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Abstract

Relying on e-learning data, I report here on an empirical investigation of daily homework progress to assess procrastination among high school students, whose behavior is susceptible to present-bias. The homework entails a non-binding goal for the students. The main findings were as follows: First, the goal encouraged a considerable number of students to study more to achieve it. Second, high achievers procrastinated until close to the deadline, particularly females for Math homework. Finally, a considerable subset of high achievers worked hard at the last minute to meet a non-binding deadline. These findings imply that a non-binding goal strongly motivates such students' self-control in goal achievement; however, the process is one of procrastination, and the deadline prevents further procrastination despite being non-binding.

Keywords: Procrastination, non-binding goal, deadline
JEL codes: D03, D91, I21

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1 Introduction

Procrastination prevails in academic contexts. According to a study by Solomon and Rothblum (1984), slightly less than half (46%) of college students tend to procrastinate in writing a term paper, 27.6% in studying for exams, and 30.1% in reading assignments. Procrastination appears to be particularly problematic among adolescents, who have greater present-bias, according to several published studies. Decision-makers with present-biased preferences put off costly activities that have delayed but significant rewards (such as studying), often resorting to less significant immediate pleasure instead, indicating that such decision-makers lack appreciation for the long-term perspective (O'Donoghue and Rabin (2001); O'Donoghue and Rabin (1999a)). Predicated on recent findings in behavioral economics, cognitive science, decision-neuroscience, and developmental neuroscience, Lavecchia, Liu, and Oreopoulos (2014) argue that teenagers are susceptible to greater present-bias, which leads to their under-investment of educational input in their human capital.

Despite the consensus that the tendency of many people to procrastinate and to have present-bias is one of the major impediments to studying, behavior-based quantitative studies of procrastination are rare,[1] perhaps due to a lack of longitudinal data recording the detailed progress of a long-standing task. Employing unique log data in an e-learning context, which enabled me to directly observe the daily homework progress of high school students, whose behavior is susceptible to present-bias, this study presents quantitative empirical evidence of procrastination in terms of daily behaviors. Furthermore, this study discusses implications for the role of deadlines in terms of the problem of procrastination.[2]

This study utilized log data that was retrieved from the e-learning service "Surala" provided by Surala Net (Chiyoda-city, Tokyo, Japan). The e-learning service provides a web-based educational environment in which elementary, middle, and high school students attend lectures, solve problem sets, and receive feedback on their achievement in three fields of study, namely Math, English, and Japanese. Unlike other e-learning services, "Surala" provides all problem set material directly on the web-site (thus, no paper and pencil are

[1] Traditionally, research in educational psychology has examined academic procrastination; however, most studies rely on students' self-reports in questionnaires called "PASS" (Solomon and Rothblum (1984)). Steel (2007) and Ferrari (1994) summarize recent findings.

[2] O'Donoghue and Rabin (1999b) argued on a theoretical basis for the optimal use of deadlines to prevent further procrastination among decision-makers with present-bias in their preferences. Ariely and Wertenbroch (2002) found on the basis of empirical data that people employ self-imposed, costly deadlines to deal with their tendency to procrastinate.

required), which enables them to record all aspects of the studying behavior of each student in fine detail. This allowed me to assess these students' procrastination in terms of their daily behaviors.

To the best of my knowledge, Burger, Charness, and Lynham (2011) is the only study that employed daily behavioral data to assess procrastination quantitatively.[3] Their study required their subjects (college students) to complete 75 hours of studying during a period of five weeks in a university library. They recorded the duration of the students' daily studying time. However, they observed no significant procrastination in the average study time of 22 goal achievers, despite the treatment condition allowing the students to allocate their study time freely over the five weeks, a condition in which they were expected to procrastinate. In addition to several inconsistent behavioral results regarding procrastination, the researchers concluded that procrastination is not easily reproduced in controlled experimental settings. To overcome such shortcomings, the present study relied on non-experimental empirical data, gathered among students at a high school (High School A) that actually assigned long-term, time-consuming homework to all freshmen in the winter recess, on which they worked as a real-world task. Nonetheless, the data satisfy certain desirable criteria of experimental settings, in that an identical task is assigned to a relatively uniform group of subjects over an identical period of time. These conditions are indispensable prerequisites for studying procrastination, which is sensitive to task structure and environment.

In addition to the advantage that the e-learning data allowed me to observe directly students' daily progress on homework assignments, the homework assignments of High School A possessed desirable properties to reveal students' tendency to procrastinate in studying with minimum confounds. The homework was not motivated by reward or punishment, but was left to voluntary engagement by the students (thus, it was non-binding homework). The environment in which procrastination matters is generally one with a "delay of gratification" paradigm; a large, significant benefit lies in the future, but in the short-term, one has to engage in costly activities with no immediate benefit (Loewenstein, Read, and Baumeister (2003)), studying being a clear example. The non-binding goal setting of the High School A homework preserved the "delay of gratification" structure of studying, as no immediate benefit of homework achievement was provided to the students. Indeed, a

[3]In addition to procrastination, Shapiro (2005) and Kaur, Kremer, and Mullainathan (2011) examined self-control problems employing daily behavioral data. Shapiro (2005) examined empirical data on daily food consumption, finding evidence for the existence of present-bias in the preferences of the people involved in the study. Kaur, Kremer, and Mullainathan (2011) found evidence in a field experiment that labor motivation was enhanced as payday approached.

recent field experimental study by Kaur, Kremer, and Mullainathan (2011) reported that labor motivation becomes significantly amplified as payday approaches, suggesting that the influence of immediate rewards also matters in procrastination in studying, possibly to an even greater extent among adolescents, who are susceptible to present-bias.[4] However, the non-binding setting in the present study was expected to minimize the effect of immediate rewards on the tendency for procrastination.

On the basis of these advantages of the daily behavioral e-learning data and the non-binding goal setting of High School A, the present study provides empirical quantitative evidence of procrastination and its implications for the role of deadlines as behavioral controls when a non-binding goal is set, as well as an evaluation of the enhancement of studying motivation by goal setting. The specific questions addressed by the study are as follows:

Question 1: Does non-binding goal setting encourage students to study more and achieve the goal?

Question 2: How do students allocate their effort to achieve the goal?

Question 3: Does a non-binding goal motivate students to study hard at the last minute before the non-binding deadline to address the sizeable remaining task resulting from their own procrastination?

The study is related primarily to the growing body of literature on behavioral control, which discusses the role of non-binding goals in self-control problems, or more broadly, that of commitment mechanisms without explicit reward or punishment (i.e., non-binding commitment).[5] Bénabou and Tirole (2004) proposed a commitment mechanism by which people exercise strong willpower to overcome present-biased preferences using internal commitment mechanisms or "personal rules" that have no explicit punishment for violations. People with uncertainty in their self-control abilities struggle to follow the non-binding rules to avoid a lapse and subsequent loss of confidence in their self-control abilities, which motivates them to perform further self-control, often excessively. Hsiaw (2013), Koch and Nafziger (2011) and Suvorov and Van de Ven (2008) focus specifically on the role of non-binding goal setting, discussing how people with present-biased preferences overcome the bias with the assistance of non-binding goal setting. According to such theoretical works, non-binding

[4]People with strong risk aversion are also expected to show less procrastination to obtain a certain reward, which would be another concern in the case of immediate rewards.

[5]Regarding the use of commitment devices with explicit punishment (i.e., binding commitment), Ariely and Wertenbroch (2002) report from their experiment that people employ self-imposed, costly deadlines to avoid procrastination.

goals generate reference dependences or psychological dis-utilities for non-attainment, which motivates the person to perform self-control. Fahn and Hakenes (2014) argued that motivations for reputation building act as a commitment mechanism for people to exercise strong willpower to overcome the present-bias in their preferences in order to show colleagues their self-control abilities. Although several theoretical models have been proposed, the dynamics of effort allocation is not well discussed in the literature, and little empirical evidence exists, perhaps due to data limitations. The present study provides empirical evidence of dynamic effort allocation in self-control problems for goal achievement in studying among high school students susceptible to present-bias.

The first research question presented above concerns an evaluation of the policy of behavioral intervention with non-binding goal setting for self-control regarding goal achievement. Heckman, Stixrud, and Urzua (2006) stressed the importance of non-cognitive abilities, including self-control and motivation. The answer to the first question provides empirical evidence on self-control abilities motivated by non-binding goal setting. The second question concerns effort allocation and procrastination in the process by which self-control for goal achievement is performed. The third question concerns the strength of a non-binding deadline in motivation enhancement, by which certain students may be motivated to work intensively immediately before a non-binding deadline. As the effort in this case may be allocated even after the deadline, without any penalty, excessive intensive work immediately before the deadline appears unreasonable. This study provides evidence as to whether certain students do so anyway.

The main findings of the present study are as follows: First the non-binding goal motivated a considerable number of students to study more to achieve it. Second, the majority of the high achievers procrastinated. This was especially the case among female high achievers in Math. Third, the non-binding goal motivated a considerable subset of high achievers to study hard at the last minute before the deadline, despite it being non-binding, the work resulting from their own procrastination in meeting the deadline. These findings jointly suggest that a non-binging goal motivates a considerable number of students to exercise strong self-control for goal achievement in studying; however in the majority, the effort exertion is put off until immediately before the deadline, with the deadline, despite being non-binding, playing a substantial role in preventing further procrastination.

The remainder of this paper is organized as follows: Section 2 describes the data. Section 3 reports on the extent to which the non-binding goal encouraged the students to study more to achieve it. Section 4 discusses the students' procrastination in the process of goal

achievement. Section 5 discusses the possible decision-making mechanism consistent with the findings. Section 6 offers concluding remarks.

2 Data

The e-learning log data retrieved for the present study comprise a longitudinal record of the students' studying behavior over the whole academic year (April 2013 to March 2014), including the winter recess, during which non-binding homework is assigned. The auxiliary data include each student's gender, academic course enrollment, and achievement test scores in November 2013, one month before the winter recess. The winter recess began on December 21st, 2013, and ended on January 6th, 2014. The whole winter recess was set as the time for the homework to be completed. With regard to the possible concern that other binding homework assignments, if any, might "crowd out" the relevant non-binding e-learning assignment, leading to spurious procrastination, anecdotal evidence from the instructors at High School A indicated that other homework assignments were minor and would have had minimum effect on in the e-learning homework.

Although there was no penalty for a delay in completion, the deadline was nominally set for January 7th, 2014, the first day of the next academic term. The school authority announced explicitly to the students that there was no penalty for non-completion of the homework and no direct impact on final grades, but encouraged their voluntary participation.[6]

Access to the homework was possible only through internet.[7] As the public internet service of the school was not available to the students during the recess period, several students without their own internet access were unable to work on the e-learning homework. Although the data on individual internet accessibility was not available, an informal survey conducted by the school authority in September 2013, a few months prior to the intervention period, revealed that approximately 18% of the students had no private access to the e-learning service.

[6]Regarding the possible concern that some students may not have believed the announcement, and thought that their achievement in the homework would impact on their final grades, this was not the case. As I mention below, a non-negligible fraction of the students had no access to internet, putting them at a selective disadvantage for grading if the announcement were to be violated. Thus, reasonably, the school authority had to strictly prohibit instructors from taking the e-learning achievement into consideration in the final grades, and this ought to have been common knowledge among the students.

[7]At the time, the e-learning service allowed access only from conventional desktop and laptop computers. No access was possible from smart-phones or tablet-type devices.

The log data in the e-learning records for each student showed when they worked, for how long, on what kind of unit, and whether or not they passed the unit successfully. In this e-learning service, almost all units consisted of one lecture and several problem sets. A unit was marked as "passed" when a student successfully solved its problem sets. A unit typically took approximately 15 minutes to complete, though several units required either more or less time. To control for the heterogeneity in unit load, I employed "standard required amount of time" reported by the e-learning system for each unit, according to user's past attemps, as a measure of load for the unit to evaluate the cumulative progress with the homework. These measures also allowed me to unify the progress in the different fields of study, namely Math and English, in a single variable.

High School A offered two academic courses, namely a General course and a Special Academic Advancement (SAA) course. The homework assignments across the two had almost identical loads. The homework for the General course consisted of 60 English units and 14 Math units, with a total of 1,875 minutes of "standard required amount of time" (1,525 minutes for English and 350 minutes for Math), whereas SAA students are assigned the identical 60 English units and 13 units for Math (315 minutes), with a total of 1,840 minutes.

Table 1 presents the descriptive statistics of the students whose performance was considered in the present study, namely the freshmen of the 2013 academic year in High School A. The total number of freshmen was 446,[8] including 312 males and 134 females. Among these, 53 students were enrolled in the SAA course, including 25 males and 28 females, and 393 students were enrolled in the General course, including 287 males and 106 females. The proportion of female differs remarkably across the two courses, with 0.4310 in the SAA course and 0.2697 in the General course.

The auxiliary data document the students' characteristics at the individual level, indicating the academic course in which a student is enrolled (a dummy variable for the SAA course), gender (a dummy variable for females), and achievement scores for a test administrated by a private company, the Benesse Corporation (City of Okayama, Okayama-prefecture, Japan). This achievement test (known as "Shinken-moshi" in Japanese) is one of the leading achievement tests for Japanese high school students who wish to assess their prospects for advancing to higher education. All freshmen in High School A were required to take the achievement test in November 2013, one month before the intervention period. The scores

[8] As additional mandatory goals had been set by instructors at some point before the intervention period for seven students who were struggling to follow in-class lectures, the data for these seven students were excluded from the analysis.

Table 1: Descriptive statistics of the students

Upper panel: Special Academic Advancement students
Lower panel: General students

Statistic	N	Mean	St. Dev.	Min	Max
Female (dummy variable)	53	0.528	0.504	0	1
Total score	51	49.751	6.266	36.800	63.700
Math score	51	51.600	7.994	36.500	70.600
English score	51	48.225	6.670	36.000	69.500

Statistic	N	Mean	St. Dev.	Min	Max
Female (dummy variable)	393	0.270	0.444	0	1
Total score	375	36.217	4.577	27.800	51.000
Math score	375	37.540	6.131	30.700	55.400
English score	375	38.556	3.594	32.000	53.500

* The scores include a few missing entries due to students' non-attendance.

serve as a proxy for the students' abilities, which were in this sense predetermined before the intervention period began. As seen in Table 1, the averaged total score of the SAA students (49.75) exceeds that of the General students (36.22), indicating that the SAA students generally outperformed the General students on the test. Indeed, admission to the SAA course is more selective, the aim being to provide effective support for its students to advance to higher education, which is not necessarily the case for the General course. The test scores also show that the SAA course predominantly includes middle-achieving students, as their standardized scores are roughly around 50 points, whereas the General course includes low-achieving students.[9] Nonetheless, the two courses have overlap significantly in terms of scores for any field of study.

The winter homework set by High School A was exogenously and uniformly assigned to all freshmen with no selection bias, which allowed me to evaluate the causal effect of the exogenous, non-binding goal setting on students' studying behavior in a simple manner. The e-learning was available to all freshmen well before the winter recess period, as of April 2013, to be precise, and the school authority encouraged their voluntary use of the e-learning service as supplemental to in-class lectures. Particularly in the winter recess, the authority additionally designated specific e-learning units, as well as a nominal, non-binding deadline as a goal. Thus, the only difference in the winter recess was the designation of target units and the nominal, non-binding deadline, which enabled me to evaluate the causal, policy effect of non-binding goal setting with minimum confounds. Moreover, the announcement of the homework was made only a few days before the winter recess began, with students incapable of predicting it in advance.[10] Taking advantage of this context, I begin in Section 3 by evaluating the treatment effect of the exogenous, non-binding goal setting on the students' studying behavior.

3 Increase in time spent on studying and goal achievement

This section addresses the first of the three questions posed in Section 1: Does non-binding goal setting encourage students to study more and achieve the goal? Based on a range of

[9] In Japan, the test scores are usually normalized with a mean of 50 and standard error of 10. The population comprised all high school freshmen who took the same achievement test.

[10] Nonetheless, some students had already unwittingly worked on several units set for the recess. These four students are excluded from the analysis of procrastination in Section 4. Specifically, I excluded students who had already "progressed" with more than 10% of the total homework on the day before the winter recess began (December 20th, 2013).

evidence, I propose that the students were causally motivated to study more to achieve the goal (perform self-control for the goal achievement), thereby evaluating the policy effect of non-binding goal setting.

3.1 Increase in time spent on studying

Did the non-binding goal setting in this context actually increase the students' time spent on studying? The upper panel of Figure 1 shows the average monthly studying time of the freshmen in minutes. The studying time includes not only the time associated with the set goal, but the entire time the students spent studying, irrespective of the goal having been set. The data show that studying time increased dramatically during the winter recess (in December and January), the intervention period during which the non-binding goal was established. The increase in January was particularly outstanding, rising to slightly below 150 minutes from around 20 minutes before December. The sharp and unique increase in studying time in the winter recess, and not in the summer recess, strongly supports the idea that it was causally motivated by the non-binding goal setting.

The second noticeable change is the sudden drop in studying time after the winter recess, returning to baseline level in February and March. This decrease in studying time implies that the studying was not an exciting activity in which students were motivated by fun or intrinsic interest. Rather, it was a costly activity to which they were averse; they were unwilling or reluctant to study, and studying required a certain level of self-control.

The non-binding goal was exogenously set uniformly for all the students by the school authority, which eliminated self-selection by the students. The non-existence of self-selection in the goal setting allowed me to evaluate its average treatment effects (ATE) in a primitive, straightforward manner, by comparing the studying time before and after the goal was established. Specifically, the studying time in the two consecutive months of the winter recess (December and January) were compared to a twofold of the averaged value in the baseline months (May to October),[11] revealing an increase in studying time of 214.81 minutes (*s.d.*

[11]The baseline months were those before the winter recess, namely May to October. April was excluded as it is the starting month of the Japanese academic year, during which instructive demonstrations and software practice is conducted, which would be a nuisance for the analysis. I excluded November simply for the conservative reason that the achievement test was administrated in November; however, including November did not significantly alter the results.

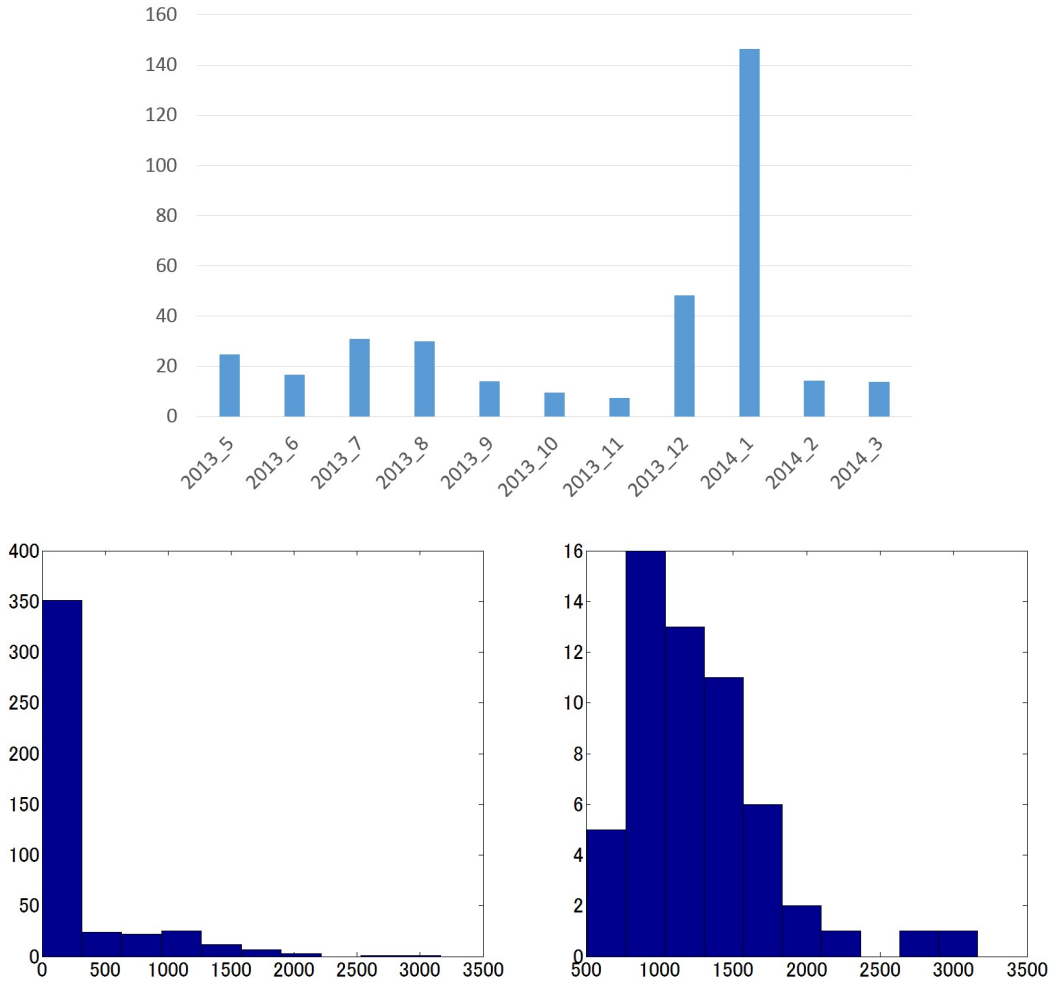

Figure 1: Time spent on studying
Upper panel: Average studying time (minutes) in each month
Lower panels: Histogram of total studying time (minutes) in Dec. and Jan.
(Left: All students. Right: High achievers)

is 21.87).[12] [13] [14] As to the variation in the increase in studying time, the histogram in the lower panels of Figure 1 show that the majority of students had an almost zero increase and a small peak is seen around 1,200 minutes or 20 hours (left panel). Restricting the sample to the high achieving students whose final achievement was over 75%, the right panel demonstrates a single peak around 1,000 minutes, with a mean value of 1,183 minutes and a median value of 1,124 minutes, indicating that the non-binding homework was a long-standing, time-consuming task that took approximately 20 hours to complete.

ATE could be heterogeneous due to students' individual characteristics. Indeed a great number of studies have reported that females are more subject to educational interventions than males.[15] To determine the heterogeneity of the policy effects of the non-binding goal

[12] One might argue that this calculation captures the increase in studying time only for e-learning, missing any increase outside of e-learning, and thereby underestimating the policy effect of the non-binding goal setting. Particularly, those who did not prefer the e-learning presentation may have covered the corresponding content with other, conventional materials. Indeed, as the structure of the "Surala" e-learning environment follows the unified curriculum established by the Japanese government, as well as including other conventional, standard materials, students were able to switch easily to avenues other than e-learning. Unfortunately, the data does not capture any study time outside of e-learning; thus, the observed increase in study time could be regarded as the lower bound of the policy effect of the non-binding goal. Nonetheless, the increase in studying time by the non-binding goal setting remained outstanding, suggesting that the possibility of outside study does not undermine the significant causal effects of the goal setting.

[13] One might be concerned that, as December and January include more free time as a school recess than the baseline months, the calculation might allow overestimation, including spurious effects of increasing study time arising from a greater amount of free time, which occurs irrespective of the goal setting. To address this issue quantitatively, I also report a conservative calculation, restricting the baseline months to those in the summer period (July and August). As these two months include a longer recess period than the two months in the winter, the modified calculation is expected to underestimate the policy effect. This amounts to 195.37 minutes (*s.d.* is 22.55), which does not differ significantly from the original, implying that the overestimation is minimal.

[14] A further concern associated with the calculation is that the goal setting may have "crowded out" studying time outside of e-learning, thereby overestimating the total increase in studying time. I do not deny the possibility of such crowding out, but propose that its impact would be minimal, based on the following two facts: First, as discuss in the footnote above, substitution with preferred material was straightforward due to the unified guidelines of the Japanese government. Second, the use of e-learning had repeatedly been encouraged by the school authority since April, with its use not prevailing until the winter recess. These two facts jointly imply that students who chose preferred material over e-learning before the winter recess, regardless of repeated, persistent encouragement to use the e-learning service by the school authority, would naturally continue to do so even during the winter recess.

[15] Angrist and Lavy (2009); Anderson (2008); Angrist, Lang, and Oreopoulos (2009); Hastings, Kane, and Staiger (2006). Furthermore, a survey on gender differences in economics (Croson and Gneezy (2009)) summarizes related findings.

setting, I performed Ordinary Least Square (OLS) regressions, explaining the increase in studying time in terms of pre-intervention, predetermined variables of students' characteristics, namely a female dummy, an SAA dummy, and the total score in the achievement test as a proxy for the students' abilities. Table 2 presents the regression results. Consistent with the literature, I found significantly larger policy effects among females (Columns (1) to (3)). Given that this selective effect on females was not observed in the studying time during the baseline months (Column (4)), it may be concluded that the females' larger increase in studying time was causally motivated by the non-binding goal setting.

Table 2: OLS regression for increase in studying time (minutes)

	Dependent variable			
	Total increase in Dec. and Jan.			(Baseline)
	(1)	(2)	(3)	(4)
Female	287.966***	299.408***	284.565***	−2.475
	(59.821)	(59.202)	(59.527)	(4.602)
SAA	−127.927	−15.156		40.431***
	(107.131)	(68.314)		(14.981)
Total score	9.326*		5.060	0.230
	(4.764)		(3.109)	(0.412)
Constant	−209.475	126.658***	−62.347	−0.168
	(169.623)	(19.644)	(115.009)	(15.905)
Observations	426	446	426	426
R^2	0.097	0.087	0.092	0.085
Adjusted R^2	0.090	0.083	0.088	0.078

*Note: Robust standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01*

3.2 Goal achievement

How many students did ultimately achieve the non-binding goal? Table 3 presents the descriptive statistics of the high achievers who had completed more than 75% of the homework

Table 3: Descriptive statistics of high achievers

Statistic	N	Mean	St. Dev.	Min	Max
Female (dummy variable)	56	0.571	0.499	0	1
SAA (dummy variable)	56	0.232	0.426	0	1
Total score	55	41.349	6.960	29.400	58.500
Achievement rate by Jan. 7	56	0.693	0.303	0.027	1.000
Achievement rate by Jan. 31	56	0.925	0.109	0.437	1.000
Achievement rate by Feb. 28	56	0.952	0.074	0.752	1.000

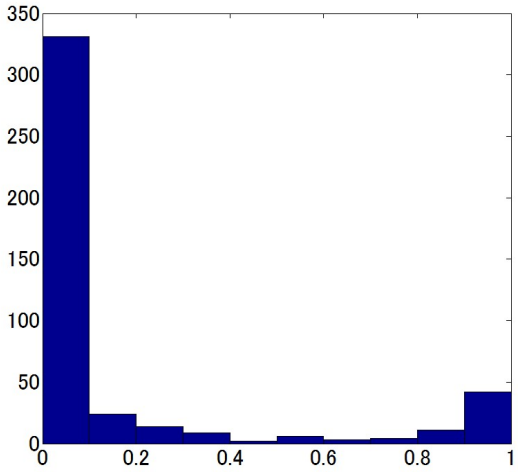

Figure 2: Histogram of final achievement rates

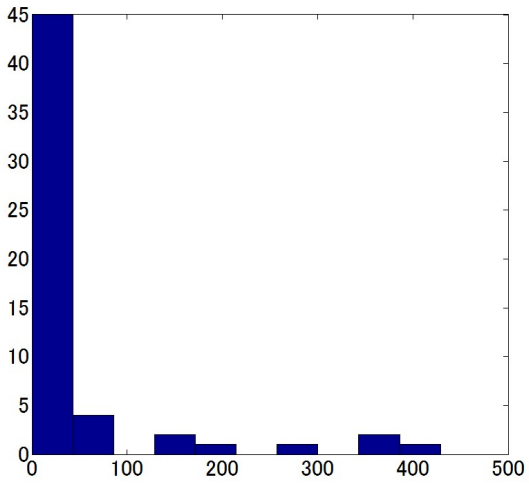

Figure 3: Histogram of high achievers' baseline monthly studying time (minutes)

by the last day of February.[16] The high achievers included 56 students, i.e., 11.9% of the entire freshman group, whereas 57 students made some progress more than 10%, but failed to complete the homework. The abilities of the high achievers identified varied widely, as their total scores varied from 29.4 to 58.5, indicating that low-achieving students also successfully completed the homework. In terms of progress, most students finished working on the homework by the end of January, with further progress even after the deadline (January 7th), which appears reasonable, given that the non-binding goal allowed them to delay the homework without penalty.

To consider the variation in final achievement, I present a histogram of the final achievement rates of the entire freshman group in Figure 2. The distribution has two obvious peaks around zero and one, indicating that the non-binding homework motivated students in two diametrically different ways: Most students were not motivated at all, perhaps even reluctant to try to work on the homework, whereas several students were motivated well enough to complete it, with a few intermediate drop-outs. This finding provides a further implication for the role of non-binding goal setting in motivation enhancement, namely that the goal does not simply motivate students to study more, but also urges them to complete

[16]The high achievers are defined here are those who had achieved the goal of more than 75% at the end of February. However, the discussion here and below holds true even if the final achievement were to be evaluated at the end of January or March. Furthermore, the discussion here and below remains robust as to the choice of the threshold value above 75%.

the task.

Additionally, to determine whether the high achievers had chronic studying habits, I present a histogram of average studying time in the baseline months in Figure 3. The histogram shows that most students are clustered around zero, indicating that most of the high achievers did not have chronic studying habits, but rather were motivated specifically by the non-binding goal setting.

As seen in Table 3, the 56 high achievers include 32 females and 13 SAA students. Whereas these high achievers comprised 11.9% of the entire freshman group, the female high achievers comprised 23.9% of all the female students, and the SAA high achievers comprised 24.5% of all the SAA students, implying that, in addition to the ATE on studying time, goal achievement also differed significantly depending on students' characteristics. To dissociate distinct contributions of various student characteristics, I once again conducted OLS regressions, explaining the final achievement rates at the end of February in terms of predetermined variables of students' characteristics (Column (1), Table 4). The results indicate that achievement was higher among female than male students, as was the case for studying time. Moreover, the higher achievement among SAA students may be explained in terms of their better abilities, rather than the course design, as the regression coefficient for their abilities differed significantly from zero, whereas that for the dummy variable course did not. The result remains robust even if the final achievement rates are measured on the original deadline of January 7th (Column (2), Table 4).

However, it is worth mentioning that, although the SAA students performed well, a considerable number of General students also achieved the goal despite their disadvantage in terms of ability. The majority of the high achievers, specifically 43 of the 56 (76.8%), were enrolled in the General course, suggesting that even low-achieving students may be considerably motivated by non-binding goal setting. Heckman, Stixrud, and Urzua (2006) points out that non-cognitive factors, such as self-control and motivation, play a substantial role in social success, especially for disadvantaged students. The present results show that self-control for goal achievement is not exclusive to high- and middle-achieving students, but also occur among low-achieving students.[17]

To summarize the results presented in this section, I report several findings on the policy effects of the non-binding goal setting in the present context. First, the non-binding goal

[17] Appendix I presents a histogram showing the (cognitive) abilities of the high achievers measured in terms of the total score in the achievement test. This shows that the majority of the high achievers (75%) were low-achieving students whose scores were below 45.

Table 4: OLS estimates for goal achievement rates

	Dependent variable	
	Until Feb. 28	(Until Jan. 7)
	(1)	(2)
Female	0.178***	0.128***
	(0.038)	(0.031)
SAA	0.011	0.025
	(0.077)	(0.068)
Total score	0.009***	0.007**
	(0.003)	(0.003)
Constant	−0.237**	−0.177*
	(0.112)	(0.101)
Observations	426	426
R^2	0.120	0.105
Adjusted R^2	0.113	0.099

*Note: Robust standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01*

setting encouraged a considerable number of students, leading them to study more and to achieve the goal. Second, students who worked on the homework were strongly motivated to complete it, with few intermediate drop-outs. Third, those high achievers were not students who habitually spent time studying, but rather those who did not study chronically. Jointly, these three findings strongly suggest that a non-binding goal causally motivates students to study more, helping them to exercise self-control for goal achievement that they would not otherwise perform voluntarily. This provides an answer to the first question posed in Section 1. An additional finding was that, although the policy effect was greater among females and high-achieving (SAA) students, a substantial number of low-achieving students were also well motivated to achieve the goal.

Result 1: Motivated by a non-binding goal, a considerable number of students, including a substantial portion of low-achieving students, studied more and achieved the goal, as they would not have done voluntarily.

4 Procrastination

In this section, I address the second and third questions posed in Section 1: How do students allocate their effort to achieve a goal, and does a non-binding goal motivate them to study hard at the last minute before the non-binding deadline to address the sizeable remaining task resulting from their own procrastination? I address these questions on the basis of daily behavioral data, focusing particularly on the behavior of the General course high achievers, who comprised the majority (approximately 90%) of all the high achievers.

The upper panel in Figure 4 shows the students' averaged cumulative progress with the homework, distinguishing between the SAA high achievers, the General high achievers, and the low achievers.[18] The red line plots the average cumulative progress of the SAA high achievers, the blue line of the General high achievers, and the gray line of the low achievers.

The outstanding feature of all three curves is the kink that emerges a day before the deadline (January 7th, 2014, denoted by the green vertical line), following rapid growth during the few days immediately before the deadline. The rapid growth indicates that they worked intensively immediately before the deadline, and the almost flat lines of the high achievers after the kinks at the deadline indicate that they suddenly stopped working intensively once the deadline had passed. These features are echoed in the lower panel, which displays the

[18] Low achievers were those whose final achievement rate was between 10% and 75%.

average daily studying time during the winter recess, together with the extended periods until the end of February. The time spent on studying rose dramatically immediately before the deadline, reaching a peak in the final three days, but uniformly dropping to almost to the zero level after the deadline. These informal observations suggest that, many high achievers relied on the deadline for their homework progress, even though it was non-binding.

Furthermore, the upper panel of Figure 4 shows distinct, heterogeneous patterns of effort allocation across the students from different academic courses. Despite the almost identical cumulative achievements at the exact moment of the deadline and after it,[19] in the time up until the deadline, the General high achievers progressed far less, or procrastinated more than the SAA high achievers. The General high achievers' progress on January 1st reached only below 20%, while that of the SAA high achievers reached 40%. The high achievers in the General course disproportionately allocated their effort immediately before the deadline, in contrast to the SAA high achievers.[20]

To test the above informal observations in a more rigorous manner by controlling the distinct contributions of heterogeneous observable characteristics of the students, I performed OLS regressions, explaining the progress in terms of the predetermined variables on students' characteristics. I extracted three mutually exclusive periods of equal length (six days) from the winter recess, named the First, Second, and Third periods. The First period was from December 21st to December 26th 2013, the Second from December 27th 2013 to January 1st 2014, and the Third from January 2nd to January 7th 2014.

The statistical model for the regression is as follows:

$$y_{t,i} = c_t + \beta_{1t} Female_i + \beta_{2t} SAA_i + \beta_{3t} Ability_i + \epsilon_{t,i} \tag{1}$$

where the dependent variable y stands for the progress. The subscript i stands for individual, and $t = \{1, 2, 3\}$ denotes the period, First, Second, and Third respectively. I used the achievement test scores as a proxy for students' abilities, as for the regressions in Section 3.

Table 5 shows the regression results. Somewhat consistently with the informal insights offered above, the SAA high achievers progressed marginally significantly more by 22.6%

[19] The Appendix discusses the identical progress of students from the two academic courses.

[20] A concern here may be that the SAA high achievers progressed earlier because they are simply able to perform the same task more quickly, implying that this result is not evidence of earlier effort exertion. However, the lower panel of Figure 4 shows that the SAA high achievers actually spent more time studying in the earlier stage of the winter recess than did the General high achievers, indicating that the SAA high achievers actually expended more effort at an earlier stage.

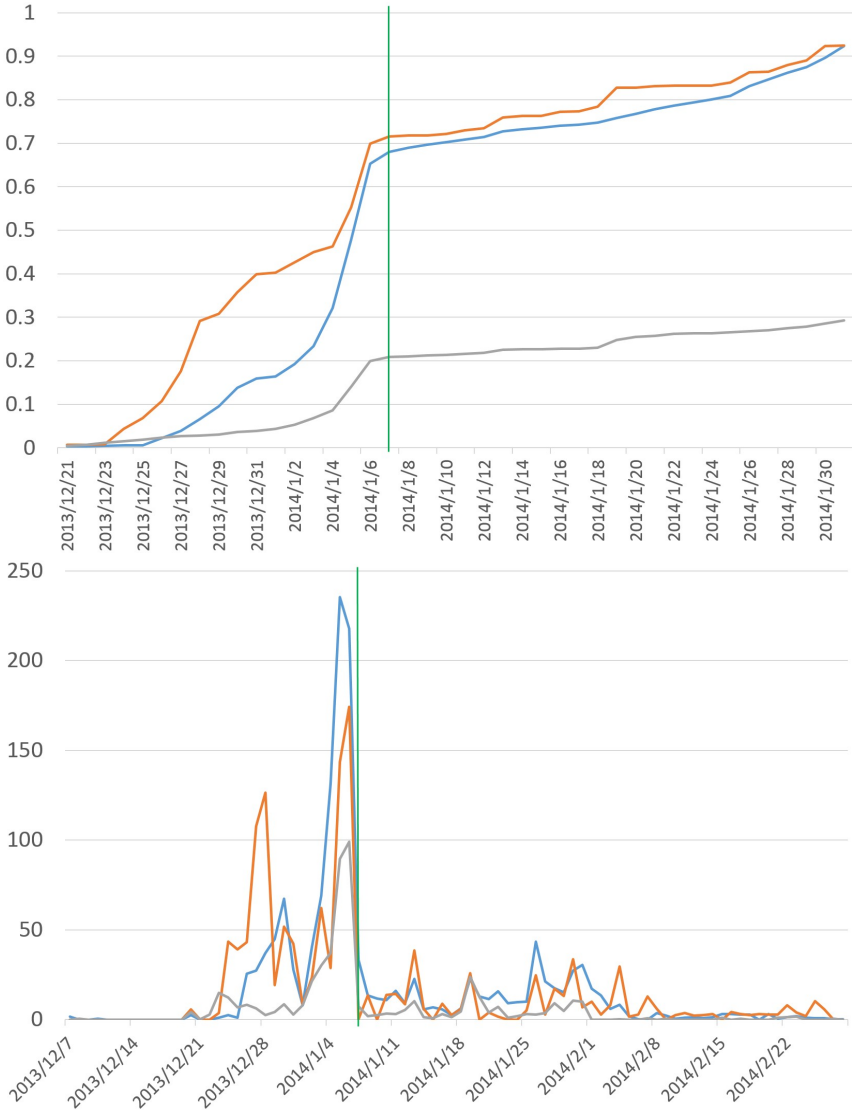

Figure 4: Daily progress
Upper panel: Averaged cumulative progress
Lower panel: Averaged studying time (minutes)

in the First and Second periods irrespective of the contribution of their abilities ($p < 0.10$, Column (4)), while they progressed less in the final three days by 21.4% (not significant), irrespective of the contribution of their abilities (Column (5)). As to the effect of their abilities, none differed significantly from zero individually; however, the signs of the point calculation suggest that the high-achieving students who earned higher scores tended to progress more in the first two periods, and less in the Third period.

Although I found only marginally significant heterogeneity of the progress in terms of the individual effects in the coefficients of the OLS regressions, the joint effects of students' characteristics revealed a significant difference in terms of heterogeneous patterns in their progress. Figure 5 presents the conditional expectations for progress conditioned on the students' characteristics, $\hat{E}[y_t|X]$, which is the fitted value implied by the OLS calculations, where X denotes the set of regressors. The red curve in the left panel shows the progress of the SAA high achievers, and the blue curve displays that of the General high achievers after controlling for gender ratio differences. In the right panel, the red curve shows the progress of the females in the General course, and the blue curve that of the males.

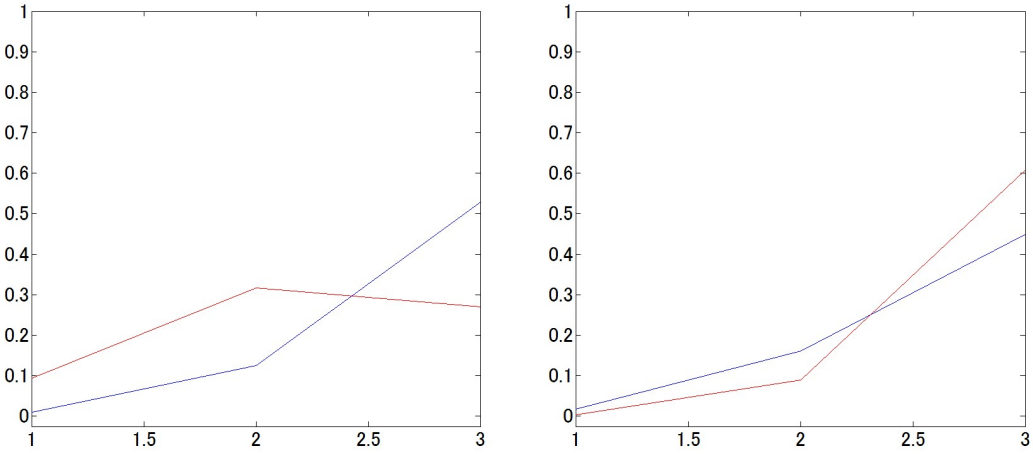

Figure 5: Progress in each period
Left panel: General (blue) and SAA (red)
Right panel: Male (blue) and Female (red) in General course
X axis: Period (First, Second, and Third)

As can be observed in the left panel, the General high achievers, who indeed comprised the majority of all high achievers (41 of 51 students), showed severe procrastination. Their

Table 5: OLS estimates for the total progress in each period

	Dependent variable				
	First	Second	Third	First and Second	Final three days
	(1)	(2)	(3)	(4)	(5)
Female	−0.019	−0.081	0.166*	−0.099	0.155**
	(0.015)	(0.070)	(0.090)	(0.076)	(0.080)
SAA	0.068	0.159	−0.228	0.226*	−0.214
	(0.041)	(0.121)	(0.139)	(0.134)	(0.136)
Total score	0.002	0.004	−0.004	0.006	0.0003
	(0.002)	(0.006)	(0.009)	(0.007)	(0.008)
Constant	−0.053	0.011	0.591*	−0.042	0.335
	(0.083)	(0.213)	(0.348)	(0.280)	(0.326)
Observations	51	51	51	51	51
R^2	0.233	0.115	0.118	0.183	0.111
Adjusted R^2	0.184	0.059	0.062	0.131	0.054

*Note: Robust standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01*

averaged cumulative progress in the First and Second periods was small, reaching merely 13.6%, whereas their final progress was substantially greater, reaching 52.9% ($p < 0.001$).[21] Indeed the final six-day progress of the General high achievers was a factor of 3.54 compared to the cumulative progress of twelve days in the first two periods. In contrast, the SAA high achievers' aggregate progress was almost identical in the Second and Third periods, namely 31.7% and 27.0%, respectively. Indeed, there was no significant difference in the progress during the two periods ($p = 0.7887$).[22] Moreover, the direct comparison between the students on the two academic courses shows that the General high achievers progressed less in the First and Second periods than did the SAA high achievers ($p < 0.05$),[23] whereas they progressed more in the Third period ($p < 0.05$).[24]

As to the gender difference in this subsample (i.e., the high achievers), the females progressed slightly less in the First and Second periods, but this difference was not significant ($p = 0.2055$), and the females progressed more in the Third period, which was statistically marginally significant ($p < 0.1$).[25] [26] Whereas we saw in Section 3 that self-control for goal achievement was outstanding among both SAA students and females, their procrastination appears diametrical as the SAA students procrastinated less, whereas the females procrastinated marginally more. This seemingly inconsistent result is partly addressed in the next subsection, which focuses on the heterogeneity of Math and English, providing the observation that the female high achievers showed substantial and peculiar procrastination in Math.

[21] The hypothesis that the progress in the Third period and the cumulative progress in the First and Second periods were identical is rejected, as the difference is 0.3930 (*s.d.* is 0.0702) and *p-value* is $2.1177 * 10^{-8}$. The standard deviation is cluster-bootstrapped between the two academic courses. Hereafter, hypothesis tests are performed by the cluster-bootstrap. Additionally, I performed a nonparametric test (Wilcoxon pair-wise test) for the General students and the hypothesis that the progress in the Third period and the cumulative progress in the First and Second periods was identical is rejected ($p < 0.001$).

[22] The hypothesis that the progress in the two periods was identical is not rejected, as the difference is 0.0477 (*s.d.* is 0.1780) and *p-value* is 0.7266.

[23] The hypothesis that the cumulative progress in the First and Second periods was identical across the two courses is rejected, as the difference is 0.2803 (*s.d.* is 0.1162) and *p-value* is 0.0178.

[24] The hypothesis that the progress in the Third period was identical across the two courses is rejected, as the difference is 0.2593 (*s.d.* is 0.1161) and *p-value* is 0.0256.

[25] The hypothesis that the progress in the Third period was identical is rejected, as the difference is 0.1579 (*s.d.* is 0.0792) and *p-value* is 0.0807.

[26] Note that the observation that the females amongst the high achievers procrastinated marginally more does not necessarily indicate that females tend to procrastinate more in general, due to the possibility of self-selection. As seen in Section 3, females are generally more encouraged to study; thus, females with a stronger tendency to procrastinate may have been included in this subsample.

The progress in the final three days of the recess (January 4th, 5th, and 6th) demonstrates the distinct, intensive progress of the General students more clearly. Figure 6 shows the histogram of the General high achievers' progress (left panel) and that of the SAA high achievers (right panel). Whereas a sizable number of students in both courses progressed almost not at all in the three days, more than half of the General high achievers progressed with no less than 45% of all the homework in just those three days (the median value of the distribution is 46.80%).[27]

The finding that the students who aimed to advance to higher education showed less procrastination do not conflict with the existing findings of a field experiment by Burger, Charness, and Lynham (2011), in which they found no significant aggregate procrastination among college students. Rather, the present findings suggest that procrastination matters among low-achieving students who do not necessarily aim to advance to higher education (i.e., General students), at least in the case of non-binding goal setting.[28]

Given that the General high achievers comprised the majority in the present sample, it may be concluded in answer to the second research question that the majority of the high achievers allocated their effort disproportionately, most intensively immediately before the deadline, or simply procrastinated.

Result 2: The majority of high achievers, namely General students, procrastinated.

Next, to answer to the third question posed in Section 1, the left panel in Figure 6 shows an outstanding peak around 75%. This peak implies that a considerable subset of the General high achievers progressed intensively by completing 75% of the homework in the final three days. Recall from Section 3 that the homework took approximately 20 hours for average high achieving students; thus, this 75% progress was by no means an easy task for General

[27]Kolmogorov-Smirnov test marginally rejects the hypothesis that the two samples are realized from an identical distribution, with *p-value* of 0.0631.

[28]Unfortunately, due to data limitations, I cannot propose a reason for the SAA students not procrastinating. One possibility is that, as the SAA course aims to advance students to higher education, their stronger will to advance might have led to less procrastination. This stronger will might have encouraged such students to exercise their willpower at an earlier stage. However, other explanations may also apply. For example, earlier progress by the SAA students might have been due to parental intervention, by which parents persuaded such students to work earlier. Another potential explanation is that the "delayed gratification" differed across the courses. The SAA students might have had more to gain from studying, advancing to higher education in the future, which further motivated them and led to less procrastinations. Alternatively, the SAA students might simply have been less exposed to temptations that prevented them from studying. The present data is unable to identify the precise mechanism.

students, who fall in the category of low achievers in terms of their studying ability. Indeed, the remaining tasks would have been a heavy burden. Recall further that the students were allowed to allocate their effort after the deadline without any penalty (as it was a non-binding deadline), and so could have avoided intensive hard work at the last minute. Nonetheless, the empirical data show that these students did indeed make the last-minute effort to complete the sizeable remaining task resulting from their own procrastination, aiming to meet the non-binding deadline.

Result 3: Motivated by a non-binding goal, a considerable subset of high achievers worked hard at the last minute to complete the sizeable remaining task resulting from their own procrastination.

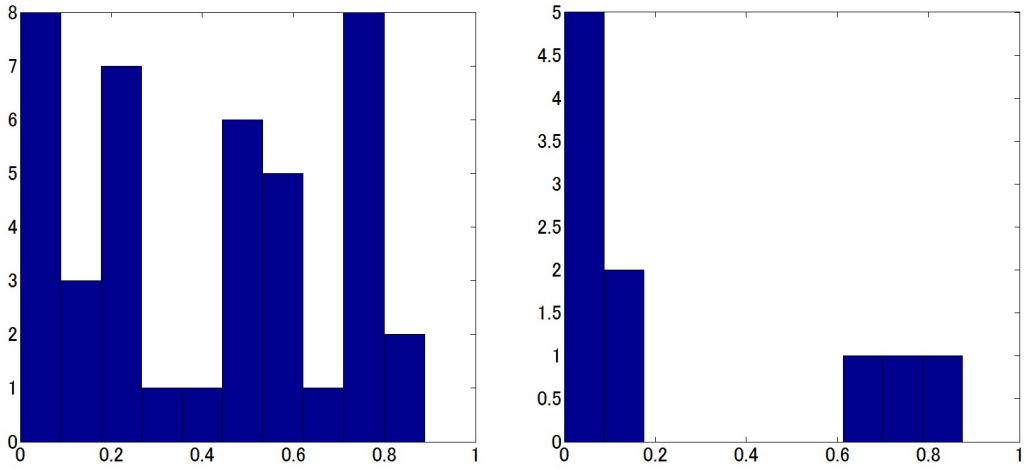

Figure 6: Histogram of progress in the final three days
Left panel: General students. Right panel: SAA students.

Females' peculiar procrastination in Math

Figure 7 shows the heterogeneous progress in each field of study, namely Math (left panel) and English (right panel) among the high achievers in each field. The mean progress is the fitted value implied by the OLS calculations explaining the progress of each subject in the same way as previously.[29] The mean progress of the male General students is represented by the blue curve, of the female General students by the red curve, and of the SAA students by

[29]The OLS calculations are provided in the Appendix.

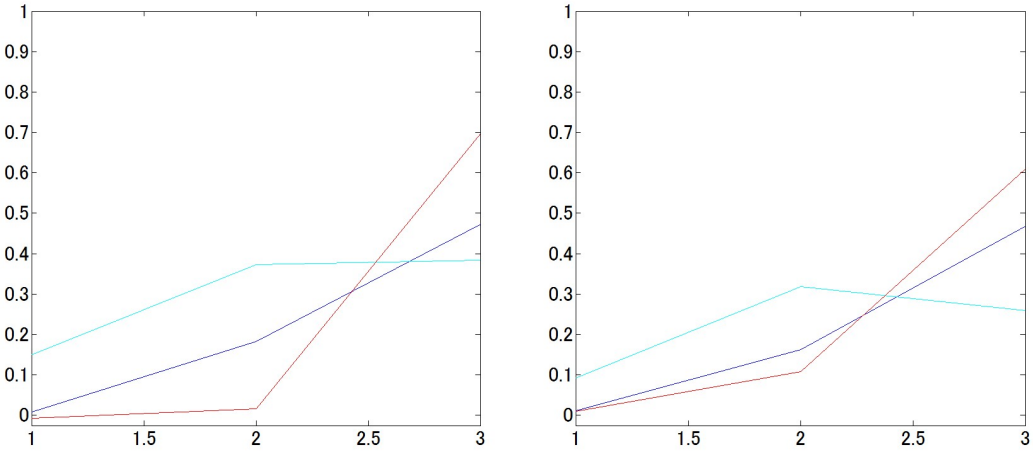

Figure 7: Progress in Math and English in each period
Left panel: Math, Right panel: English
Blue: Male, Red: Female, Cyan: SAA students

the cyan curve. Interestingly, there was no significant difference in the pattern of progress across Math and English for either the SAA students or the male General students. However, the female General students showed a distinctly peculiar procrastination in Math. The female General students showed almost zero progress in the First and Second periods, and then progressed dramatically by 69.8% in the final period, this progress being significantly greater ($p < 0.001$).[30] The direct comparison across genders shows that the females' progress in the first two periods was significantly less than the males' progress ($p < 0.05$);[31] however, their progress in the final period was significantly greater ($p < 0.05$).[32] Existing studies have shown that females have a tendency to avoid working on Math due to their aversive attitudes to Math.[33] Furthermore, I provide additional evidence in the Appendix that supports the

[30]The hypothesis that the progress in the Third period was identical to the cumulative progress in the first two periods is rejected, as the difference is 0.6880 (*s.d.* is 0.0957) and *p-value* is $6.4371 * 10^{-13}$. Additionally, I performed a nonparametric test (Wilcoxon pair-wise test) and the hypothesis is rejected ($p < 0.001$).

[31]The hypothesis that the progress in the first two periods was identical across genders is rejected, as the difference is 0.1809 (*s.d.* is 0.0774) and *p-value* is 0.0194.

[32]The hypothesis that the progress in the Third period was identical across genders is rejected, as the difference is 0.2248 (*s.d.* is 0.1093) and *p-value* is 0.0398.

[33]Wilder and Powell (1989) provide a comprehensive survey on the issue.

notion of females' Math avoidance,[34] which jointly suggest that females' Math aversion is the most convincing theory behind the selective procrastination in Math observed in the present study.

This finding provides a further implication for the role of non-binding goal setting, reinforcing the answers to the second and third questions posed in Section 1: Females in this study procrastinated in Math, possibly due to Math aversion; however, their motivation, enhanced by the non-binding goal setting, strongly encouraged them to work hard at the last minute to meet the deadline, despite it being non-binding, perhaps helping them to overcome their aversion to Math.

To summarize this section, the present study found that the majority of high achievers in the General course procrastinated until the non-binding deadline but worked intensively immediately before it. Specifically, a sizable subset of the General high achievers progressed intensively only in the final three days, indicating that the non-binding deadline motivated them to complete the sizeable remaining task resulting from their own procrastination at the last minute. Moreover, the female students' procrastination was particularly outstanding in Math, as they progressed almost not at all in the first two periods, perhaps due to their Math aversion, but they overcame this aversion in the final period, progressing dramatically to meet the deadline, despite it being non-binding. Jointly, these findings suggest that even a non-binding deadline plays a substantial role in motivating students to work and preventing further procrastination.

5 Possible explanations by economic decision-making models

Why were these students motivated to meet the non-binding deadline despite the sizeable remaining task and/or the mental stress of their task aversion? Several theoretical studies on implicit commitment in the absence of reward or punishment have shown that the mechanisms of implicit commitment actually encourages people to exert strong willpower to overcome their present-bias and pursue a long-term benefit, as briefly discussed in Section 1 (Bénabou and Tirole (2004); Hsiaw (2013); Koch and Nafziger (2011); Suvorov and Van de Ven (2008); Fahn and Hakenes (2014)).

[34] In the Appendix, I discuss two further possible explanations; however, I found no positive evidence to support these. Moreover, I provide positive evidence that females in another institution using the same e-learning service actually showed avoidance for Math.

The results of the present study broadly agree with this theoretical work on implicit commitment mechanisms. The non-binding goal-setting in this case may have acted as an implicit commitment, causally encouraging the students, who regarded the difficulty of the goal as appropriate for them, and therefore enacted self-control to overcome their present-bias in studying. However, due to data limitations, the exact decision-making mechanism that occurred here cannot be fully identified, and the psychological factors generating the dis-utility of non-attainment of the goal remain hidden.

Nonetheless, the present study empirically and quantitatively reveals the timing of the effort being exercised immediately before the deadline, which has been elusive in the empirical literature. Although this was a case of a non-binding deadline, the delay of effort exertion or procrastination observed here is consistent with theoretical models of procrastination in which agents with present-biased preferences avoid immediate costs and put off costly activities in delayed gratification paradigms (O'Donoghue and Rabin (2001); O'Donoghue and Rabin (1999a); O'Donoghue and Rabin (1999b)). However, in contrast to the binding deadlines in such literature, and perhaps motivated to avoid the psychological dis-utility of the non-attainment of the goal, the students in this study tried to meet the deadline, despite it being non-binding, performing self-control to study at the last minute.

In terms of this explanation, two distinct types of self-control are included in the decision-making process, namely self-control for goal achievement and self-control for preventing procrastination in the process. The explanation above implies that these two forms of self-control are not necessarily exercised at the same time. Possibly, they are exercised through dissociated mechanisms. At the very least, self-control for goal achievement motivated by a non-binding deadline does not appear to necessarily prevent procrastination in the process. The findings here point to the need for future theoretical work modeling self-control and the associated dynamic allocation of effort, and on the role of deadlines in behavioral control in procrastination, or more broadly on the commitment mechanism.

6 Concluding remarks

Utilizing the advantages of unique, real-world data available from an e-learning service in which students' daily homework progress was directly observable, and of a non-binding homework context that straightforwardly revealed students' procrastination, this study empirically evaluated procrastination among high school students, recognizing that students' behavior is known to be susceptible to present-bias, and the associated influence of a dead-

line. The main findings of the study are as follows: First, the non-binding goal setting successfully encouraged a considerable number of students to spend more time studying to achieve the goal. The extent of goal achievement was remarkable among females and SAA students; however, many low-achieving students also successfully achieved the goal. Second, the high achievers in the General course, who indeed comprised the majority of all high achievers, procrastinated until close to the deadline and worked intensively immediately before the deadline. This was particularly true for the Math homework among the female high achievers. Finally, a sizable subset of the high achievers worked hard at the last minute before the deadline, trying to complete the sizeable remaining task resulting from their own procrastination and/or mental stress from their task aversion to meet the deadline, despite it being non-binding.

These findings jointly suggest that a non-binging goal may motivate considerable numbers of students to exercise strong self-control for goal achievement. However, for the majority, the effort exertion is put off until immediately before the deadline, and the deadline, even if it is non-binding, plays a substantial role in preventing further procrastination. These findings may inform future theoretical work on dynamic decision-making involving self-control.

This study represents just one small step toward an understanding of procrastination. Further research is required to determine whether and how the manner in which the allocation of effort differs according to task structure, environment, and commitment mechanisms. Intuitively, effort allocation should depend on a range of factors, primarily on task structure. Indeed, theoretical works cited in Bénabou and Tirole (2004) and Hsiaw (2013) employed task structures in which people had to continue to exercise their willpower to achieve a goal, such as abstaining from smoking, which does not permit the decision-maker's last-minute intensive work to achieve the goal, as was the case in the present study. Further research, including theoretical and empirical work, is required to enrich decision-making models to describe procrastination in detail.

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Appendices

A Test scores and academic courses

Table 6: Correlation matrix of SAA course and test scores

Statistic	SAA	Total	Math	English
SAA	1	0.6755	0.5828	0.6107
Total	-	1	0.8699	0.8372
Math	-	-	1	0.6045
English	-	-	-	1

Table 6 displays the correlation matrix for achievement test scores and academic courses (a dummy variable for the SAA course). These data show that the SAA dummy and test scores have strong correlations, namely 0.6755 for total score (the cumulative score for Math, English, and Japanese), 0.5828 for Math, and 0.6107 for English, respectively.

B Discussion of habit formation

In this section I discuss the possibility that the studying habits in the winter recess continued even in the post-intervention period. Charness and Gneezy (2009) and Levitt, List, Neckermann, and Sadoff (2012) report that their intervention successfully led to students' habituation of desirable activities, namely exercising in a gym and studying, respectively. I discuss here whether this was also the case in the present context.

The upper panel of Figure 1 suggests that no persistent increase in aggregate studying time occurred. However, studying habits might have been formed selectively by the high achievers. To determine whether this was the case, I performed OLS regressions (Table 7), explaining the increase in studying time in February (Columns (1) and (2)) and March (Column (3)), with achievement rates evaluated at the end of January (Column (1)), those on January 7th (Column (2)), which was the original deadline for the homework, and those at the end of February (Column (3)).

Table 7: OLS estimates for increase in studying time post-intervention

	Dependent variable		
	Increase in Feb.		Increase in Mar.
	(1)	(2)	(3)
Achievement until Jan. 31	38.640		
	(25.900)		
Achievement until Jan. 7		−12.462	
		(21.529)	
Achievement until Feb. 28			−30.084**
			(13.278)
Female	1.655	10.036	10.332*
	(9.127)	(9.668)	(6.347)
SAA	−29.273	−28.624	−3.825
	(18.315)	(17.818)	(14.237)
Total score	0.109	0.540	0.567
	(0.696)	(0.746)	(0.445)
Constant	−6.106	−17.401	−20.154
	(27.596)	(28.826)	(16.908)
Observations	426	426	426
R^2	0.030	0.011	0.037
Adjusted R^2	0.020	0.002	0.028

*Note: Robust standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01*

The regression results are mixed: The studying time in February was larger among the students who had achieved more by January 31st, as the regression coefficient for the achievement rates is positive (but not significant, Column (1)). However, inconsistent with this the coefficient becomes negative when the achievement rates are evaluated on January 7th (Column (2)). Moreover, also inconsistently, the result in Column (3) demonstrates that the high achievers tended to study less in March. These regression results jointly provide no consistent or convincing evidence that particular studying habits emerged in the post-intervention period.

C Histogram of high achievers' abilities

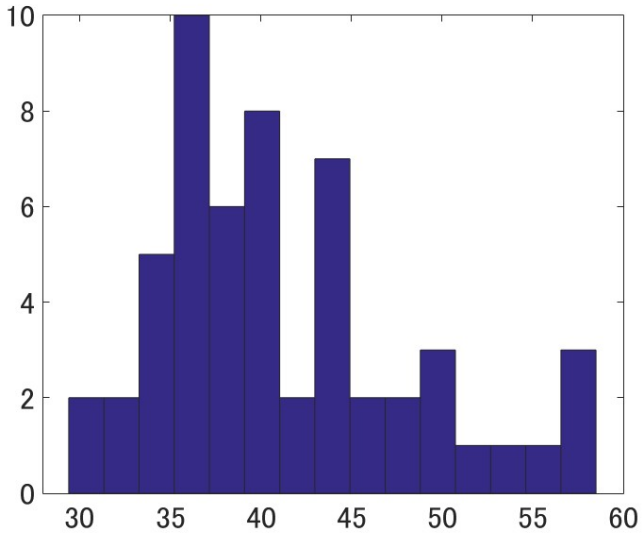

Figure 8: Histogram of high achievers' (cognitive) abilities

Figure 8 displays the histogram of the high achievers' cognitive abilities, measured in terms of the total score on the achievement test. Not only the middle- to high-achieving students, who achieved around 50 or more, but also many low-achieving students, managed to achieve the goal, and these latter students comprised the majority. The proportion of low-achieving students whose score was below 45 is 75%.

D Discussion of progress at the deadline

Table 8: OLS estimates for progress until the deadline

	Dependent variable
	Until Jan. 7
Female	0.060
	(0.090)
SAA	0.002
	(0.112)
Total score	0.002
	(0.008)
Constant	0.558
	(0.333)
Observations	51
R^2	0.015
Adjusted R^2	−0.048

Note: Robust standard errors are in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

In this section, I provide evidence that progress at the exact time of the deadline (January 7th, 2014) was almost identical among high achievers, regardless of their academic course, gender, and abilities. The upper panel of Figure 4 shows that the progress at the deadline was almost identical between the General and the SAA students. This first impression is confirmed in the results of the following OLS regressions, explaining the progress in terms of the students' observable heterogeneous characteristics (Table 8), in which no explanatory variable significantly differs from zero. The progress at the deadline was almost identical across academic courses and genders, in contrast to the distinct progress until close to the deadline, as reported in Section 4.

E Discussion of progress after the deadline

In this section, I discuss progress after the deadline. Figure 9 shows the histogram of high achievers' progress after the deadline. Most of the students are clustered around zero, indicating that most completed the homework by the deadline. With respect to the heterogeneity, Table 9 displays the results of OLS regressions, explaining the progress after the deadline in terms of students' characteristics. No regression coefficient differs significantly from zero, suggesting that the high achievers' progress after the deadline was almost identical regardless of academic course, gender, and abilities, which contrasts significantly with the distinct progress until close to the deadline, as reported in Section 4.

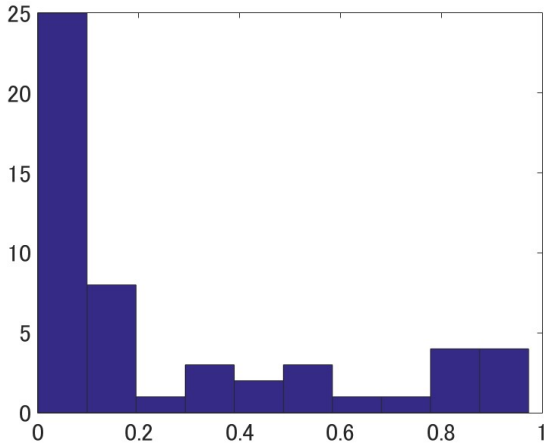

Figure 9: Histogram of high achievers' progress after the deadline

F Respective progress in Math and English

In this section, I provide the OLS estimates for the progress in Math and English, respectively, which were used to draw the plots in Figure 7. Table 10 presents the summary statistics for the subsample (upper panel for Math and lower panel for English). The subsample includes the students whose final achievement rate evaluated on February 28th, 2014, was no less than 75% (and whose progress on December 20th was less than 10% for excluding students who progress substantially before the intervension period). Table 11 demonstrates the estimates from the OLS regressions for Math progress. The regression model is identical to that in Table 5, which underlies the plots in the left panel of Figure

Table 9: OLS estimates for progress after the deadline

	Dependent variable
	Progress
Female	−0.037 (0.098)
SAA	0.034 (0.117)
Total score	−0.005 (0.009)
Constant	0.499 (0.361)
Observations	51
R^2	0.014
Adjusted R^2	−0.049

*Note: Robust standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01*

7. Similarly, Table 12 show the OLS regressions for English progress, which underlies the plots in the right panel of Figure 7.

G Discussion of alternative explanations for female procrastination in Math

In the following two sections, I pursue explanations for the females' selective procrastination in Math, which contrasted with the males, who showed no tendency to procrastinate selectively in Math. In this section, I first explore the possibility of explanations other than females' aversion to Math, showing that none of these is positively supported by the data.

The first potential explanation to be discussed is that, in this particular subsample, females were weaker than males in Math, therefore taking more time to pass each Math unit, regardless of whether or not they had Math-aversion.[35] To determine this, I performed an OLS regression, explaining the achievement test scores in Math in terms of students' char-

[35] In fact, many studies have documented that females are weaker in Math than males. An incomplete list includes Guiso, Monte, Sapienza, and Zingales (2008), Ellison and Swanson (2010), Fryer and Levitt (2010), Niederle and Vesterlund (2010), and Joensen and Nielsen (2014)).

Table 10: Summary statistics for high achievers in Math and English

Upper panel: Math. Lower panel: English

Statistic	N	Mean	St. Dev.	Min	Max
Female	64	0.578	0.498	0	1
SAA	64	0.219	0.417	0	1
Math score	62	41.748	8.104	30.700	60.600
Achievement by Jan. 7	64	0.743	0.389	0.000	1.000
Achievement by Feb. 28	64	0.990	0.037	0.800	1.000

Statistic	N	Mean	St. Dev.	Min	Max
Female	53	0.547	0.503	0	1
SAA	53	0.208	0.409	0	1
English score	50	41.560	5.577	34.000	57.000
Achievement by Jan. 7	53	0.702	0.366	0.000	1.000
Achievement by Feb. 28	53	0.979	0.042	0.810	1.000

Table 11: OLS estimates for Math progress in each period

	Dependent variable		
	First	Second	Third
	(1)	(2)	(3)
Female	−0.017	−0.179**	0.234**
	(0.041)	(0.077)	(0.112)
SAA	0.141	0.227**	−0.169
	(0.085)	(0.108)	(0.153)
Math score	0.001	0.004	−0.003
	(0.001)	(0.005)	(0.008)
Constant	−0.021	0.032	0.579*
	(0.047)	(0.207)	(0.329)
Observations	62	62	62
R^2	0.144	0.193	0.092
Adjusted R^2	0.100	0.151	0.045

*Note: Robust standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01*

Table 12: OLS estimates for English progress in each period

	Dependent variable		
	First	Second	Third
	(1)	(2)	(3)
Female	−0.012	−0.065	0.145
	(0.013)	(0.086)	(0.110)
SAA	0.060	0.160	−0.273*
	(0.038)	(0.155)	(0.140)
English score	0.004	0.004	−0.001
	(0.003)	(0.012)	(0.011)
Constant	−0.127	0.015	0.505
	(0.104)	(0.459)	(0.452)
Observations	50	50	50
R^2	0.224	0.070	0.090
Adjusted R^2	0.173	0.009	0.031

*Note: Robust standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01*

Table 13: OLS estimates for Math scores

	Dependent variable
	Math score
Female	2.004 (1.710)
SAA	10.478*** (1.910)
Constant	38.219*** (1.346)
Observations	62
R^2	0.332
Adjusted R^2	0.309

*Note: Robust standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01*

acteristics (Table 13). The coefficient for the female dummy would be negatively significant if the explanation holds. However, the coefficient for the female dummy does not differ significantly from zero. Moreover, the point estimate is positive, suggesting that the females in this subsample may even be better than males in Math.

Table 14: OLS estimates for Math progress until January 1st

	Dependent variable
	Math progress until Jan. 1st
Female	−0.197**
	(0.077)
SAA	0.352**
	(0.133)
Math score	0.004
	(0.005)
Eng. progress until Jan. 1	0.142
	(0.172)
Constant	0.026
	(0.214)
Observations	62
R^2	0.303
Adjusted R^2	0.254

*Note: Robust standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01*

The second possible explanation to be discussed is that females made English progress earlier and Math progress was simply "crowded out" until the end of second period (January 1st). To explore the possibility of such "crowding out" of Math, I added a conditional variable, namely progress in English until January 1st, to the regression specification (4) in Table 11. The coefficient would be negative if the "crowding out" had occurred. The regression result is presented in Table 14. Contrary to this potential explanation, the coefficient is not significantly different from zero, and the sign is positive, with other coefficients remaining almost unaffected. This result contradicts the explanation that "crowding out" by English progress occurred in Math progress among the present females, leading to the Math progress

being delayed until the end of the second period.

H Additional discussion of females' Math aversion

In this section, I provide positive evidence for females' Math-aversion in further data from the same e-learning service in another educational institution, namely College B. College B used the Surala e-learning system until March 2014 to allow students to review the three-year middle school curriculum effectively and promptly within a year, as required by the authority to prepare for incoming internships in middle schools in the following years. Specifically, the college establish a required course for almost all freshmen using the e-learning system, in which they required the students to freely choose 400 units out of 722 possible units to work on during the academic year. The units included Math, English, and Japanese. There were 472 freshmen in the 2013 academic year (April 2013 to March 2014), including 313 males and 159 females. Examining the different choice patterns for Math units across genders, I discuss whether or not the females in this sample showed aversion to Math.

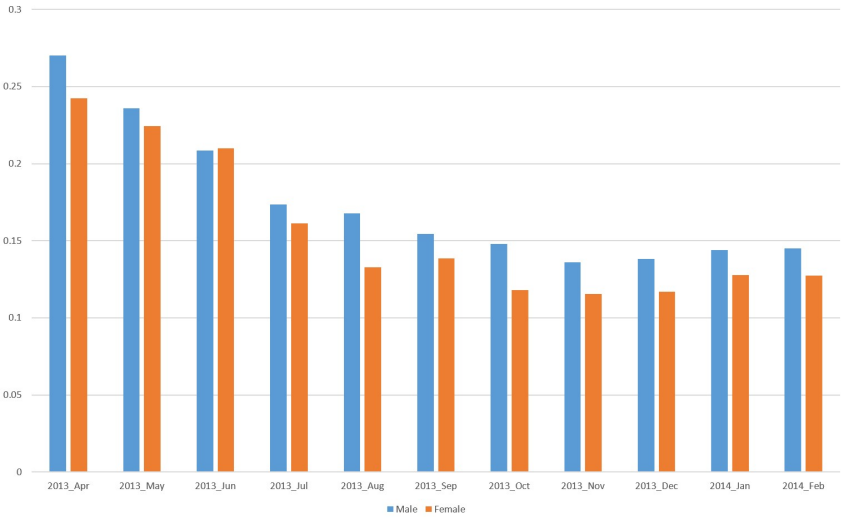

Figure 10: Fractions of choices for Math units in each month

Figure 10 displays the number of Math units passed monthly by the students as a fraction of all the units passed. Consistent with expectations, the females chose to complete fewer Math units than the males, suggesting their tendency to avoid Math. To examine the fe-

Table 15: OLS estimates for Math choices

	Dependent variable			
	Fraction of Math			
	(1)	(2)	(3)	(4)
Female	-0.030^{***}	-0.046^{**}	-0.038^{***}	-0.062^{***}
	(0.011)	(0.019)	(0.013)	(0.021)
Constant	0.150^{***}	0.172^{***}	0.160^{***}	0.181^{***}
	(0.007)	(0.012)	(0.009)	(0.015)
Observations	2,569	1,136	1,980	897
R^2	0.004	0.007	0.006	0.013
Adjusted R^2	0.003	0.006	0.005	0.012

Note 1: Cluster-robust (individual-level) standard errors are in parentheses. *p<0.1; **p<0.05; ***p<0.01

Note 2: (1) Pooled OLS on the entire data

(2) Until September 1st

(3) Those who finally almost achieved the requirement (more than 97.5%)

(4) Conditioned on both (2) and (3)

males' lesser selection of Math units in more detail, I performed pooled OLS regressions, explaining individual monthly proportions of Math choices in terms of a female dummy (Table 15). The OLS regression for the whole sample (Column (1)) reveals that the regression coefficient for the female dummy is significantly negative, implying that females were inclined to avoid Math. To check the robustness of the result, I restricted the subsample until the end of August, the earlier period in which the students' voluntary choice may be more directly revealed, as they had a larger set of incomplete units from which to select (Column (2)). Again, the regression coefficient differs significantly from zero in the negative direction. Moreover, I also examined another subsample, including only students who eventually completed 400 units successfully to achieve the goal (Column (3)), and confirmed that the regression coefficient remained significantly negative. Finally, I examined the case that fulfills both conditions above, namely that for high achievers' choice in the earlier stage (Column (4)), and the regression coefficient was even more negative than before. These results jointly and robustly suggest that females tend to have a stronger aversion to Math than males.