Fong, G. W., and Hommer, D. (2001). Anticipation of increasing monetary reward selectively recruits nucleus accumbens. *The Journal of Neuroscience*, 21:RC159.

Laibson, D. (1994). *Essays in Hyperbolic Discounting.* PhD thesis, Massachusetts Institute of Technology.

Loewenstein, G. and O'Donoghue, T. (2005). Animal spirits: Affective and deliberative processes in economic behavior. Working paper 04-14, Cornell University.

McClure, S. M., Ericson, K. M., Laibson, D. I., Loewenstein, G., and Cohen, J. D. (2007). Time discounting for primary rewards. *The Journal of Neuroscience*, 27:5796–5804.

McClure, S. M., Laibson, D., Loewenstein, G., and Cohen, J. D. (2004). Separate neural systems value immediate and delayed monetary rewards. *Science*, 306:503–507.

McLeish, K. N. and Oxoby, R. J. (2007). Gender, affect and intertemporal consistency: An experimental approach. Discussion paper no. 2663, IZA.

Meier, S. and Sprenger, C. (2010). Present-biased preferences and credit card borrowing. *American Economic Journal: Applied Economics*, 2:193–210.

Mischel, W. (1974). Process in delay of gratification. In Berkowitz, L., editor, *Advances in Experimental Social Psychology*, pages 249–292. Academic Press, San Diego, California.

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

O'Donoghue, T. and Rabin, M. (1999b). Incentives for procrastinators. *The Quarterly Journal of Economics*, 114:769–816.

O'Donoghue, T. and Rabin, M. (2001). Choice and procrastination. *The Quarterly Journal of Economics*, 116:121–160.

Phelps, E. S. and Pollak, R. A. (1968). On second-best national saving and game-equilibrium growth. *Review of Economic Studies*, 35:85–199.

Read, D. and van Leeuwen, B. (1998). Predicting hunger: The effects of appetite and delay on choice. *Organizational Behavior and Human Decision Processes*, 76:189–205.

Reuben, E., Sapienza, P., and Zingales, L. (2007). Procrastination and impatience. Working paper No. 13713, NBER.

Reuben, E., Sapienza, P., and Zingales, L. (2008). A description of the Templeton Chicago MBAs longitudinal study. Working paper, University of Chicago.

Reuben, E., Sapienza, P., and Zingales, L. (2010). Time discounting for primary and monetary rewards. *Economics Letters*, 106:125–127.

Sapadin, L. and Maguire, J. (1997). *It's About Time!: The Six Styles of Procrastination and How to Overcome Them.* Penguin Books, New York.

Schouwenburg, H. C. (1992). Procrastinators and fear of failure: An exploration of reasons for procrastination. *European Journal of Personality*, 6:225–236.

Shoda, Y., Mischel, W., and Peake, P. K. (1990). Predicting adolescent cognitive and self-regulatory competencies from preschool delay of gratification: Identifying diagnostic conditions. *Developmental Psychology*, 26:978–986.

Steel, P. (2007). The nature of procrastination: A meta-analytic and theoretical review of quintessential self-regulatory failure. *Psychological Bulletin*, 133:65–94.

Strotz, R. H. (1956). Myopia and inconsistency in dynamic utility maximization. *Review of Economic Studies*, 23:165–180.

Sutter, M., Kocher, M. G., Glätzle-Rüetzler, D., and Trautmann, S. T. (2013). Impatience and uncertainty: Experimental decisions predict adolescents' field behavior. *American Economic Review*, 103:510–531.