ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

International Bachelor Economics and Business Economics

Bachelor Thesis Behavioural and Health Economics

The Effectiveness of Text Message Commitment Devices in Reducing Sleep Procrastination

Abstract

Sleep procrastination has negative physical and mental health consequences. This study aims to determine the efficacy of an intervention aimed at reducing sleep procrastination. Participants were randomly assigned to either a treatment condition in which they had to send daily text messages stating their intended bedtime or a control condition in which they only had to keep a sleep diary. The text messages served as a commitment device, with the receiver serving as an accountability partner. Results show that the use of the commitment device was associated with a reduction in sleep procrastination compared to the control group. Because of the experimental design, a distinction between sophisticated and naive people could be made. However, no significant impact was found. According to these findings, commitment devices may be a promising tool for improving sleep patterns. Future research should look into the use of commitment devices in larger and more diverse populations, as well as the potential application of this approach to other areas where habit formation and procrastination are prevalent.

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1. Introduction

Many individuals tend to make plans that are more ambitious than they can realistically achieve (Ainslie, 1975). One example is the bedtime ritual: a desired bedtime is set with the goal of waking up well-rested. However, as the evening progresses, procrastination sets in, and bedtime is pushed further into the night as suddenly watching television or scrolling on one's phone is prioritized. This phenomenon can be explained by inconsistencies in preferences over time (Frederick et al., 2002). Time consistency, or the ability to maintain consistent bedtime preferences across different periods, is crucial for achieving optimal nightly rest. When bedtime preferences change throughout the day, the actual bedtime is delayed, resulting in a reduction in the amount of sleep obtained. This inconsistency leads to long-term losses because the amount of sleep obtained is less than desired.

With almost a third of the population sleeping too little (CDC, 2022; Hersenstichting, 2023), it is essential to investigate accessible ways to improve sleep quality and quantity. Improving the sleep of a large segment of the population can lead to significant improvements in health and well-being, as well as economic benefits for society. Therefore, expanding the current academic literature on sleep deprivation and strategies to mitigate it is socially relevant.

In this research, the effectiveness of a commitment device in overcoming time inconsistency regarding bedtime behaviour will be investigated. A commitment device is a tool used to help individuals stick to their goals and overcome their tendencies towards procrastination and impulsivity (Bryan et al., 2010a). Specifically, this study will test the effectiveness of texting an accountability partner as a commitment device, which is a widely accessible and easily implemented tool. If the results show a substantial effect, this simple intervention can improve the sleep of many individuals.

This paper will be organized into four main chapters. In Chapter 1, I will provide an introduction to the topic of bedtime procrastination and its negative impact on sleep quality and overall health. Chapter 2 will present a comprehensive theoretical framework. Specifically, I will elaborate on the negative impact of sleep deprivation and time inconsistency, and how commitment devices can be used to overcome these issues. I will also discuss the role of chronotype differences and sophistication in bedtime procrastination. In Chapter 3, I will detail the methodology used to test the hypothesis. Participants will be university students in the Netherlands, and data will be collected using a self-assessment questionnaire and sleep diaries. I will also provide information on how individual differences in chronotype and sophistication will be measured and accounted for. This chapter will provide a detailed description of the research design and methods used, including information on participant recruitment and data analysis. Chapter 4 will present the results of the study and discuss the findings in relation to the theoretical framework presented in Chapter 2. I will synthesize the findings and propose future research directions at the conclusion in Chapter 5.

Overall, this paper aims to provide a comprehensive examination of bedtime procrastination, and how commitment devices can be used to overcome this behaviour. By presenting a theoretical framework, detailed methodology, and research findings, this paper will contribute to the existing literature on sleep behaviour and provide practical implications for individuals seeking to improve their sleep habits.

2. Theoretical framework

2.1 Consequences of insufficient sleep

Sleep deprivation has numerous negative effects. Sleep affects both physical and mental health, which has a variety of economic consequences. According to the Centre for Disease Control and Prevention, about 35% of adults in the United States do not get enough sleep on a regular basis (CDC, 2020). Also in the Netherlands, where my experiment is taking place, more than 60 percent of adults claim to not be happy with their sleep habits (Hersenstichting, 2023). Because of this high prevalence, the impact is significant, both physically and economically.

Sleep deprivation has a negative impact on physical health. This is because adequate sleep is a natural process required to physically and mentally recharge for the next day. Sufficient sleep is thus important for maintaining overall well-being, regulating mood, and supporting cognitive function (Sonnentag et al., 2009). Among young adults, insufficient sleep has also been linked to impaired academic performance, mood disorders, and increased risk of obesity and other health problems (Owens et al., 2014).

Inadequate sleep also has a negative economic impact. This is reflected in societal costs comprised of direct healthcare costs, productivity losses, absenteeism, accident costs, informal care, and decreased well-being (Hillman et al., 2018). This adds up to 1.35 to 2.92 percent of GDP, according to research conducted in five OECD countries: Canada, the United States, Germany, Japan, and the United Kingdom (Hafner et al., 2017).

2.2 Time inconsistency

Time inconsistency is a phenomenon in decision-making in which an individual's preferences or choices change over time in ways that contradict their initial intentions or plans (Ericson & Laibson, 2019). Well-known examples include failure to stick to diets, exercise routines, or monthly saving plans (Ainslie, 1975). Going against the initial plans can have drawbacks in the long run. R.H. Strotz (1955) was the first to illustrate this, presenting an example of decreasing impatience. He showed people prefer 100 dollars today over 110 dollars tomorrow, as well as 110 dollars over 100 dollars if both options were paid out a month later. This shows that people are prone to give in to their present desires, making their preferences change over different points in time. This can even result in suboptimal outcomes, such as the 10-dollar decreased payout.

Research on time inconsistency focuses on three variables: ideal behaviour, predicted behaviour, and ex-ante actual behaviour. Comparing these reveals whether there is preference reversal and, if so, whether the participant anticipated this (Wong, 2008). Wong's study on university students measured the time inconsistency of exam preparation by measuring the optimal, predicted,

and actual study plans for an exam. This gives a measure for both predicted procrastination and unpredicted procrastination. This distinction will be elaborated on in 2.5.

2.3 Commitment device

A commitment device is a self-imposed constraint that helps people to stick to their long-term goals despite the temptation of immediate rewards. Commitment devices have been shown to be effective in helping individuals follow through on their intentions to engage in behaviours like exercise, healthy eating, and saving money (Bryan et al., 2010a). By committing to a specific goal and setting up a system of accountability, people can increase their chances of achieving their desired outcome. Commitment devices that entail real economic costs or benefits are referred to as "hard commitments", while any device that has primarily psychological consequences is classified as a "soft commitment" (Bryan et al., 2010a). An example of a soft commitment device is the use of an accountability partner. Research has shown that enlisting the support of a friend or loved one can be an effective strategy for achieving and maintaining goals (Gollwitzer & Sheeran, 2006). This person serves as an accountability partner, and this motivator is effective because it provides an external source of accountability (Baca-Motes et al., 2013).

In the context of sleep procrastination, Avery et al. (2019) investigated the effectiveness of a hard commitment device involving monetary incentives for adhering to a prescribed bedtime. The study found significant positive effects of the commitment device. Meier et al. (2012) examined the use of peer pressure as a commitment device for increasing savings. The results indicated that regular accountability and follow-up were crucial factors for boosting savings commitment, while in-person meetings or peer pressure did not have an additional impact beyond texting.

2.4 Chronotype

To comprehensively examine the effect of commitment devices, it is crucial to consider individual differences, such as one's chronotype - whether they are a "morning person" or an "evening person" (Horne & Östberg, 1976). This characteristic is defined as feeling more alert and productive in the morning or evening. The extent of bedtime procrastination is found to be related to chronotype (Kühnel et al., 2018). Later chronotypes, or evening people, tended to report more bedtime procrastination than earlier chronotypes. An evening person prefers to stay up late and sleep in, so will likely be tempted to procrastinate more. Kühnel and her colleagues (2018) concluded that bedtime procrastination was not a matter of self-control, but rather a biological preference.

While it has been suggested that bedtime procrastination is a biological preference rather than a self-control issue, it is important to consider other factors that may contribute to procrastination (Kroese et al., 2018). As chronotype is related to bedtime procrastination, it is critical

to take this factor into account when examining the efficacy of commitment devices (Kroese et al., 2018).

2.5 Sophistication & Naivete

Sophistication refers to an individual's ability to recognize that their preferences may be inconsistent over time and to take action to avoid procrastination (Pollak, 1968). On the other hand, individuals who exhibit time-inconsistent behaviour but are unaware of their lack of self-control are considered naive. It is essential to distinguish between time-inconsistent preferences and time-inconsistent behaviour, as repetition and feedback can help individuals become more sophisticated about their time-inconsistent tendencies (O'Donoghue & Rabin, 1999).

Sophistication can be measured through self-assessment or experimental data. For example, Wong (2008) classified students as sophisticated or naive based on whether their predicted and actual study plans were the same or not. Wong found that 60% of the students were partially naive, indicating that even when people are aware of their time-inconsistent preferences, they may still underestimate their time-inconsistent behaviour.

Sophistication can be measured either through self-assessment or experimental data. Beshears et al. (2016) used questionnaires to measure individuals' self-control ability and their anticipation of future consumption values in present decision-making. Similarly, Wong (2008) estimated sophistication by comparing predicted and unpredicted delays in plans, based on tracking students' desired, predicted, and realized plans. This approach revealed differences in procrastination levels and the extent to which students anticipated delays. It was also used to estimate the degree of sophistication in decision-making processes.

2.6 Conclusions Theoretical Framework

Despite the extensive research on sleep behaviour and time inconsistency, there are significant gaps in the existing literature regarding bedtime procrastination in combination with time inconsistency. Prior studies have failed to examine the effectiveness of commitment devices, particularly accountability partners, in overcoming time inconsistency in bedtime behaviour. Additionally, while previous research has investigated the impact of soft and hard commitment devices on saving and bedtime behaviour, respectively, no connection has been established between soft commitment devices and bedtime procrastination. The present study seeks to address these gaps by focusing on individuals' bedtime rituals and exploring the potential of a soft commitment device to overcome time inconsistency. Moreover, the study will also examine the role of chronotype and sophistication as potential moderators in the effectiveness of the commitment device. The research question that guides this study is:

Can a commitment device help people overcome their time inconsistent behaviour regarding bedtime behaviour?

First, I investigate the effect of the commitment device. I hypothesize the commitment device will be effective in decreasing bedtime procrastination based on the effectiveness of commitment devices in other domains (i.e. Meier et al., 2012). Therefore, my first hypothesis is:

H1. A commitment device will significantly decrease the difference between the planned and actual bedtime.

Next, I control for the effect of chronotype as I think this plays an important role in bedtime procrastination based on the findings from Kroese et al. (2016). Therefore, my second hypothesis is:

H2. A commitment device will result in a greater difference between planned and actual bedtime for evening people, compared to morning people.

Additionally, I will investigate individual differences in self-awareness, specifically the level of sophistication individuals possess in recognizing their time-inconsistent preferences and behaviour. I will explore how this level of sophistication interacts with the effectiveness of the commitment device. To the best of my knowledge, this interaction has not been previously studied. Based on the general tendency for sophisticates to be more proactive in implementing commitment devices and less likely to procrastinate (Ariely & Wertenbroch, 2002; Bryan et al., 2010b), I will propose the following hypothesis:

H3. The commitment device will result in a greater difference between planned and actual bedtime for sophisticated individuals than for naïve individuals.

3. Method

To answer the research question, I conducted an experiment on university students to see if introducing a commitment device reduces procrastination when it comes to going to bed. The experiment consisted of recruiting participants and letting them fill in two questionnaires as well as keeping a sleep diary. The questionnaires served as the data source. One was conducted before the experiment week, asking general questions and inquiring about bedtime ambitions and expectations. A second survey was filled in after the experiment week to acquire the data from the sleep diaries. This section will go into detail about the participants, measures, and analyses that were used to answer the research question.

3.1 Participants

Participants were recruited in February 2023 through the university study economics WhatsApp group. The text message asked if people wanted to participate in a study about bedtime rituals. The inclusion criteria were that the participant needed to be older than 18 and willing to keep a sleep diary for a week. It was communicated that one of the participants would win a €25, - gift card. Of the 200 students in the chat, 45 agreed to participate. They were all over the age of 18 and agreed to keep a sleep diary for a week. Because all participants had to begin the trial the same week, the survey was only open for seven days before the trial week. This enabled me to give them the treatment by texting them all at once. On Monday, all participants received a text message reminding them to keep a sleep diary for the coming week. Following the research week, participants were asked to complete a follow-up survey on Saturday. They were reminded on Monday if they had not completed the survey. A second reminder was not sent out on purpose because there would have been too much time between the experiment week and the completion of the survey, resulting in less precise answers. Because fourteen participants did not complete the post-experiment survey, the data only includes 31 people.

3.2 Measures

Before taking part in the trial, all participants were asked a series of demographic questions and questions regarding their sleep habits. This data was gathered using a self-report questionnaire with 21 items that was created with Qualtrics software (Qualtrics, 2022). Demographic questions included age, gender, education level, and sleeping arrangements, which will be used to assess group balance. Gender was used as a control variable due to potential differences in sleep patterns between males and females (Krishnan & Collop, 2006). Participants also answered a series of questions regarding their chronotype. Appendix A provides a detailed list of the questionnaire items. Before the experiment week, the participants provided their desired and expected bedtimes.

All participants were instructed to keep a sleep diary and record the time they went to bed each night. Going to bed was defined as actively attempting to fall asleep. The diary was handed in after the experiment by filling in the final survey so I had the actual bedtimes of all the participants on the five nights of the experiment. Additionally, the treatment group was instructed to record the time they texted their friend or family member and the intended bedtime communicated. As an example, they were given the following line from a sleep diary: *Monday: texted at 22:00 "I'll go to bed at 23:00". Ended up going to bed at 23:30.* This acted purely as additional encouragement and reinforcement of the commitment device.

3.3 Variables

Treatment

The participants were assigned to one of three groups at random. All participants were informed that the survey was about their bedtime intentions and that they would need to keep track of their bedtimes for a week after the survey.

The first group was the control group (n=11). They were only asked about their bedtime intentions and answered the demographic questions and the questions asserting chronotype.

The treatment group (n=8) was instructed to use a commitment device by texting an accountability partner every night. Specifically, they were asked to text their ideal bedtime to a friend or family member. To facilitate adherence, the treatment group received a daily reminder at 9 p.m. from the experimenter via WhatsApp.

The third group was given the option to choose between using a commitment device or solely keeping a sleep diary. The group was divided into two subgroups: those who actively chose the commitment device (n=7) and those who did not (n=5). Participants who chose to use a commitment device were instructed to text their intended bedtimes to an accountability partner every night and received the same treatment as the treatment group. Meanwhile, participants who chose not to use a commitment device received the same treatment as the control group.

Due to the small sample size, the group that chose to use the commitment device and the trial group were combined to form a treatment group (n=15).

Chronotype

Ten questions from the Munich Chronotype Questionnaire were chosen to assess the participant's chronotype (Roenneberg et al., 2003). The questions are listed in Appendix A. The participants were asked ten behavioural and self-evaluation questions about their sleep rituals. The behavioural questions determined whether participants awoke earlier than their alarm clock (indicating "morning people") or slept differently on weekends than they did on weekdays. There were also self-evaluation questions about the participants' assumed chronotype that they had to rate on a

scale of 1 thru 10; "*I would consider myself an "early bird" preferring to wake up early and go to bed on time*".

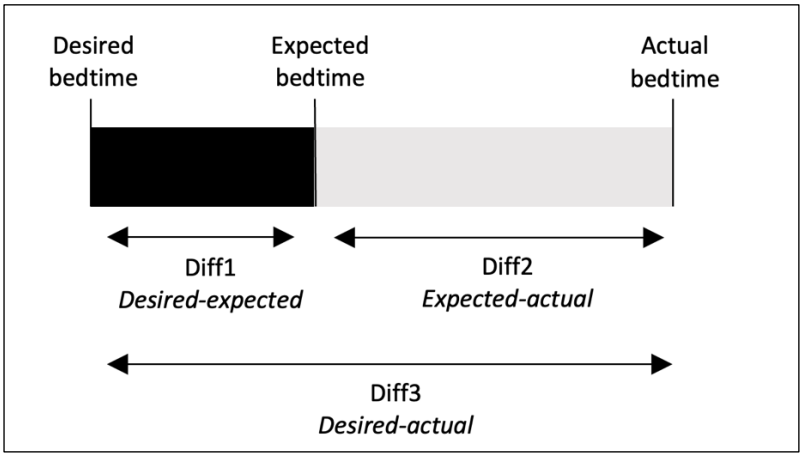
These data points were combined to produce chronotype scores ranging from 1 to 10, with higher scores indicating a preference for staying up late and sleeping in. People with scores of 1 to 5 were classified as "morning people", while those with scores of 5 and higher were classified as "evening people". I created a binary variable by dividing the group into morning and evening people.

Sleep procrastination

The difference between expected and actual bedtime was selected as the dependent variable in this study, as it reflects the amount of unpredicted procrastination in individuals' sleep behaviour. As such, analysing this variable can provide valuable insights into the factors that influence bedtime procrastination. This is based on the methodology of Wong's study (2008), which suggested using desired, expected, and actual plans to investigate time inconsistency. Figure 1 depicts a visual explanation of the data recorded.

Figure 1

Visual representation of sleep variables



Note. A figure describing the three differences between times of going to bed that will be used for the statistical analyses.

Sophistication

I summed the differences between desired, expected and actual bedtimes of the five working days that were analysed. This provides three variables; the first is the difference between desired and expected bedtime *desired-expected* for the whole week. The second is the difference between expected and actual bedtime *expected-actual* and the third is the sum of the earlier two, so the difference between desired and actual bedtime *desired-actual*. In line with Wong's research (2008), the *Expected-actual* encompasses unexpected procrastination. Decreasing this value, so making it

closer to 0 means better predicting one's actual bedtime, so more sophistication. This value will be used to construct an independent variable that approximates the sophistication of the participants.

A continuous variable was created by dividing *desired-expected* by *desired-actual*. The variable indicates how much of the difference between desired and actual bedtimes was predicted ahead of time. If the variable is between 0 and 1, the participant predicted some of the procrastination. The closer to 1, the more accurate the assessment of one's procrastination. If the value is greater than 1, the participant overestimated his or her ability to procrastinate.

3.4 Analysis

To analyse whether the commitment device is effective in reducing bedtime procrastination, I conducted several statistical tests**.** The treatment effect will be investigated using a treatment group comprised of randomly selected treated individuals and those who actively opted-in to the commitment device. A randomisation check will be performed to see if control and treatment are balanced to assess if the groups are comparable. This will be accomplished by running a two-sample t-test on each of the characteristics. Following the balance test, I'll examine the hypotheses.

Hypothesis 1

My first hypothesis was that a commitment device would reduce bedtime procrastination significantly. To put this theory to the test, I'll run a linear regression with *expected-actual* as the dependent variable and treatment as the independent variable. I will control for gender.

Hypothesis 2

My second hypothesis was that a commitment device would be more beneficial to evening people. To test this, I'll add the continuous chronotype variable and a chronotype-treatment interaction term to the previously mentioned regression.

Hypothesis 3

My third hypothesis proposes that sophisticated individuals benefit more from the commitment device. To test this, I will perform a linear regression with *expected-actual* as the dependent variable and sophistication, treatment, and their interaction as independent variables.

Finally, I will look at the differences between the four groups. Those who actively chose to use a commitment device will be investigated separately. I will first use a one-way ANOVA test to compare the means of bedtime procrastination across the four groups to see if the treatment groups differ significantly from one another. Then I run a regression analysis to quantify the relationship between the dependent variable and the independent variables (treatments) and to determine the extent to which each treatment group explained variance in the dependent variable. All analyses were performed using Stata with a significance level of $p < .05$.

4. Results & Discussion

4.1 Results

Descriptive statistics

The age of the participants varied from 20 to 52 years old. Only two participants were over the age of 25. 62% are female and most finished or are currently pursuing a university degree. Most of the participants slept alone (74%). All descriptive statistics can be found in Table 1.

My study's sample size of 31 may be considered small, limiting its statistical power. Due to time constraints, I was unable to extend the recruitment of participants by a week. I maximized the precision of my measurements to compensate for the limitations of a small sample size.

Table 1

Descriptive statistics

		Obs.	Mean	St. dev.	Min	Max
Age		31	24.267	7.597	20	52
Gender		31	0.625	0.492	0	1
Sleeping alone		31	0.742	0.445	0	1
Chronotype		31	5.909	2.429	1.5	9.50
Naivete		31	0.653	1.243	-4.00	4.33
Bedtime-differences	Desired-Expected	31	-3.914	3.805	-14	6.00
	Excepected-Actual	31	-2.435	4.725	-12	10.00
	Desired-Actual	31	-6.315	3.753	-13.5	-0.50
Education	Completed secondary school	4	0.133	0.336	0	1
	Some university but no degree	5	0.167	0.369	0	1
	University Bachelors Degree	18	0.633	0.499	0	1
	Graduate or professional Degree (MA. MBA. PhD. etc.)	4	0.133	0.336	0	1
Grouptype	Control	11	0.367	0.486	0	1
	Treatment	8	0.325	0.442	0	1
	CD_yes	7	0.233	0.430	0	1
	CD_no	5	0.167	0.379	0	1

Note 1. Gender is equal to zero for males and one for females. Sleeping alone is 0 if sleeping alone most nights and 1 if sleeping with somebody most nights.

Note 2. Education has been divided into four distinct dummy variables. Education is the highest level of education attained.

Note 3. Obs indicate observations, St.dev. indicates standard deviation. n = 31.

Balance test

Before examining the hypotheses, I checked if the control and treatment groups are similar. This was the case as for all relevant independent variables the differences were insignificant. The results are shown in Table 2.

Table 2

Balance test of control and treatment group

Variables	Control	Treatment	Difference
Gender	0.56	0.67	-0.10
	(.128)	(.126)	(.180)
Age	24.31	24.27	0,05
	(1.866)	(1.994)	(2.728)
Chronotype	6.19	6.00	0.19
	(.561)	(.665)	(.866)
Sophistication	0.55	0.763	-0.21
	(.171)	(.431)	(.453)
Observations	*16*	*15*	*31*

Notes. The results of a balance test were obtained by performing two-sided two-sample t-tests on each variable. The standard errors are represented by numbers in parentheses. Differences show the difference between the treatment group's mean and the control group's mean. The treatment represents the commitment device group $***$ $p < 0.01$, $**$ $p < 0.05$, $*$ $p < 0.1$.

Hypothesis 1

The results of the linear regression analysis, which examined the relationship between treatment and bedtime procrastination while controlling for gender, support Hypothesis 1 ($t(2.58) = 3.51$, $p < .05$). Specifically, over the course of five working days, participants in the treatment group exhibited an average difference of 3.5 hours less between their expected and actual bedtimes compared to those in the control group. Table 3 displays the regression results. Therefore, the findings provide evidence that the commitment device effectively reduced bedtime procrastination, in line with the first hypothesis. Additionally, gender was found to be a significant predictor of bedtime procrastination, which is consistent with previous research indicating differences in sleep habits between genders (Krishnan & Collop, 2006). Females in the sample had a significantly higher expected-actual gap than males, suggesting they were less accurate in predicting their bedtime procrastination.

Table 3

Regression Results of treatment and gender on the difference between Actual and expected bedtime

	Coefficient	Std. Error	t-statistic	P-value	95% Confidence Interval
Treatment	3.525	1.364	2.58	0.015	0.731 to 6.319
Gender	-5.278	1.399	-3.77	0.001	-8.144 to -2.411
Constant	-0.906	1.229	-0.74	0.467	-3.423 to 1.611

Note1: Dependent variable = difference between desired and actual bedtimes over 5 working days

Note2: Gender, 0 = male and 1 = female

Note3: n = 31 and adjusted R-squared = 0.3622

Hypothesis 2

When researching the effect of chronotype and its interaction with the treatment, the interaction term was found to be statistically insignificant, with a p-value of 0.988. Therefore, the results do not provide support for the idea that the commitment device would benefit evening people more. Table 4 shows the full regression output.

Table 4

*Regression of bedtime procrastination with treatment, gender, chronotype and the interaction term chronotype*treatment as independent variables*

	Coefficient	Std. Error	t-statistic	P-value	95% Confidence Interval
Treatment	0.060	4.052	0.01	0.988	-8.268 to 8.389
Gender	-4.777	1.486	-3.22	0.003	-7.830 to -1.724
Chronotype	-0.087	0.444	-0.20	0.847	-1.000 to 0.826
Chrono*treatment	0.566	0.617	0.92	0.368	-0.703 to 1.835
Constant	-0.651	2.913	-0.22	0.825	-6.639 to 5.338

Note 1: Dependent variable = difference between desired and actual bedtimes over 5 working days

Note 2: Treatment is a dummy variable. where the reference category is the omitted category.

Note 3: Gender, 0 = male and 1 = female

Note 3: n = 31, adjusted R-squared = 0.3478

Hypothesis 3

To test my third hypothesis that the commitment device would be more effective for sophisticated individuals, I conducted a linear regression with an interaction term of treatment and

sophistication. However, the results did not support the hypothesis, as the interaction term was statistically insignificant, $t(-1.51) = -1.99$, $p = .144$. The data showed that more sophisticated participants who received the treatment responded less to it. The full regression output is presented in Table 5.

Table 5

Regression of bedtime procrastination with treatment, gender, sophistication, and their interaction as independent variables

	Coefficient	Std. Error	t-statistic	P-value	95% Confidence Interval
Treatment	3.924	1.322	2.97	0.006	1.207 to 6.642
Gender	-2.240	1.365	-1.64	0.113	-5.045 to 0.565
Sophistication	3.771	1.309	2.88	0.008	1.081 to 6.461
Treatment*soph.	-1.989	1.321	-1.51	0.144	-4.705 to 0.773
Constant	-4.690	1.487	-3.15	0.004	-7.748 to -1.633

Note 1: Dependent variable = difference between desired and actual bedtimes over 5 working days

Note 2: Treatment is a dummy variable. where the reference category is the omitted category.

Note 3: Gender, 0 = male and 1 = female, sophistication is a continuous variable with higher values indicating greater sophistication.

Note 3: n = 31 and adjusted R-squared = 0.5825

To investigate the effectiveness of the commitment device in reducing bedtime procrastination, I compared the differences between four trial groups: a control group, a trial group that used the commitment device, a group that actively chose to use the commitment device and a group that did not want to use it. Table 6 summarizes the means and standard deviations of each group, based on *expected-actual* bedtimes. The one-way ANOVA did not reveal significant differences in sleep procrastination across the four groups, $F(3, 27) = 2.66$, $p = .069$. Table 7 shows the ANOVA results, with no significant differences between groups found.

Table 6

Summary statistics of sleep procrastination scores for each group

Group	Mean	Standard deviation	Frequency
Control	-3.68	5.25	11
Trial	-1.88	2.77	8
CD_yes	1.07	4.30	7

CD_no	-5.50	4.39	5

Note 1: Means and Standard deviations are taken for expected-actual bedtimes

Note 2: CD_yes indicates the group that wanted to use the commitment device. CD_no did not want to use the commitment device.

Table 7

Results of one-way ANOVA comparing sleep procrastination across four research groups

	Sum of Squares	D.o.F.	Mean Square	F-statistic	p-value
Between groups	152.645	3	50.882	2.66	0.069
Within groups	517.100	27	19.152		
Total	669.746	30	22.325		

Note 1: D.o.F. = degrees of freedom

Note 2: Sleep procrastination is taken as expected-actual bedtime. *n* = 31

To explore the impact of choosing to use a commitment device, a regression analysis was conducted, as presented in Table 9. The results reveal that actively opting for the commitment device leads to the greatest reduction in bedtime procrastination. Specifically, the group that freely chose to use the commitment device by texting a friend or family member every night for a week demonstrated a significant reduction in procrastination ($t(2.23) = 4.19$, $p < .05$). In the regression model, the CD_yes variable had a positive coefficient of 4.190 (SE = 1.881, $p = 0.035$), suggesting that selecting the commitment device was associated with a decrease in the expected-actual gap of bedtime procrastination. The other variables, including Trial, CD_no, and Gender, were not significant predictors of bedtime procrastination.

Table 9

Regression Analysis Results for regression explaining the expected-actual gap

	Coefficient	**Standard Error**	**t-value**	**p-value**	**95% CI**
Trial	3.183	1.935	1.65	0.112	-.802 to 7.168
CDyes	4.190	1.881	2.23	0.035	.317 to 8.064
CDno	-.592	2.126	-.28	0.783	-4.971 to 3.786
Gender	-4.816	1.568	-3.07	0.005	-8.045 to -1.587
Constant	-1.055	1.447	-0.73	0.473	-4.035 to 1.926

Note1. n = 31, R-squared = 0.4387. Adjusted R-squared = 0.3489. F(4. 25) = 4.88. CI = Confidence Interval.

Note2. The dependent variable is the expected-actual bedtime in hours.

4.2 Discussion

Findings

This study investigated the effectiveness of texting an accountability partner as a commitment device to combat bedtime procrastination, which is a form of time-inconsistent behaviour. The experiment involved 31 university students who completed a five-day sleep diary while providing information about their sleeping habits and demographics. Participants were divided into three groups at random. The treatment group was told to text their intended bedtime to an accountability partner. The control group received no intervention. A third group was given the opportunity to actively choose the commitment device, resulting in a voluntary treatment and voluntary control group.

The first hypothesis, which predicted that the commitment device would significantly decrease bedtime procrastination, was supported by the results. Over five working days, the treatment group showed a 3.5-hour decrease in the difference between their expected and actual bedtimes compared to the control group. This effect was inferred from the regression analysis that included treatment and gender. These findings suggest that using a commitment device is a promising measure to combat time inconsistency, which is consistent with previous research on the effectiveness of commitment devices in harnessing people against their time-inconsistent preferences (i.a. Avery et al., 2019).

The second hypothesis, which predicted that individuals with an "evening type" chronotype would benefit more from the intervention, was not supported by the results. The regression analysis that included treatment, gender, chronotype, and the interaction term of chronotype*treatment found that only gender had a significant coefficient. It is possible that chronotype acted as a confounding variable, influencing both the use of the commitment device and bedtime procrastination, thereby making it appear that the commitment device was not significant when the chronotype was controlled for. This implies that the relationship between the treatment and bedtime procrastination may be determined by the value of the chronotype variable. Although the effect is not statistically significant, it may still be practically significant. The lack of statistical significance could be due to the small sample size or the model not fully capturing the relationship between the variables.

The third hypothesis, which predicted that more sophisticated individuals would benefit more from the intervention, was also not supported by the results. The regression analysis that included a sophistication measure and its interaction with treatment showed that the interaction term was

statistically insignificant. However, the sophistication variable was built using the dependent variable of bedtime procrastination, which could cause endogeneity issues in the model. Including a variable derived from the dependent variable may result in biased coefficient estimates, which limits the validity of the findings.

A voluntary commitment device was also used in this study, where participants actively chose to text a friend or family member their intended bedtime for a week. The CD-yes group had significantly lower bedtime procrastination scores, which suggests that the commitment device was effective. However, voluntary opting in could also correlate with a higher motivation to combat procrastination in the first place. It could also be that actively choosing to use the commitment device motivated participants to book results.

Limitations

Despite the promising findings of this study, several limitations must be acknowledged. Firstly, the small sample size of 31 university students limits the statistical power of the tests performed. This restricted the ability to detect significant effects, which could have led to an underestimation of the intervention's true impact. A larger sample size would improve the reliability and generalizability of our findings. Further, the treatment group had to be combined with the CD-yes group to create a larger treatment group, potentially influencing the results. A more extensive participant acquisition strategy is required for future research.

The study's limited number of data points is also a challenge. Although I observed participants for five working days, with five data points to compare the difference between expected and actual bedtimes, this may not be sufficient to provide an overall picture of sleep procrastination. To address this, future studies should either extend the observation period or employ alternative methodologies, such as computing an average procrastination time or using a difference-in-differences approach.

Another limitation of the study was the construction of the sophistication variable. I computed the independent variable of sophistication for the regression using the dependent variable of bedtime procrastination since I did not measure sophistication separately. Consequently, I cannot draw definitive conclusions about the third hypothesis which stated that the commitment device would work better for sophisticated individuals. Future research should separate sophistication and investigate its relationship with bedtime procrastination and the use of commitment devices.

Finally, it is important to note that the participants in my study were highly educated university students, which may introduce bias. Previous research suggests that higher education is associated with higher IQs, better-educated parents, and a greater likelihood to adopt commitment devices (Cobb-Clark et al., 2021). Thus, future research should aim to include a more diverse population to improve the generalizability of the findings.

Future research

This study has provided some evidence that commitment devices may be an effective measure for combating bedtime procrastination. Future research could extend this study to explore the intervention's long-term effects on sleep behaviour and investigate whether other commitment devices or interventions may also be effective.

The study's sample was made up of university students, who have more adaptable sleeping habits. Future research could look into whether the intervention works as well in different age groups or populations with less flexible schedules. Future research could also look into the effect of peer support or accountability groups in conjunction with commitment devices, as these factors may improve the intervention's effectiveness.

Furthermore, more rigorous research on the mechanisms underlying commitment devices' effectiveness in combating time inconsistency is required. Future research could employ qualitative methods to gain a better understanding of people's motivations for using commitment devices, the factors that make them effective, and the potential barriers to adoption.

Lastly, it was taken as an assumption that bedtime procrastination is a result of time-inconsistent behaviour. When following up on this research domain this assumption must be tested as well. The high standard deviation of the independent variable ‘expected-actual’ could be because of the complicated nature and differences between individuals of bedtime procrastination. Looking into this might improve the research in this domain.

5. Conclusion

The study aimed to investigate the effectiveness of a commitment device in reducing sleep procrastination behaviour. My results showed that the use of a commitment device in the form of text messages helped reduce procrastination among the participants. Despite the limitations of the small sample size and the highly educated population, the results provide promising evidence for future research to further explore using commitment devices to reduce sleep procrastination.

In conclusion, my study highlights the potential benefits of using a commitment device as a tool for reducing sleep procrastination. Sleep is an essential biological process that plays a vital role in physical and mental health. Adequate sleep is important for maintaining overall well-being. regulating mood, and supporting cognitive function (Sonnentag et al., 2009). Sleeping enough is also economically efficient as insufficient sleep is linked to lower workplace productivity (Rosekind et al., 2010). Accessible ways to improve sleep quality are important for policies aimed at improving overall well-being. The findings may also be applicable in other areas where habit formation or procrastination plays a role. Future research can continue to build on these initial findings and explore the full extent of their applications like in the realm of weight loss or handling school deadlines. Improving sleep habits is essential for overall well-being, mood regulation, and cognitive function. Additionally, sufficient sleep has economic implications, as it is linked to higher workplace productivity. Accessible methods for improving sleep can benefit public health policies, and the findings of my study could also have implications in other areas where habit formation or procrastination plays a role. Future research can build on these preliminary findings to investigate the full scope of their applications, such as in weight loss or managing deadlines in academic or professional settings. Overall, my research adds to the growing body of knowledge about the importance of sleep and sheds light on a potential strategy for reducing sleep procrastination.

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7. Appendix

A. Qualtrics survey

1. Demographic questions

How old are you?

Please, specify your gender

- ◯ Male
- ◯ Female
- ◯ Non-binary / third gender
- ◯ Prefer not to say

What is the highest level of education you have completed?

- ◯ Some primary school
- ◯ Completed primary
- ◯ Some Secondary school
- ◯ Completed secondary school
- ◯ Vocational or Similar
- ◯ Some university but no degree
- ◯ University Bachelors Degree
- ◯ Graduate or professional degree (MA, MS, MBA, PhD, JD, MD, DDS etc.)
- ◯ Prefer not to say

Do you sleep alone most nights during the week (monday - friday)

- ◯ Yes
- ◯ No

2. Questions assessing chronotype

We will now ask a couple questions about your sleeping habits on work days

<u>On work days</u>, I have to wake up at _____o'clock

On work days, I regularly wake up

- ○ Before my alarm
- ○ At the alarm

On nights before workdays, I go to bed at _____o'clock

it then takes me _____min to fall asleep

On <u>free days</u> (please only judge normal free days, i.e., without parties etc.)
My dream would be to wake up at ____o'clock

On free days, I normally wake up at _____o'clock

On a free day, if I wake up at around the normal (workday) alarm time, I try to get back to sleep

- ○ Yes
- ○ No

I would consider myself an "early bird" (you prefer to wake up early and go to bed in time)

1 2 3 4 5 6 7 8 9 10

1 = dislikes to wake up early, 10 = morning person

I would consider myself an "evening person" (you prefer to stay up late and sleep in)

1 2 3 4 5 6 7 8 9 10

1 = dislikes to sleep in, 10 = evening person

3. Assessing bedtime ambition

Please note down, for every day of the week how late you <u>want</u> to go to bed.

Going to bed is the time you put off the lights, put away your phone and actively try to fall asleep.

Monday evening	
Tuesday evening	
Wednesday evening	
Thursday evening	
Friday evening	

Sometimes you plan to go to bed early but procrastinate, for example you might spend more time on your phone or watching television.

Please note down, for every day of the week how late you <u>will probably</u> go to bed.

Going to bed is the time you put off the lights, put away your phone and actively try to fall asleep.

Monday evening	
Tuesday evening	
Wednesday evening	
Thursday evening	
Friday evening	

4. Follow-up survey collecting actual bedtime

Sometimes you plan to go to bed early but procrastinate, for example you might spend more time on your phone or watching television.

Please note down, for every day of the week how late you <u>actually</u> went to bed.

Going to bed is the time you put off the lights, put away your phone and actively try to fall asleep.

Monday evening	
Tuesday evening	
Wednesday evening	
Thursday evening	
Friday evening	