

‘Pay-Later’ vs. ‘Pay-As-You-Go’: Experimental Evidence on Present-Biased Overconsumption and the Importance of Timing

Madeline Werthschulte[†]

November 10, 2020

Abstract

When consuming goods provided by public utilities, such as telecommunication, water, gas or electricity, the predominant payment scheme is pay-later billing. This paper identifies one potential consequence of pay-later schemes, present-biased overconsumption of the respective good, and tests the effectiveness of pay-as-you-go schemes in reducing consumption. Specifically, I run a lab experiment which mimics an energy consumption choice and randomizes the timing of when consumption costs are paid: Either immediately (‘pay-as-you-go’) or one-week after consumption (‘pay-later’). Results show that pay-as-you-go billing significantly decreases consumption, and in particular wasteful consumption. As the design controls for contaminating effects, these results can be solely attributed to present-biased discounting under the pay-later scheme. These results imply that pay-as-you-go schemes will be welfare improving both from agent’s own perspective and from a social perspective if externalities are involved. In contrast, classic price-based policies will need correctives to account for present bias arising under pay-later schemes.

JEL Classification: C91, D15, D91, Q49

Keywords: Payment schemes, present bias, discounting, lab experiment, energy

Acknowledgments: I am grateful for the insightful comments and discussions provided by Alecia Cassidy, Christoph Feldhaus, Jörg Lingens, Andreas Löschel, Michael Price, Peter Werner and by seminar participants at Aachen, Mannheim, Heidelberg, at the 2019 European meeting of the ESA and the 2020 EAERE meeting. I also thank colleagues and research assistants who helped executing the payments, especially Anna Beikert, Lukas Reinhardt and Horia Guias. This experiment was pre-registered at the AEA RCT Registry under trial number AEARCTR-0003503 (<https://www.socialscisearch.org/trials/3503/history/36623>). I gratefully acknowledge financial support from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 727524 - project ENABLE.EU ”Enabling the Energy Union through understanding the drivers of individual and collective energy choices in Europe”.

[†] Werthschulte: University of Münster and ZEW - Leibniz Centre for European Economic Research. Correspondence to: Madeline Werthschulte, ZEW Mannheim, L 7, 1, 68161 Mannheim, Germany, werthschulte@zew.de.

1 Introduction

When consuming goods provided by public utilities, such as telecommunication, water, gas or electricity, the predominant payment scheme is pay-later billing. Pay-later billing shifts the payment of consumption costs into the future, such that an intertemporal trade-off between immediate benefits and future payments evolves. If consumers are present-biased, the evolving intertemporal trade-off will lead to an undervaluation of future costs, and hence to an overconsumption of the respective good. Importantly, agents themselves would like to consume less when asked *ex ante*. This overconsumption is of particular importance if the consumed good is prone to environmental externalities, as for the mentioned examples. Pay-later schemes then give rise to an internality and exacerbate the externality of consumption.

To tackle such suboptimal consumption, this paper builds on insights from incentive-design studies, and tests whether pay-as-you-go schemes decrease consumption. The theoretical argument of that literature is that hyperbolic discounting agents increase effort with decreasing time lag to payday (Cutler and Everett 2010, Kaur, Kremer, and Mullainathan 2015, Aggarwal, Dizon-Ross, and Zucker 2020). Under the assumption of $\beta\delta$ -discounting (Laibson 1997), only immediate payments will increase effort provision (Aggarwal, Dizon-Ross, and Zucker 2020). To extend these findings to a bill payment set-up, I run a lab experiment in which participants can buy ‘energy’ to ease the difficulty of a real effort task. While these consumption benefits are always immediate, I randomly vary the timing of when participants pay the corresponding costs: Either immediately or one week after consumption — i.e. either in a pay-as-you-go or pay-later scheme.

In addition, the lab experiment is designed to unravel the causal mechanism of why pay-as-you-go schemes reduce consumption. As the experimental design holds information and saliency of costs constant across both groups, any difference in consumption must stem from differences in discounting. Further, as payment is delayed by just one week for the pay-later group, standard exponential discounting does not influence consumption choices.¹ Only with present bias, consumption of the pay-later group will be higher compared to the pay-as-you-go group.

Results show that pay-later billing increases consumption by on average 14 percent compared to pay-as-you-go billing, which is significant at the 10-percent level. Further, pay-later strongly increases the probability of ‘wasteful’ consumption, i.e. consumption without direct benefits, which is significant at the 1-percent level. These results have two implications. First, pay-as-you-go schemes are able to substantially reduce consumption. Importantly, since all participants received real-time information about costs, this reduction is observed when feedback systems are already in place. This highlights the importance of the timing of payment, beyond arguments of information provision and uncertainty. Second, since present bias does not play a role under immediate payment, the reduction in consumption in response to the change in payment schemes stems from a dissolved internality. Accordingly, agents themselves would like to avoid overconsumption under pay-later billing.

¹An exponential discounting parameter smaller than one for one-week discounting implies unreasonably large discounting on a yearly basis (Shapiro 2005, O’Donoghue and Rabin 2015).

This evidence strongly speaks in favor of reconsidering the use of pay-later schemes, particularly if externalities are involved. Then, both consumers and society will profit from alternate payment schemes. Both pre-payment and pay-as-you-go schemes are easy implementable given the advances of smart technologies. Further, results suggest that Pigouvian taxes need correctives to account for pay-later billing inducing consumers to undervalue future costs. Failing to account for present-biased discounting of the future bill implies taxes set too low to achieve the social optimum.

In the context of energy consumption, there is few prior literature on present bias and pay-later billing. Closest to this work, Werthschulte and Löschel (2019) find a significant correlation between electricity consumption and experimentally elicited present bias, and Jack and Smith (2020) exploit a switch from pay-later billing to pay-ahead billing and find that households respond with significant electricity consumption reductions. While the combination of present bias and pay-later billing is one potential explanation for such results, these studies are only suggestive.² This study goes a step further by (i) testing the effectiveness of pay-as-you-go schemes in reducing consumption and (ii) being able to trace such effectiveness back to present bias.

The behavioral finance literature in contrast, already broadly discusses present bias arising from the pay-later scheme of credit card payment.³ Using structural consumption models, the empirical literature identifies present bias to explain credit card choice (Shui and Ausubel 2004), credit card debt paydown (Kuchler and Pagel 2020) and credit card borrowing (Angeletos et al. 2001, Laibson, Repetto, and Tobacman 2007). Further, Meier and Sprenger (2010) find experimentally elicited present bias to be significantly correlated with credit card debt. However, these findings have been challenged by recent literature arguing that other factors, such as transactions costs or rational inattention, might explain observed behavior as well (Kaplan and Violante 2014, Keys and Wang 2019). Building on this criticism, this study supplements prior work with a novel method to identify present bias, which bases on a lab experiment and random variation in exposure to discounting.

Finally, prior literature on how to design contracts in presence of self-control problems, focuses on set-ups with immediate effort costs and future earnings. Examples are medication intake (Cutler and Everett 2010), physical activity (Aggarwal, Dizon-Ross, and Zucker 2020) and work effort (Kaur, Kremer, and Mullainathan 2015). However, findings are rather mixed. While, Kaur, Kremer, and Mullainathan (2015) find effort provision on payday itself to be 8 percent higher as compared to one week before payday, hence evidence of hyperbolic discounting of wage payments, Aggarwal, Dizon-Ross, and Zucker (2020) do not find significant differences in daily steps whether exercise payment is daily, weekly or monthly, thus arguing against present bias. As I compare consumption choices when payment is either immediately or one week ahead, this study extends the insights gained by the contract-design literature to the domain of bill payment.

²Other studies in the domain of energy billing have focused on information and saliency effects of receiving a bill (Gilbert and Zivin 2014, Sexton 2015, Grubb and Osborne 2015, Wichman 2017, Gilbert and Zivin 2020).

³See Beshears et al. (2018) for an extensive overview on the behavioral finance literature.

Both the mixed results of incentive-design studies and the recent criticism in behavioral finance mirror a broader methodological discussion under which conditions present bias over monetary payments actually occurs (Andreoni and Sprenger 2012, Augenblick, Niederle, and Sprenger 2015, Sprenger 2015, Carvalho, Meier, and Wang 2016, Ericson and Laibson 2019, Cohen et al. 2020, Augenblick and Rabin 2019). This paper adds by studying another set-up which assumes participants to be present-biased over monetary payments — their future (energy) bill — and finds evidence which can only be explained by present-biased discounting.

The next section describes the sample, the organization of the experiment and the design in detail. Section 3 gives the results, which are discussed in Section 4. Section 5 briefly concludes.

2 Experimental design

The experiment was organized as a longitudinal lab experiment across two sequential dates in November 2018 with one-week distance between the participation dates. Figure 1 gives an overview of the design.⁴ Participants were recruited via the online recruitment tool ORSEE (Greiner 2015) and asked to register on the institute’s website for one out of ten sessions. In total 213 students registered, of which 171 eventually participated.⁵

The first participation date took place in the computer pool of the Department of Economics at the University of Münster in Germany. Upon log-in to the computer, participants were randomized into either a ‘pay-later’ or a ‘pay-as-you-go’ scheme. Then participants were informed that they are required to solve real effort tasks. Each task asks the participant to find a certain letter in a table full of one-hundred random letters. Only if all occurrences of that letter, and no false letters, were selected, the participant could click on a ‘Continue’-button and proceed to the next task. The letter and the table were randomly determined by the computer and newly generated for every task. The required number of tasks was fixed at 25 tables. To make participants familiar with the task, they first solved three non-payoff-relevant tasks.

Context is added by the real effort task mimicking an energy consumption decision. This was done by displaying a dark computer screen, making it quite difficult to identify the different letters in the table. By clicking a light switch, participants increase screen brightness. Hence, with ‘light switched on’ the task was easier to solve, letters and table are easier to

⁴Originally, the design is a cross-over design over a total of four sequential participation dates. In the following, I just concentrate on the between-subjects experiment conducted on participation date 1 and 2. In the within-subjects experiment, the treatments were reversely implemented on date 3 and 4. The main motivation of adding the within-subjects design was the fear of dropouts in the between-subjects design, which would have endangered the assumption of random treatment allocation. In fact, I only observe one single dropout from date 1 to date 2. A discussion of the within-subjects results and instructions of the full experiment are given in the Appendix.

⁵Each session allowed for 25 participants, such that I was theoretically able to recruit 250 students. Using the results from non-incentivized pilots and treatment effects as observed in similar studies (Augenblick and Rabin 2019, Kaur, Kremer, and Mullainathan 2015), a power calculation gave a required sample size of 200 participants for a between-subjects design. As 20 percent of the registered students did surprisingly not show up on the first participation date, I am slightly underpowered.

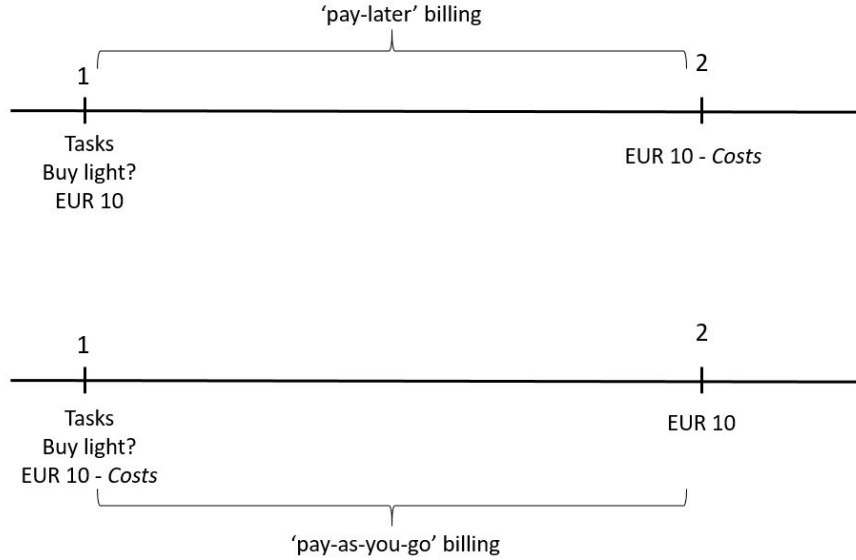


Figure 1: Overview of experimental design

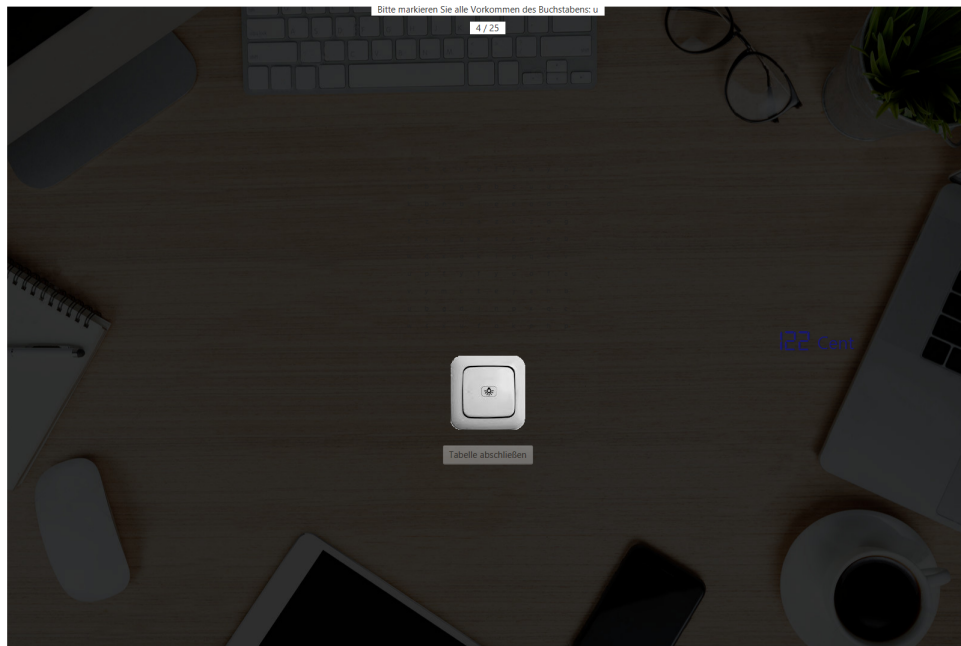
identify. Figure 2 displays the computer screens while solving the tasks with light either switched off or on.

For each second light is switched on, participants had to pay an ‘electricity’ price of 0.005 euros. The two payment schemes are introduced by varying the timing of when light costs are paid. In the pay-as-you-go scheme, light costs were subtracted from a first show-up fee of 10 euros paid right after the tasks were finished — i.e. immediately after consumption. In the pay-later scheme, light costs were subtracted from a second show-up fee of 10 euros paid on participation date 2 — i.e. one week after consumption.⁶ The instructions highlighted the resulting trade-off: ‘Every second you switch on light today, decreases your payment in **one week (pay-later) /today (pay-as-you-go)** by 0.5 eurocent.’

Importantly, all participants had to appear on both participation dates and received both show-up fees of 10 euros each. Further, a ‘meter’ gave participants of both groups information about their light costs in real-time. This meter was always displayed and equally visible for both groups. All payments were made in cash at our offices.

In summary, the experiment is designed to capture the relevant aspects of consumption and payment of a good which is subject to bill payment. Hence, ‘light’ gives immediate benefits of reducing effort cost from completing the tasks while the timing of when the ‘energy bill’ is paid is randomly varied. Accordingly, my main outcome variable is the seconds of light the participants consumes. Another outcome variable is ‘wasteful’ consumption. If a participant

⁶It was not communicated to participants what happens if their costs exceed the amount of the show-up fee. Such a situation was not expected to happen (and did not happen) as pilots were used to calibrate the electricity price and screen darkness such that participants will receive at least 5 euros on each participation date. In fact, the maximal light costs were 3.54 euros.



(a) Task with light switched off



(b) Task with light switched on

Figure 2: Computer screen while solving tasks

solves a task with always light switched on, the participants still continues to consume light after she found the last letter and just needs to click the ‘Continue’-button, which was not affected by screen brightness. Since light gives no benefit after the last letter has been found, I define a participant who has light switched on from the second she enters the task until the second she exits the task, i.e. for the full task duration, to exhibit wasteful consumption.

As the pay-later group experiences marginal benefits from light consumption on date 1 and marginal costs on date 2, I assume costs to be quasi-hyperbolically discounted (Laibson 1997). For participants in the pay-as-you-go group, the intertemporal trade-off is dissolved since payment occurs immediately after consumption.⁷ Hence, discounting does not affect the optimal light choice of the pay-as-you-go group. As the only difference between groups is one-week discounting, I predict light consumption, and likewise the likelihood of wasteful consumption, of the pay-later group to be higher compared to the pay-as-you-go group. Importantly, this prediction only holds if participants are present-biased. As will be elaborated in greater detail in Section 4, the exponential discounting parameter must be close to one for weekly discounting, to make sense on a yearly basis. Thus, without present bias light consumption of both groups will be indistinguishable. The next section tests this hypothesis.

3 Results

Table 1 gives the main summary statistics for the outcome variable *light*, measured in seconds and aggregated over the 25 tasks, for the two billing groups. Both groups contain 85 participants.⁸ The average participant in the pay-later scheme consumed 364 seconds light in total, which equals about 6 minutes light, or 1.82 euros light costs. The average participant in the pay-as-you-go scheme consumed 320 seconds, or 5 minutes, light in total, which corresponds to average light costs of 1.60 euros.

The average difference in light consumption is 44 seconds, or 14 percent, more light consumption under the pay-later scheme, which is significant at the 10-percent level given a t-test. Further, considering the percentiles of both groups, the whole distribution of light consumption appears to be shifted to right for the pay-later group, which is supported by a Mann-Whitney-test rejecting equal medians at the 10-percent level.

Figure 3 (A) displays how light consumption evolves across the 25 tasks for both payment schemes. As the negative slope shows, participants in both groups decrease light consumption with higher task numbers. This is consistent with participants learning and improving as the tasks proceed, making them consuming less light. There is however no significant difference in learning between groups.

Panel B gives the share of light seconds relative to the total time spent on solving the

⁷The lag between solving tasks in the computer pool and paying at our offices is less than 30 minutes. Following the results by Augenblick (2018), 30 minutes can be still considered as ‘now’.

⁸One participant of the pay-later group is excluded as this participant did not appear on participation date 2 to pay her bill. This participant also needed more than double the time of the average participant to finish the tasks and seemed to not understand instructions. Results are however robust towards including this participant.

Table 1: Summary statistics of light consumption in seconds by billing group

Variable	Average	Percentile					N
	[Std. dev.]	10th	25th	50th	75th	90th	
$\sum_t \text{light} \text{pay-later}$	364.41 [162.92]	155.23	254.12	393.05	476.54	558.38	85
$\sum_t \text{light} \text{pay-as-you-go}$	319.66 [169.26]	57.81	189.16	349.88	438.84	506.86	85

Note: Standard deviations in parentheses.

task, i.e. a light share of 1 means that the participant had light switched on for the full task duration. Two things are notable about Figure 3 (B). First, confirming Panel A, the light share is higher for the pay-later group compared to the pay-as-you-go-group along all tasks. Second, light share is broadly constant across tasks. Since, light consumption decreased, this implies that the time spent on solving tasks decreased as well. Averaged across the 25 tasks, the average light share in pay-as-you-go is 44 percent and in pay-later 57 percent. The difference of about 12 percentage points is significant at the 5-percent level.

Finally, Figure 3 (C) gives the fraction of participants with light switched on for the full task duration, i.e. the fraction of participants with a light share of 1. As outlined in Section 2, I define such light consumption as ‘wasteful’, since these participants continue to consume light despite the last letter of the table was found. Again, there is a larger fraction in the pay-later group exhibiting such wasteful consumption. This difference between groups stays broadly constant along the 25 tasks.⁹ On the aggregate level, about 30 percent in the pay-later group have light always switched on, compared to 16 percent under pay-as-you-go billing. This difference is significant at the 1-percent level.

To examine these patterns in detail, I run panel regressions of task-level (i) light consumption in seconds and (ii) engagement in ‘wasteful’ consumption, i.e. having light always switched on, on an indicator for being in the pay-as-you-go scheme. All regressions include session and task fixed effects. Table 2 gives the results.

In line with the raw data comparisons, the pay-as-you-go scheme significantly decreases light consumption compared to pay-later billing. Those with immediate payment consume on average about two seconds less for every task, which is significant at the 10-percent level. Further, participants in pay-as-you-go have a 13 percent lower probability of having light always switched on, which is significant at the 1-percent level — thus, are less likely to engage in wasteful consumption.

⁹The sharp increase after the first task is explained by participants entering the first task with light switched off by design, i.e. by design participants are inhibited from having light always switched on during the first task.

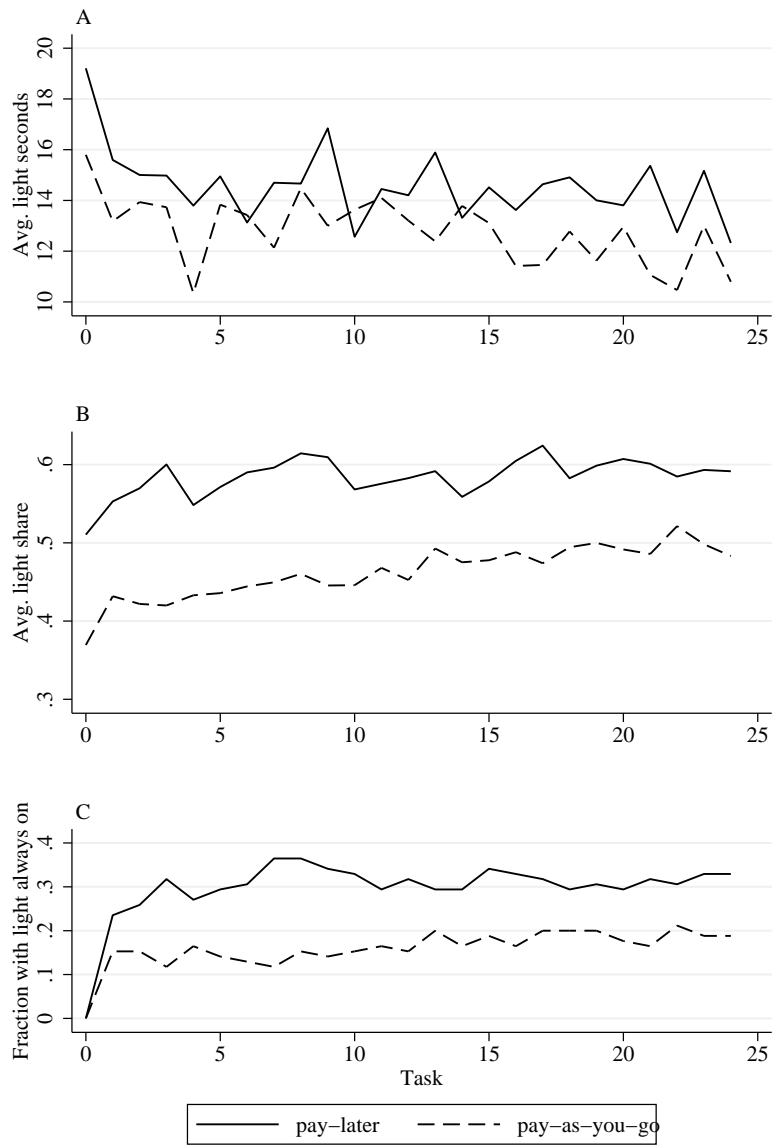


Figure 3: Summary statistics by task and group

Table 2: Panel regression of light consumption per task on billing scheme

	(1)	(2)
	Light in sec	Light always on
pay-as-you-go	-1.708*	-0.133***
	(1.008)	(0.0516)
Session FE	X	X
Task FE	X	X
N	4250	4250

Note: Robust standard errors are clustered on participant level. Significance levels: * : $p < 0.10$, ** : $p < 0.05$, *** : $p < 0.01$.

Both the descriptive and the regression results provide evidence of participants in the pay-as-you-go scheme consuming significantly less, particularly less ‘wastefully’, than participants in the pay-later scheme.¹⁰ These results can be causally attributed to present-biased over-consumption in the pay-later scheme, if (1) marginal cost functions of light consumption are identical for participation date 1 and 2, i.e. differences between groups are solely caused by changes in discounting, and (2) there is no short-term exponential discounting (i.e. $\delta = 1$). The next section discusses these two conditions.

4 Discussion

To ensure that the observed changes in consumption are solely due to changes in discounting, the lab experiment was designed to control for potentially contaminating factors. First, a ‘meter’ displaying costs in real-time was implemented for both groups. Hence, both group were equally aware and informed about costs. Second, both groups faced equal transaction costs since all participants had to appear on both participation dates, independently of when they actually pay their light costs.

¹⁰Further, additional analyses on the time spent solving the tasks reveal strong spill-over effects of the payment schemes. Participants paying their light costs immediately seem to substitute light consumption by spending more time on solving the tasks than pay-later participants. Differences in the time spent are significant at the 1-percent level and indicate an increase by on average 5 seconds per task for the pay-as-you-go group. Apart from providing further evidence that the change in payment schemes strongly affected participants’ consumption patterns, this result hints also at participants underestimating their opportunity costs to a large extent.

Third, to equalize payment credibility a grace period of three days was offered to collect the second payment. This grace period was communicated to participants upfront, to ensure that participants knew if anything unexpectedly happens on participation date 2, inhibiting them to come to our offices, they can also pick up the second payment a day earlier or a day later. Participants also knew that they will receive multiple reminder emails about the different dates and payments throughout the experiment, so they cannot simply forget participation date 2. Further, participants knew how to contact the institute or myself, both by email, telephone and in person. Finally, since light costs were subtracted from the show-up fee of 10 euros, there was always an incentive to arrive for payment.¹¹

Given these considerations, the observed consumption difference between the pay-later and pay-as-you-go groups must stem from present bias. As the pay-later group discounts marginal costs by only one week, the exponential discounting parameter, δ , must be close to one. Any other δ for one-week discounting would imply unreasonably large yearly discounting. However, with $\delta \approx 1$ the significant difference in light consumption must be driven by short-term discounting, i.e. present bias.¹²

To outline this argument, I run a back-of-the-envelope calculation to estimate the δ parameter consistent with both my results and only δ -discounting. To do so, I assume that the participant receives linear numeraire utility from the experimental payments, and disutility from the tasks in the form of effort costs. Following, Kaur, Kremer, and Mullainathan (2015) effort costs have the functional form of $c(tasks, light) = \frac{1}{\theta} (\frac{tasks}{light})^\theta$, such that costs increase with the number of tasks and decrease with light consumption. The resulting first order condition for the pay-as-you-go group can then be solved for θ , when plugging in the observed average light consumption of that group. Using this estimated θ , the first order condition of the pay-later group gives the δ consistent with my results. Accordingly, my results are consistent with a yearly discount factor of $\delta^{year} = 0.002$. Such an exponential discount factor means that the average participant in the pay-later group values his utility in 51 years 500 times more than his utility in 50 years. As such valuation is highly unlikely, the results I observe cannot be explained by exponential discounting alone.

In contrast, the results are much easier to reconcile with the assumption of quasi-hyperbolic discounting. For example, my results are consistent with a $\delta \approx 1$ and $\beta = 0.89$. Such a present bias parameter is quite well in line with recent estimations of other lab experiments using real effort tasks (e.g., $\beta \in [0.81; 0.84]$ in Augenblick and Rabin (2019), and $\beta = 0.888$ in Augenblick, Niederle, and Sprenger (2015)). Hence, the observed effectiveness of the pay-as-you-go scheme in reducing consumption can be traced back to pay-later schemes giving rise to present-biased overconsumption. The next section concludes and discusses the implications of this result.

¹¹The minimal payment was 6.46 euros.

¹²This argument is also put forward by O'Donoghue and Rabin (2015) in their Lesson No. 3: "Any Noticeable Short-Term Discounting is Evidence of Present Bias" (p. 274). The same identification strategy of present bias has also been used by Kaur, Kremer, and Mullainathan (2015), Aggarwal, Dizon-Ross, and Zucker (2020) and Kim (2017). I decided against identifying present bias from time-inconsistent choices due to practical concerns. Given the specific nature of this real-effort task, ex ante light consumption choices might not necessarily deviate from actual light consumption choices due to time-inconsistency, but instead due to the complexity to correctly predict task difficulty, learning over time and demand for light.

5 Conclusion

This study investigates present-biased overconsumption as a potential consequence of a payment scheme we experience frequently in our daily life's, pay-later billing, and tests the effectiveness of a pay-as-you-go scheme in reducing consumption. To do so, I run a lab experiment which mimics an energy consumption choice and randomizes participants into paying the corresponding energy bill either one week after consumption ('pay-later') or immediately ('pay-as-you-go'). Results show that participants consume significantly more in the pay-later scheme, and are particularly more likely to engage in wasteful consumption. Importantly, as the experimental design controls for contaminating factors, this difference in consumption must be driven by extreme short-term, or (quasi-)hyperbolic, discounting.

These results have two direct implications. First, they strongly advocate a shift to pay-as-you-go schemes, particularly if externalities are involved. Then, pay-as-you-go schemes realize a double dividend by avoiding undesirable overconsumption both from present-biased agents' and society's perspective. Already existent in some and currently debated in other markets is pay-ahead billing (Jack and Smith 2020). Both pay-ahead and pay-as-you-go schemes dissolve the temporal lag between consumption and payment, and are easily implementable given the advances of smart technologies. Importantly, as both payment groups received real-time cost information, the observed effects are beyond the effects realized through the roll-out of smart feedback systems (see e.g., Lynham et al. (2016), Jessoe and Rapson (2014)).

Second, these results raise doubt in the effectiveness of price-based policies to reduce consumption of a good billed under a pay-later scheme. If future costs are overly devalued due to present-biased discounting, agents may be less sensitive to changes in prices. As a consequence, Pigouvian taxes will need correctives to account for such undervaluation and to achieve the socially desired consumption level. I leave it to future research to investigate how present bias affects price elasticities in pay-later schemes, and the corresponding implications for optimal taxation, more closely. Further, disentangling and estimating the effect sizes of discounting, saliency and informational effects both in the lab and in the field, can be fruitful to understand the overlaying mechanisms of pay-later schemes.

References

- Aggarwal, Shilpa, Rebecca Dizon-Ross, and Ariel D Zucker. 2020. "Incentivizing Behavioral Change: The Role of Time Preferences." *NBER Working Paper 27079*.
- Andreoni, James, and Charles Sprenger. 2012. "Estimating time preferences from convex budgets." *The American Economic Review* 102 (7): 3333–3356.
- Angeletos, George-Marios, David Laibson, Andrea Repetto, Jeremy Tobacman, and Stephen Weinberg. 2001. "The hyperbolic consumption model: Calibration, simulation, and empirical evaluation." *Journal of Economic Perspectives* 15 (3): 47–68.
- Augenblick, Ned. 2018. "Short-Term Time Discounting of Unpleasant Tasks." *Working Paper. UC Berkeley*.

- Augenblick, Ned, Muriel Niederle, and Charles Sprenger. 2015. "Working over time: Dynamic inconsistency in real effort tasks." *The Quarterly Journal of Economics* 130 (3): 1067–1115.
- Augenblick, Ned, and Matthew Rabin. 2019. "An Experiment on Time Preference and Misprediction in Unpleasant Tasks." *Review of Economic Studies* 86 (3): 941–975.
- Beshears, John, James J Choi, David Laibson, and Brigitte C Madrian. 2018. "Behavioral household finance." In *Handbook of Behavioral Economics: Applications and Foundations 1*, Volume 1, 177–276. Elsevier.
- Carvalho, Leandro S., Stephan Meier, and Stephanie W. Wang. 2016. "Poverty and economic decision-making: Evidence from changes in financial resources at payday." *American Economic Review* 106 (2): 260–284.
- Cohen, Jonathan, Keith Marzilli Ericson, David Laibson, and John Myles White. 2020. "Measuring time preferences." *Journal of Economic Literature* 58 (2): 299–347.
- Cutler, David M, and Wendy Everett. 2010. "Thinking outside the pillbox—medication adherence as a priority for health care reform." *New England Journal of Medicine* 362 (17): 1553–1555.
- Ericson, Keith Marzilli, and David Laibson. 2019. "Intertemporal choice." In *Handbook of Behavioral Economics: Applications and Foundations 1*, Volume 2, 1–67. Elsevier.
- Gilbert, Ben, and Joshua Graff Zivin. 2014. "Dynamic salience with intermittent billing: Evidence from smart electricity meters." *Journal of Economic Behavior & Organization* 107:176–190.
- Gilbert, Ben, and Joshua S Graff Zivin. 2020. "Dynamic corrective taxes with time-varying salience." *Journal of Environmental Economics and Management* 103:102–356.
- Greiner, Ben. 2015. "Subject pool recruitment procedures: organizing experiments with ORSEE." *Journal of the Economic Science Association* 1 (1): 114–125.
- Grubb, Michael D, and Matthew Osborne. 2015. "Cellular service demand: Biased beliefs, learning, and bill shock." *American Economic Review* 105 (1): 234–71.
- Jack, Kelsey, and Grant Smith. 2020. "Charging Ahead: Prepaid Metering, Electricity Use, and Utility Revenue." *American Economic Journal: Applied Economics* 12 (2): 134–68.
- Jessoe, Katrina, and David Rapson. 2014. "Knowledge is (less) power: Experimental evidence from residential energy use." *American Economic Review* 104 (4): 1417–38.
- Kaplan, Greg, and Giovanni L Violante. 2014. "A model of the consumption response to fiscal stimulus payments." *Econometrica* 82 (4): 1199–1239.
- Kaur, Supreet, Michael Kremer, and Sendhil Mullainathan. 2015. "Self-control at work." *Journal of Political Economy* 123 (6): 1227–1277.
- Keys, Benjamin J, and Jialan Wang. 2019. "Minimum payments and debt paydown in consumer credit cards." *Journal of Financial Economics* 131 (3): 528–548.
- Kim, Jeongbin. 2017. "The effects of time preferences on cooperation: Experimental evidence from infinitely repeated games." *Working paper. Brown University.*

- Kuchler, Theresa, and Michaela Pagel. 2020. "Sticking to your plan: The role of present bias for credit card paydown." *Journal of Financial Economics*.
- Laibson, David. 1997. "Golden eggs and hyperbolic discounting." *The Quarterly Journal of Economics* 112 (2): 443–478.
- Laibson, David, Andrea Repetto, and Jeremy Tobacman. 2007. "Estimating discount functions with consumption choices over the lifecycle." *NBER Working Paper 13314*.
- Lynham, John, Kohei Nitta, Tatsuyoshi Saijo, and Nori Tarui. 2016. "Why does real-time information reduce energy consumption?" *Energy Economics* 54:173–181.
- Meier, Stephan, and Charles Sprenger. 2010. "Present-biased preferences and credit card borrowing." *American Economic Journal: Applied Economics* 2 (1): 193–210.
- O'Donoghue, Ted, and Matthew Rabin. 2015. "Present bias: Lessons learned and to be learned." *American Economic Review Papers and Proceedings* 105 (5): 273–79.
- Sexton, Steven. 2015. "Automatic bill payment and salience effects: Evidence from electricity consumption." *Review of Economics and Statistics* 97 (2): 229–241.
- Shapiro, Jesse M. 2005. "Is there a daily discount rate? Evidence from the food stamp nutrition cycle." *Journal of Public Economics* 89 (2-3): 303–325.
- Shui, Haiyan, and Lawrence M Ausubel. 2004. "Time inconsistency in the credit card market." *Working Paper*.
- Sprenger, Charles. 2015. "Judging experimental evidence on dynamic inconsistency." *American Economic Review: Papers and Proceedings* 105 (5): 280–85.
- Werthschulte, Madeline, and Andreas Löschel. 2019. "Cost misperceptions and energy consumption: Experimental evidence for present bias and biased price beliefs." *CAWM Discussion Paper 111*.
- Wichman, Casey J. 2017. "Information provision and consumer behavior: A natural experiment in billing frequency." *Journal of Public Economics* 152:13–33.

Appendix

A Figures and tables

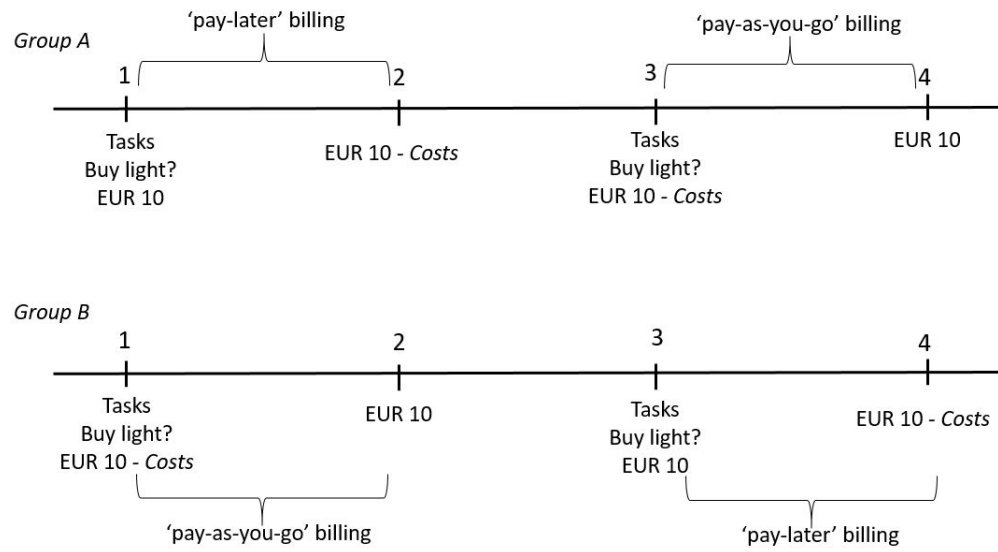


Figure A1: Full experimental design with cross-over treatment assignment

Table A1: Within-subjects panel regression of light consumption per task on billing scheme

	(1)	(2)
	Light in sec	Light always on
pay-as-you-go	-0.351	0.00275
	(0.371)	(0.0175)
Session FE	X	X
Task FE	X	X
N	8075	8075

Note: Robust standard errors are clustered on participant level. Significance levels: * : $p < 0.10$, ** : $p < 0.05$, *** : $p < 0.01$.

Table A1 gives within-subjects results, comparing participants' decisions between date 1 and date 3. The panel is unbalanced in the sense that 18 participants are just observed on date 1 but not on date 3. The pay-as-you go coefficient for light consumption has the same sign as in the between-subjects analysis, but is not significant. Based on anecdotal evidence, I attribute this lack of significance to participants not noticing the change in payment schemes. When appearing at our offices on date 3, many participants seemed to be confused by the fact that their payment schemes have changed compared to date 1. Further, alternate explanations would have increased the effect of changed payment schemes (e.g. experimenter demand or social comparison of earnings on date 1). The indicator for light always on becomes negative in the within-regression but is close to zero and far from significance at any conventional level.

B Translated instructions

Instructions are translated from the original German version.

B1 Sequence of screens - Date 1

Welcome to our experiment!

We would like to thank you for your participation in this experiment. The experiment takes place on four dates:

1. **Tue., Oct 30, 2018, at 1pm**
2. **Tue., Nov 6, 2018**
3. **Tue., Nov 13, 2018, at 1pm**
4. **Tue., Nov 20, 2018**

The first and third session will take place in the computer pool WIWI 2 and last approximately an hour. In the second and fourth session you are supposed to pick up your pay-off. This will take only a couple of minutes. All participants, who show up at each of the sessions, will receive a remuneration of at least 20 euros. The exact amount depends on your decisions in the experiment. You will receive detailed information for each session in advance via e-mail.

Your ID:

ID: [4-digit combination of characters]

This is your personal ID for all four sessions of the experiment. **Please bring your ID to each of the sessions.**

General information:

We kindly ask you to be quiet and not to talk to your neighbor throughout the whole experiment. Please store personal items (such as mobile phones) in your bags.

The computer is supposed to be used for the tasks of the experiment, only.

If you have any question, please raise your hand. An instructor will approach you then.

User ID:

Login [Randomization into Group A/Group B]

The four sessions of the experiment are divided into two parts. This is part one:

1. **Today** you are supposed to work on a task and receive a first payment of 10 euros.
2. **Next week**, you will receive a second payment of 10 euros. You can pick up the amount on [Today + 7 days] (+/- one day). You are not supposed to complete any other task and only will pick up the payment. We will inform you via e-mail on time.

The second part of the experiment takes place on [Today + 14 days] and on [Today + 21 days]. For completing the second part, you will receive another payment. This payment is independent of the first part of the experiment. You will receive more specific information before the start of the second part via e-mail.

Now we are going to explain to you today's task.

Continue

The task for today:

- Successively, you will be shown 25 tables. Each table contains exactly 100 alphabetic characters. In each of the 25 tables, you are required to click on a specified character. The required character will appear at the top of your screen.
- This character may appear more than once in the table. You are supposed to click on all above-specified characters that appear in the table. Example: Click on all characters 'a' that occur in the table.
- You can only continue with the table, when you have clicked on all occurrences of the specified character. To this end, please use the button "Finish this table".
- Your payment is independent from the number of tables. You need to finish all 25 tables. As soon as you have finished all tables, you can leave the room and pick up your first payment.
- Each table appears in a low image contrast. To heighten the contrast, you can switch on 'light' by clicking on a light switch.
- We charge you electricity costs of 0.5 eurocents per second of light. An electricity meter will show you the current electricity costs. Those will be subtracted from your payment.

We start the experiment with a few exercise rounds so that you can make yourself familiar with the task and the screen. These rounds have no influence on your payment. If you have any question, please raise your hand. An instructor will approach you then.

Continue

We are going to start with three exercise rounds.

Note: These are exercise rounds. Thus, your electricity costs will **not** be charged. The electricity costs shown are hypothetical. These exercise rounds have no influence on your payment.

Continue

Exercise rounds

Thank you. You have finished the exercise rounds. From now on, the electricity costs will be charged.

Now you will be successively shown 25 tables. **As soon as you have finished all tables, you can leave the room and pick up your first payment.**

[Group A]

Please note: Your electricity costs are due in one week, when you will pick up the second payment. Thus, you will receive a payment of 10 euros today. Next week, you will receive the second payment of 10 euros minus the electricity costs.

This means: Each second light switched on **today**, reduces **next week's** payment by 0.5 eurocents.

[Group B]

Please note: Your electricity costs are due today, when you pick up the first payment. Thus, you will receive a payment of 10 euros today minus the electricity costs. Next week, you will receive the second payment of 10 euros.

This means: Each second light switched on **today**, reduces **today's** payment by 0.5 eurocents.

Continue

Tasks

Thank you! You have now completed the task.

You have had the light switched on for [x] seconds today. Your electricity costs are [x] eurocents.

[Group A]

You can now pick up your first payment of 10 euros. Your electricity costs are due next week when you pick up the second payment.

You receive the payment at this address:

Am Stadtgraben 9
48143 Münster
Room 17

The instructors may provide you with directions for the address. We kindly ask you to leave the room quietly in order not to disturb the other participants. **Please remember to take your personal ID with you.**

Thank you for your participation!

[Group B]

You can now pick up the first payment of 10 euros minus the electricity costs. Thus, you receive [x] euros today.

You receive the payment at this address:
Am Stadtgraben 9
48143 Münster
Room 12

The instructors may provide you with directions for the address. We kindly ask you to leave the room quietly in order not to disturb the other participants. **Please remember to take your personal ID with you.**

Thank you for your participation!

B2 Sequence of screens - Date 3

User ID:

Login

The experiment consists of two parts. This is part two:

1. **Today** you are supposed to work on a task and receive a first payment of 10 euros.
2. **Next week**, you will receive a second payment of 10 euros. You can pick up the payment on [Today + 7 days] (+/- one day). You are not supposed to complete any other task and only will pick up the second payment. We will inform you via e-mail on time.

Now we are going to explain to you today's task.

Continue

The task for today:

- Successively, you will be shown 25 tables. Each table contains exactly 100 alphabetic characters. In each of the 25 tables, you are required to click on a specified character. The required character will appear at the top of your screen.
- This character may appear more than once in the table. You are supposed to click on all above-specified characters that appear in the table. Example: Click on all characters 'a' that occur in the table.
- You can only continue with the table, when you have clicked on all occurrences of the specified character. To this end, please use the button "Finish this table".
- Your payment is independent from the number of tables. You need to finish all 25 tables. As soon as you have finished all tables, you can leave the room and pick up your first payment.
- Each table appears in a low image contrast. To heighten the contrast, you can switch on 'light' by clicking on a light switch.
- We charge you electricity costs of 0.5 eurocents per second of light. An electricity meter will show you the current electricity costs. Those will be subtracted from your payment.

We start the experiment with a few exercise rounds so that you can make yourself familiar with the task and the screen. These rounds have no influence on your payment. If you have any question, please raise your hand. An instructor will approach you then.

Continue

We are going to start with three exercise rounds.

Note: These are exercise rounds. Thus, your electricity costs will **not** be charged. The electricity costs shown are hypothetical. These exercise rounds have no influence on your payment.

Continue

Exercise rounds

Thank you. You have finished the exercise rounds. From now on, the electricity costs will be charged.

Now you will be successively shown 25 tables. **As soon as you have finished all tables, you can leave the room and pick up your first payment.**

[Group A]

Please note: Your electricity costs are due today, when you pick up the first payment. Thus, you will receive a payment of 10 euros today minus the electricity costs. Next week, you will receive the second payment of 10 euros.

This means: Each second light switched on **today**, reduces **today's** payment by 0.5 eurocents.

[Group B]

Please note: Your electricity costs are due in one week, when you will pick up the second payment. Thus, you will receive a payment of 10 euros today. Next week, you will receive the second payment of 10 euros minus the electricity costs.

This means: Each second light switched on **today**, reduces **next week's** payment by 0.5 eurocents.

Continue

Tasks

Thank you! You have now completed the task.

You have had the light switched on for [x] seconds today. Your electricity costs are [x] eurocents.

[Group A]

You can now pick up the first payment of 10 euros minus the electricity costs. Thus, you receive [x] euros today.

You receive the payment at this address:

Am Stadtgraben 9

48143 Münster

Room 12

Before you pick up your payment, we kindly ask you to answer a brief survey. The survey duration is less than 10 minutes.

[Group B]

You can now pick up your first payment of 10 euros. Your electricity costs are due next week when you pick up the second payment.

You receive the payment at this address:

Am Stadtgraben 9

48143 Münster

Room 17

Before you pick up your payment, we kindly ask you to answer a brief survey. The survey duration is less than 10 minutes.

Continue [redirection to online-survey]