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The Incidence of Tariff Schedules and Price Information on Inattentive Consumers: A Lab Experiment*

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Abstract

We design an induced value laboratory consumption choice experiment where complex tariff schemes trigger nonlinear simplification heuristics that lead individuals to over- or underconsume public goods such as electricity, gas, or drinking water. By studying this ‘schmeduling’ bias, we investigate how an informational nudge could reduce it. Participants choose consumption levels repeatedly under different tariff schemes, where the marginal price per unit either remains constant (constant block rate, i.e., CBR) or increases above a certain threshold (increasing block rate, or IBR). We observe that the vast majority of choices are optimal, but a significant number of them reveal overconsumption. To investigate the impact of the informational nudge on these errors, some of our participants received a marginal price reminder. In that case, the learning effect helps to achieve convergence towards the optimal consumption value. To explain these effects, we use econometric models relying on microeconomic behavioral inattention to price to capture the magnitude of consumers’ inattention, observing, in particular, how the informational nudge is decreasing it.

Keywords: Increasing Block Rate; Constant Block Rate; Schmeduling; Information Reminder; Behavioral Inattention

JEL codes: C91, D12, Q25

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Abstract

We design an induced value laboratory consumption choice experiment where complex tariff schemes trigger nonlinear simplification heuristics that lead individuals to over- or underconsume public goods such as electricity, gas, or drinking water. By studying this ‘schmeduling’ bias, we investigate how an informational nudge could reduce it. Participants choose consumption levels repeatedly under different tariff schemes, where the marginal price per unit either remains constant (constant block rate, i.e., CBR) or increases above a certain threshold (increasing block rate, or IBR). We observe that the vast majority of choices are optimal, but a significant number of them reveal overconsumption. To investigate the impact of the informational nudge on these errors, some of our participants received a marginal price reminder. In that case, the learning effect helps to achieve convergence towards the optimal consumption value. To explain these effects, we use econometric models relying on microeconomic behavioral inattention to price to capture the magnitude of consumers’ inattention, observing, in particular, how the informational nudge is decreasing it.

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1. Introduction

Utilities often choose price-incentive based policies to manage and regulate facilities such as electricity, gas, or drinking water. Among price policies frequently used to charge for resource use are tariff schemes, which generally consist of either having a unit price that is constant across the consumption level (constant block rate, or CBR) or that increases with this level (as in the increasing block rate scheme, hereafter IBR). Among the fields of implementation is the case of water, where IBR is currently used in the United States, as well as in many European and developing countries, Ben Zaied et al. [1] for example.

The IBR tariff schedule has three main differences from the CBR schedule. First, the unit price level is constant over a certain consumption block and then increases over another block when the upper limit is reached, making the unit price a nonlinear function of chosen consumption. Second, the marginal price increases stepwise when a threshold (block) is reached, making the unit price a discontinuous function of consumption. Third, if chosen consumption is higher than this upper limit, then the total bill is a sum of consumption expenses that aggregates over different blocks for which unit price changes.

These complex tariff schemes tend to obscure the relationship between price and quantity for households, which triggers the use of simplification heuristics by individuals. For instance, Blaufus et al. [2] found evidence that taxpayers frequently use these heuristics. More specifically, as underlined by Liebman and Zeckhauser [3], multitiered pricing based on nonlinear pricing, e.g., the IBR tariff scheme, makes it more difficult for the consumer to perceive the marginal price of additional consumption. Moreover, there are other characteristics of public utilities pricing that exacerbate what the authors called ‘schmeduling’, which is the contraction of a ‘misperceived schedule’. One possible form of schmeduling is *ironing* where the consumer that faces an increasing marginal price for consumption makes his decision upon an average price, which leads to overconsumption. Another form is *spotlighting*, when the consumer responds to local prices and ignores the full schedule, which would give underconsumption in the case of increasing marginal price. A possible psychological explanation is that people rely on nonlinear simplification heuristics when facing complex financial incentives.

The empirical evidence is mixed. In a recent paper, Rees-Jones and Taubinsky [4] found empirical evidence for ironing behavior when studying the US income tax schedule. There is also evidence of ironing behavior found by Ito [5], Wichman [6], and Binet et al. [7] who showed that water customers respond to the average price under an IBR tariff scheme. In other research, Brent and Ward [8] found evidence in favor of spotlighting, observing that consumers have poor information about the marginal price and tend to overestimate the cost of water consumption, which tends to inhibit consumption. An interesting point raised by these authors is that if information about marginal price is more visible, learning the true cost of water may trigger additional consumption, thus favoring a rebound effect. Overall, the effect of additional information about marginal price might either deter or encourage consumption.

To disentangle the effects of monetary incentives and price information on consumption choices, we implement a laboratory experiment where different pricing schedules may come along with additional information about the marginal price. Alternatively, we use an information nudge (Alcott and Kessler [9]; Brent and Ward [8]) to increase the salience of the price signal and evaluate its impact on consumption choices.

As we aim to have clear behavioral predictions for participants’ optimal consumption choices, we built an induced-value experiment (Smith [10], Lusk and Shogren [11]). In such a setting, we measure the individual’s deviation from her optimal choice derived from the induced utility function and budgetary constraints. These deviations are costly for our participants since the maximum net payoff is obtained when choosing the optimal level. As deviations occur in the laboratory, we focus on the possibility of behavioral inattention to price signals (Gabaix [12]). Such inattention to price was discussed recently by Wang et al. [13]. They observed that consumers are rationally inattentive due to the implementation

of simplified heuristics. Martin et al. [14] show that there is some asymmetry in the weighing of reference prices between sellers and buyers when they interact repeatedly and found evidence that the provision of past prices recall to participants reduces recency effect.

Our lab experiment is helpful for measuring behavioral inattention for at least three reasons. First, as noted by DellaVigna [15] and Gabaix [16], the easiest way to identify attention issues is for the observer to measure a clear and unambiguous deviation from the agent's optimal action. This is the natural standard benchmark for which an individual's attention is perfect. The second reason is that by using a pure individual decision-making setting where no interaction occurs between subjects, we limit possible moral considerations or social preferences coming from our participants, which could exist in any field study about energy or water choice (see Alcott and Kessler [9]). As we strictly focus on price misperception and inattention, we want to rule out any uncontrolled social nudge from our experiment, which could exist if, e.g., decision-makers are able to compare their consumption with others, as in Ferraro and Price [17], Bernedo et al. [18], or Torres and Carlsson [19]. The last interest of having a lab experiment lies in the absence of *evocative framing* for the choice framework, as experimental instructions or computer interfaces for choices are generally not contextualized as they are in a water or energy consumption problem. This avoids at most any personal considerations that could be related to ecological preferences, aversion to wasting a scarce resource, taste for public goods, etc. For instance, Cason and Raymond [20] run an economic experiment about emissions permits and find that in the context of treatment, participants pollute more than in the neutral treatment. In contrast, Pevnitskaya and Ryvkin [21], running a comparable setting, observed that participants pollute less under the framed treatment labeled in environmental terms. Bernorld et al. [22] obtained more mixed results and prevented the generalization of framing effects in the laboratory. As noted by Alekseev et al. [23], *evocative framing*, which relies on a real-life situation but can also evoke strong emotions, should be used carefully since they can interact with the participants' observable characteristics. We consider that the features of our experimental design contribute to a more straightforward measure of individuals' behavioral inattention compared to field experiments, for example.

To be more specific, our experimental treatments consist of having two different pricing schedules (CBR or IBR) where participants get a price reminder (an information nudge) after a certain number of periods of getting no price reminder². In our setting, participants experience only a single price schedule (between-subject design) but are exposed to two information conditions in a within-subject design

² As noticed by Gabaix [16], "*If people don't pay attention, perhaps a reminder will help. In terms of modeling, such a reminder could be a "free signal"*". This is precisely the way we pave, since some of our participants get a price reminder when choosing consumption level in order to draw their attention to the price and help them to make better consumption choices (i.e., choices that improve their own welfare).

(having no price reminder for a time and then receiving a price reminder). As consumption choices are repeated 20 times under the same information condition, we control, to some extent, for individual learning, which might affect possible deviations from optimal choices. More importantly, we also assess the extent of inattention regarding the tariff and observe its evolution over time for each different treatment.

Our main results are the following. First, the vast majority of actual consumption choices are consistent with optimal choices; however, overconsumption occurs as well as underconsumption, the latter being less frequent than the former. Second, treatment effects are strong: deviations are less frequent under the IBR tariff scheme than under the CBR tariff scheme. Price reminders also help to reduce deviation from the optimal choice under IBR and, to a lesser effect, under CBR. Finally, we explain experimental deviations by building upon behavioral inattention to price models. Following Gabaix [16], we observe significant inattention levels in our participants that are affected by our various experimental treatments. Inattention is high without price reminder and decreases with price reminder.

The remainder of the paper is organized as follows. In Section 2, we provide details about our experimental design. In Section 3, experimental results are presented. Finally, Section 4 concludes our paper.

2. Experimental Design

Our experimental design consists of an induced-value setting (as in Murphy et al. [24] ; Huck and Wallace [25]) where exogenous preferences for consumption are given for each participant by relying on a utility function. We also set exogenous individual constraints for consumption, in particular the tariff scheme, endowment, and consumption for other goods. The following subsections explain our particular microeconomic calibration (2.1) and the experimental conditions that we implemented in the laboratory (2.2.). The last subsection (2.3) derives the experimental predictions.

2.1 Microeconomic specification and experimental calibration

To tackle possible heterogeneity in individual optimal consumption choices, we use the Stone-Geary approach (Stone [26]) to model consumption goods – such as residential water demand as in Gaudin et al. [27] or Martinez-Espineria and Nauges [28]. This specification for individual demand enables us to differentiate a captive component for consumption that is independent of prices and income in the short run, from a variable that is price- and income-dependent. The corresponding demand function of the good priced as a fixed charge F and a block rate tariff p is the result of the maximization of the following utility function (1):

$$U_i(q, l) = \beta \ln(q - c) + (1 - \beta) \ln(l - \gamma) \quad (1)$$

where the consumption level is $q > c$, $l > \gamma$ denotes the composite good level, $0 < \beta < 1$ and $c > 0$ stand for parameters that can be interpreted as the marginal budget share and a committed quantity for a good priced with block rates, respectively, and $\gamma > 0$ is a committed quantity for the aggregate of other consumption goods.

Assuming a unitary price for the composite good, the budget constraint can be written as follows:

$$Y_i + D + F = pq + l \quad (2)$$

where Y_i is household income and p is the marginal price. If we consider the traditional IBR tariff schedule, D is the variable for Nordin's difference, expressing the refund that the consumer would be entitled if she paid her entire consumption at the marginal price. As shown in equation (2), the corresponding budget constraint of the consumer is obtained by multiplying the consumption level by the marginal price. The thresholds appear through an income effect, adding Nordin's D to the consumer's income. However, as the contribution of our paper focuses on marginal price misperception or inattention, we retain a simplified IBR, with Nordin's D and the fixed part equal to zero. We thus ignore the income effects of the tariff scheme to focus on the impact of increasing the marginal price on consumption choice.

The corresponding expenditure function for the block rate priced good, or the solution to this optimization problem, is written as follows:

$$pq = pc + \beta(Y - F + D - pc - \gamma) \quad (3)$$

We, therefore, calibrate optimal consumption choices by assuming two possible levels of individual endowment (High H or Low L) and two classes of utility functions that imply four types of consumers in our experimental sessions, as shown in the following table:

Table 1. Characteristics of the utility function and endowments for each participant type

Minimum Consumption	$c_1 = 1$	$c_2 = 6$
Budget share for the good	$\beta_1 = 0.1$	$\beta_2 = 0.01$
Endowment (Low or High)		
$Y_L = 50$	Type 1 (U_{1L})	Type 3 (U_{2L})
$Y_H = 200$	Type 2 (U_{1H})	Type 4 (U_{2H})

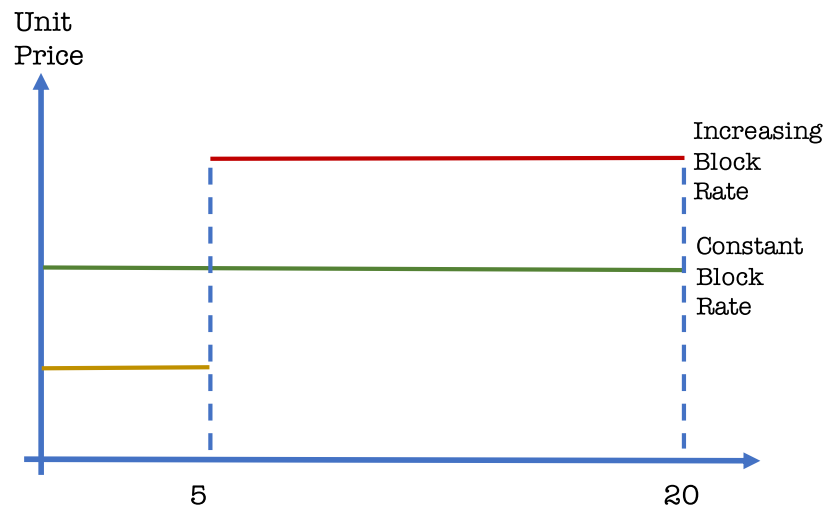
Values for the parameters c and β define two extreme individual profiles to create heterogeneity in preferences in our experimental design.

2.2 Experimental treatments and conditions

Our experiment consists of a 2x2 design, where 2 pricing structures are combined --- a CBR scheme and an IBR scheme --- with 2 levels of price information reminders obtained during the choice period --- "no information reminder" and "information reminder". CBR corresponds to a marginal price of the

consumption good that remains the same, regardless of the consumption level chosen by a participant. An IBR scheme consists of setting a threshold where the marginal price is $p_1=1$ if consumption is below or equal to the threshold of 5 and $p_2=3$ if the consumption level is higher than the threshold. The following figure explains the possible tariff structures that participants face:

Figure 1. IBR and CBR standard tariff schemes

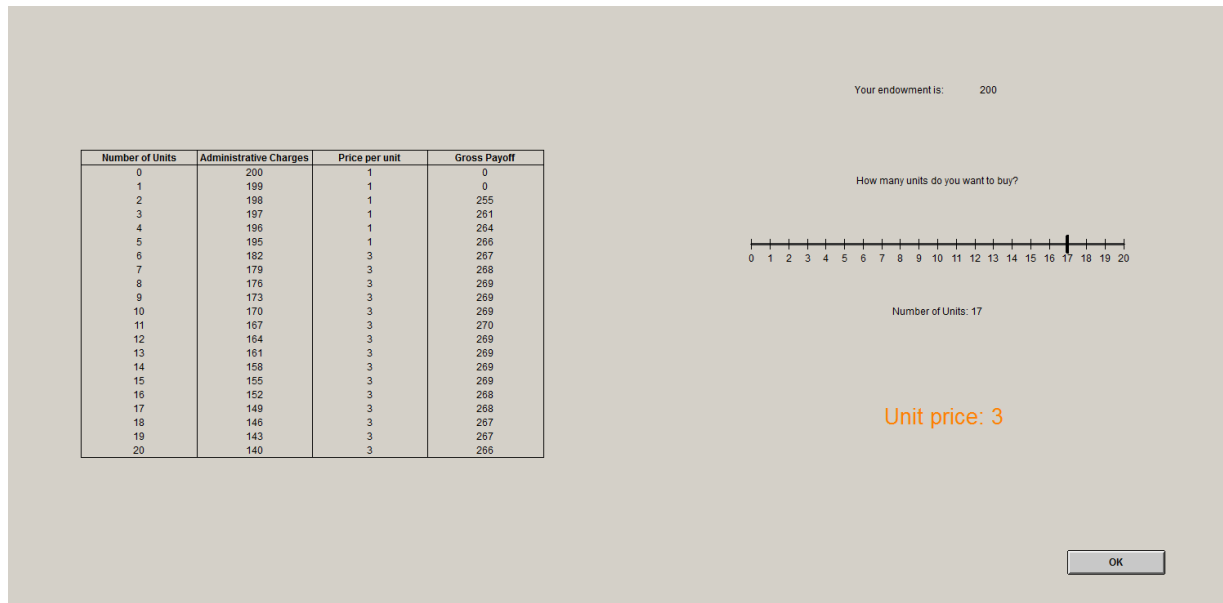


Therefore, if we consider, for instance, a quantity equal to 7, the standard bill (e.g., for public utility goods such as water or electricity) would be equal to $5 p_1 + 2 p_2 + F$; however, in the lab we added a modified version of this traditional IBR. Unlike the usual IBR scheme, when consumption exceeds the threshold, the unit price $p=3$ is applied to all the quantities chosen. This methodological choice is retained, as it simplifies the participants' bill computation during the experiment and allows us to concentrate on the scheduling bias that mainly arises from the misperception of the marginal price values.

In each session, a participant of a certain type should choose repeatedly for 20 periods under the “No Information Reminder” (NIR hereafter) condition, and then choose for another 20 periods under the “Information Reminder” (IR) condition, with the tariff scheme being the same for the whole session (within-subject design).

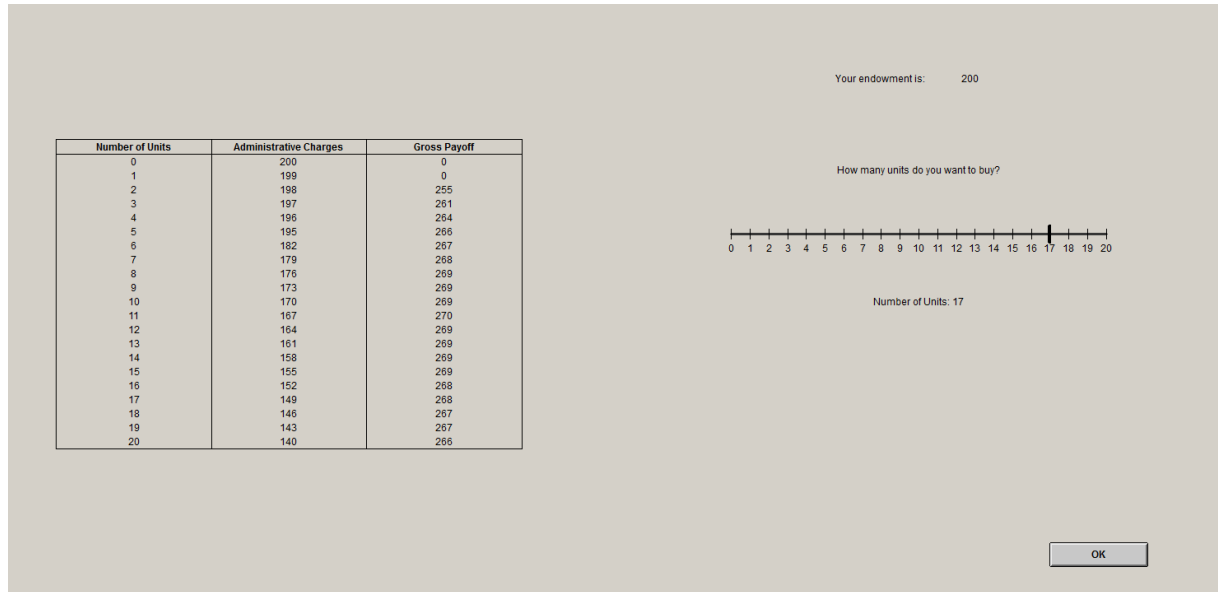
Before making choices, participants were carefully told what the situation choice was. The payoff each participant received depended on her consumption choice level, given the tariff scheme and exogenous gains arising from the underlying net utility (see details on the instructions in the appendix). The following capture of our computerized interface displays the kind of information reminder we provided:

Figure 2. Screen capture of Z-Tree for a Type 2 participant under IBR + price information reminder (translated from French)



The information we provided was minimal, just a price reminder permanently displayed depending on possible consumption choice. Being perfectly aware of the pricing scheme to which he was exposed, each participant changed the cursor position from 0 to 20 and was able to see an information reminder about the unit price for the particular position of the cursor. For example, (see figure above), if the participants set the cursor to a consumption level of 17, they saw a reminder that the unit price was 3 (displayed in orange). If the cursor was moved below 6 units, the message indicated that the unit price was 1 (displayed in green). Under the other condition, labeled “No Information Reminder” (NIR), the situation choice was exactly the same with the exception of the information reminder, as the following screen capture shows in Figure 3:

Figure 3. Screen capture of Z-Tree for a participant of Type 2 under nonlinear tariff + no price reminder (translated from French)



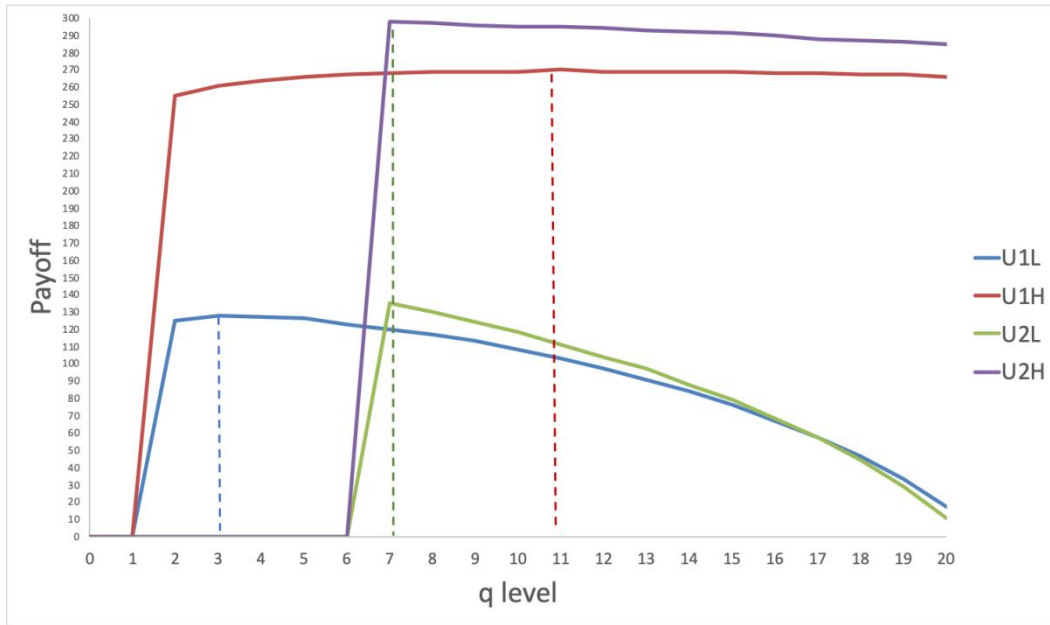
Our information is simply a *marginal price reminder* and not a clarification about the pricing scheme, which was explicitly and completely explained and provided in the instructions phase at the beginning of the experiment. This is a behavioral nudge, as we provided individuals with information about a choice they face (Coffman et al. [29]).

2.3. Theoretical predictions and behavioral conjectures

2.3.1. Theoretical predictions

Assuming perfect rationality, the optimal quantity that should be chosen by each consumer type provides the maximum payoff. Given our particular calibration of preferences, following the Stone-Geary function and endowments for participants, we compute the optimal solution for each consumer type, which provides us with the incentive structure for monetary payoffs that were presented to participants. The payoff function is as follows (see figure below):

Figure 4. Maximizing-payoff consumption level for each participant type



On the horizontal axis, possible consumption levels are given, from 0 to 20. The vertical axis presents the monetary payoff depending on the consumption level. Solid lines show how monetary payoffs evolve with consumption level, and dotted lines indicate optimal consumption for each consumer type ($q^*=3$ for U_{1L} , $q^*=7$ for U_{2L} and U_{2H} , $q^*=11$ for U_{1H}).

2.3.2. Behavioral conjectures

In practice, details of the tariff scheme often do not appear clearly on the bill, and it can be difficult to understand it. Either the complete tariff scheme does not appear on the bill or it appears but is buried in a mass of other information, so households do not read or understand it. Therefore, as emphasized by Wang et al. [13], the units for which consumers are charged are different from the units on which consumers base their consumption choices. Last but not least, Liebman and Zeckhauser [3] argue that consumption tends to be far greater than the optimal level in the case of *ironing* but lower than the optimal value in the case of *spotlighting*, which leads to the first conjecture:

Conjecture 1: *In the case of price misperception or inattention, we expect participants to choose a quantity different from the optimal value due to scheduling. Some will choose higher consumption levels in the case of ironing, and others will choose lower levels in the case of spotlighting.*

From a policy perspective, price information reminders are recommended in the spirit of Thaler and Sunstein [30] to “nudge” consumers to help them optimize their consumption choices. In the case of overconsumption, the general idea is that an essential good (such as water or energy) can be saved simply by clearly suggesting the right options to households without imposing constraints, being coercive, or limiting the liberty of choices (Loewenstein and Chater [31]). In our experimental analysis,

participants no longer need to search for the marginal price in the form. Therefore, our experimental setting will allow us to test the validity of the following prediction:

Conjecture 2: *Price reminder information treatment should correct price misperception and favor convergence towards the optimal consumption level.*

A large body of literature provides empirical analyses to estimate the price elasticity of water or electricity consumption to evaluate the impact of price incentives, see for example Nosvelli and Musolesi [32]. Our lab methodology addresses this challenging issue in a controlled experimental framework by comparing, everything being equal, the consumption choices of participants under the CBR and IBR tariff schemes. However, the theoretical predictions are unclear, as shown in conjecture 3:

Conjecture 3: *Our experimental design addresses the impact of the tariff structure on consumption choices. However, two opposite effects may influence consumption. On the one hand, compared to CBR, the IBR tariff scheme may reduce overconsumption if the consumer is price sensitive. On the other hand, the IBR tariff may appear as a complex tariff scheme, increasing errors due to other factors, like a possible scheduling bias.*

3. Experimental Results

All sessions were performed in the experimental economics platform at University of Rennes, France, the LABEX-EM. All participants (120) were students of various origins (law and economics, management, etc.) and were recruited through the software ORSEE (Greiner [33]). After an experimenter read the instructions loudly, an incentivized experiment was run under the software Z-Tree (Fischbacher [34]). 5 sessions of 24 participants each were held. The following table summarizes the participants' characteristics and treatments of the five experimental sessions for the 4 types, U_{1L} , U_{1H} , U_{2L} , and U_{2H} .

Table 2. Description of the experimental sessions

Session	Description of the participants	Treatments
1	12 participants U_{1L} 12 participants U_{2L}	CBR tariff scheme 20 first periods NIR, 20 latest periods IR
2	12 participants U_{1H} 12 participants U_{2H}	CBR tariff scheme 20 first periods NIR, 20 latest periods IR
3	12 participants U_{1L} 12 participants U_{2L}	IBR tariff scheme 20 first periods NIR, 20 latest periods IR
4	12 participants U_{1H} 12 participants U_{2H}	IBR tariff scheme 20 first periods NIR, 20 latest periods IR
5	12 participants U_{1H} 12 participants U_{2H}	IBR tariff scheme 20 first periods IR, 20 latest periods NIR

The optimal quantity is equal to 3 for U_{1L} , 7 for U_{2L} , 7 for U_{2H} , and 11 for U_{1H} . IR: Information Reminder, NIR: No Information Reminder.

We organize the discussion of our results as follows. In subsection 3.1, using descriptive statistics and tests, we compare individual consumption choices to their corresponding optimal values. To go further, in subsection 3.2, we provide multivariate regression analyses allowing us to identify the contribution of each treatment simultaneously, everything being equal. We use random-effect Tobit regressions to deal with censored data, as the dependent variable is the absolute value of the relative deviation between the quantity and the optimum, in the optimum ratio.

3.1. Consumption choices and deviations from optimal choices

We first provide summary statistics about consumption choices that were made in the laboratory. Basic descriptive statistics about relative deviations are given in table 3 below.

Table 3. Summary statistics about relative deviations to optimal quantity choice

	Total	Treatment CBR+NIR	Treatment CBR+IR	Treatment IBR+NIR	Treatment IBR+IR
Average frequency of optimal choice (%)	79.12	69.27	76.77	82.85	83.54
Average frequency of positive relative deviation (%)	17.21	27.6	20.1	12.43	13.12
Average frequency of negative relative deviation (%)	3.67	3.12	3.12	4.72	3.33
Mean value of relative deviation (s.d)	+0.191 (0.663)	+0.355 (0.891)	+0.216 (0.715)	+0.130 (0.563)	+0.126 (0.503)
Mean value of relative overconsumption (s.d)	+1.205 (1.111)	+1.326 (1.247)	+1.220 (1.035)	+1.182 (1.110)	+1.042 (0.960)
Mean value of relative underconsumption (s.d.)	-0.450 (0.424)	-0.342 (0.236)	-0.942 (0.742)	-0.360 (0.206)	-0.338 (0.223)
Total Number of obs.	4,800	960	960	1,440	1,440

Lecture note: The mean value of the relative deviation is defined as $RD = \sum_{it} \frac{(q_{it}^{obs} - q_{it}^*)}{q_{it}^*} / n_i$, where i denotes the subject number and t the period number. For instance, considering all data, this deviation is equal to +0.191, meaning that on average, participants choose a quantity that is 19.1% higher than their optimal choice. S.d. is used to abbreviate standard deviation.

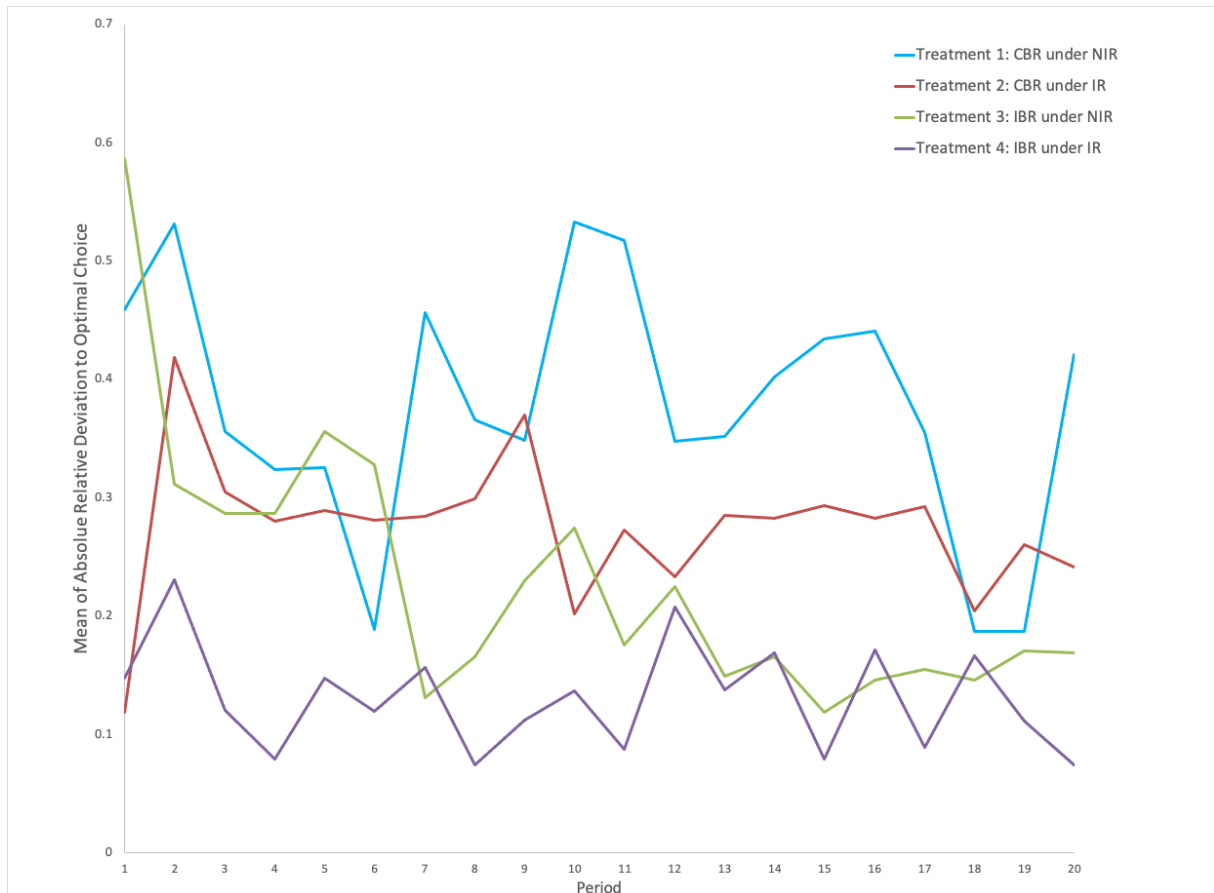
Overall, the vast majority of choices (more than 79%) are consistent with optimal choices, meaning that positive or negative deviations occur for 21% of all consumption choices, which is partially in accordance with conjecture 1. Deviations consist more often of overconsumption than underconsumption, with the former occurring for 17.21% of all choices and the latter occurring only in 3.67%, which suggests that *ironing* dominates *spotlighting*³. Moreover, the average overconsumption (+1.205) is higher than the average underconsumption (-0.45), which might be explained by marginal price understatement for some participants.

In addition, considering positive deviations with no price reminder, participants deviate from the optimal value less frequently under the IBR schedule (12.43%) than under the CBR schedule (27.6%). The following figure illustrates how, on average, absolute relative deviations evolve over time.

³ In that, our experimental results are consistent with the ones obtained by Rees-Jones and Taubinsky [4], who find strong evidence for ironing in the case of the U.S. Federal Income Tax schedule by using a field experiment.

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Figure 5. Average absolute relative deviations per treatment over time



Under the no-information reminder treatment, deviations are higher when participants face CBR (treatment 1) compared to IBR (treatment 3), which could be explained by greater price incentives under IBR. Figure 5 also shows that the price reminder decreases deviation frequency under CBR and IBR. Finally, under IBR, consumption choices become stationary after a learning period of between 4 and 7 periods.

As complementary evidence, typical comparison statistical tests can be performed for within-subject comparisons (Student's t-test for matched data and the nonparametric Wilcoxon signed-rank test) or between-subject comparisons (Student's t-test and Mann-Whitney rank-sum test) and give similar results in the following table:

Table 4. Comparison tests for relative deviation to optimal choice

	Student Test	Mann-Whitney/Wilcoxon Matched Pairs
Between-Subjects comparison		
NIR: CBR vs IBR	T=+2.363 P=0.021**	z= +2.897 p=0.038**
IR: CBR vs IBR	T=+1.078 P=0.317	z=+0.032 p=0.975
Within-Subject comparison		
CBR: NIR vs IR	T=+2.045 P=0.046**	z=+3.157 p=0.016**
IBR: NIR vs IR	T=+0.189 P=0.851	z=+0.505 p=0.613

Indeed, under the No Information Reminder condition, the average deviation is higher for CBR than for IBR, and the average deviation is higher when comparing the No Information Reminder condition to the Information Reminder condition. However, a significant effect of price reminders occurs under CBR but not under IBR.

3.2 Econometric analyses

To go further, we provide multivariate regression analyses allowing us to identify the contribution of each treatment simultaneously, everything being equal. Summary statistics of the variables used are reported below:

Table 5. Summary statistics of the variables used in the econometric model

Variable	Unit	Mean	Min	Max	Stand. Dev
$\frac{ q_{it}^{obs} - q^* }{q^*}$	Censored data between 0 and 5.66	0.21	0	5.66	0.62
price Information reminder (IR)	1=IR, 0=NIR	0.5	0	1	0.5
Period	Times series from 1 to 20	10.5	1	20	5.76
Endowment	Integer 50, 200	140	50	200	73.49
Tariff	1=CBR, 0=IBR	0.4	0	1	0.49
Payoff (lagged)	Euros	78	0	98	27
Type	0=U ₁ , 1=U ₂	0.5	0	1	0.5
Sex	1=female, 0=male	0.5	0	1	0.49
Age	Years	19.07	17	27	1.52
Switch	Integer	6.41	2	10	1.99

We use random-effect Tobit regressions to deal with censored data as the dependent variable, and the absolute value of the deviation ratio has values between 0 and 5.66. Four specifications are first compared. The first set of estimates (regression 1 in Table 6) identifies the global effect of the price information reminder (IR) on consumption choice, whatever the treatment considered, including the dummy variable IR, which takes a value of 1 under the price reminder case and 0 otherwise. Regressions 2-4 cross the specific effect of the IR with the other treatments considered, namely, the tariff type (CBR versus IBR) and the endowment level (Low versus High), according to the two preferences types (U1 or U2). We also add a *period* variable to each model, which ranges from 1 to 20, to check for the existence of a learning effect during the sessions and each treatment. We expect, everything being equal, a negative influence of price reminder on the dependent variable but no specific effect of preference types. Next, a negative influence of *period* on the quantity chosen would reveal the existence of a learning effect. In regression 2, we add controls for participants' characteristics, including their age and sex, and a variable measuring their aversion towards risk (*switch*⁴). We expect no significant effects of these individual characteristics on their decision choice.

Second, we compare estimates from two subsamples, data from sessions 1 to 4, and then data from session 5, for which the price reminder occurs during the first 20 periods. The results are shown in the following table:

⁴ The variable *switch* corresponds to the number of safe lotteries chosen against a risky lottery in the Holt-Laury procedure for eliciting the risk-aversion level for a given participant. A switch that equals 4 implies risk neutrality. For more details, see Holt and Laury [35].

Table 6. Regression panel data analyses of deviation from the optimal value ratio

Sample Specification Variables	Sessions 1-4 Regression 1 Common effect	Session 5 Regression 1 Common effect	Sessions 1-4 Regression 2 Tariff' effects of IR	Sessions 1-4 Regression 3 Endowment' effects of IR	Sessions 1-4 Regression 4 Preferences' effects of IR
Price IR	-0.41*** (0.00)	0.58*** (0.000)			
IR&CBR			-0.30*** (0.00)		
IR&IBR			-0.56*** (0.00)		
IR&low endow				-0.37*** (0.00)	
IR&high endow				-0.44*** (0.00)	
IR&U ₁					-0.48*** (0.000)
IR&U ₂					-0.35*** (0.00)
Period	-0.031*** (0.00)	-0.047*** (0.000)	-0.03*** (0.00)	-0.03*** (0.00)	-0.03** (0.00)
Payoff _{t-1}	-0.0028*** (0.007)		-0.0027*** (0.008)	-0.027*** (0.008)	-0.0027*** (0.01)
Sexe			0.99*** (0.00)	1.008*** (0.00)	1.007*** (0.00)
Log Likelihood	-1,232	-284	-1,220	-1,223	-1,222
Number of obs.	3,703	960	3,703	3,703	3,703

NB: *p*-values for the Student significance test are in brackets. *** indicates significance at the 1% risk level (** and * for 5% and 10%, respectively). In session 5, endowment is dropped, as all the participants have the same value. Switch and lagged payoff are also dropped to ensure estimate convergence. Regressions are obtained using a stepwise backward procedure to address participants' characteristics.

Our results first show that the way marginal price information is presented to consumers matters, which is in accordance with conjecture 2. Indeed, all things being equal, if we consider only sessions 1 to 4, the price information reminder treatment reduces the deviation ratio by 0.41, which is not negligible as the average value of the ratio is 0.21. However, convergence towards the optimum is not observed in session 5, where participants benefit from price reminder first. Despite the price reminder, deviation to the optimum is positive, confirming the existence of a strong learning effect before converging to the optimum.

Likewise, the estimates demonstrate the existence of a significant learning effect; when the time period increases by one, the deviation ratio decreases by -0.031. Such a learning effect means that after 20 periods, consumption is reduced by -0.62. We conclude that the learning effect is at least as substantial as the price reminder effect (both impact individual choices but at different periods of the experiment). Last, financial incentives also promote convergence towards the optimum because an increase in the lagged payoffs significantly reduces deviation from the optimal value.

To go further into the analysis, the effect of the price reminder can be distinguished according to the type of tariff (CBR versus IBR, in regression 2), the endowment levels (low or high, in regression 3), and the consumer types (U_1 versus U_2 , in regression 4). The results from regression 2 show that price reminder is more conducive to convergence when the consumer faces IBR, i.e., a complex tariff scheme than in the case of CBR pricing (estimates equal to -0.56 and -0.30, respectively). Next, price information tends to significantly favor convergence towards the optimum in relatively similar proportions in both endowment levels and consumer types. Finally, the individual characteristics and preferences are not statistically significant, with the exception of gender. Indeed, we observe that women make more mistakes than men.

Finally, our results suggest that regardless of the specification considered, both information improvement and learning effects are significant for participants from sessions 1 to 4. To disentangle learning from price recall effects, we provide robustness tests and estimate regression 1 again excluding the payoffs for sessions 1 to 4, removing the first time periods one by one:

Table 7. Regression panel data analyses of consumption choices from the subperiods

Time period	t=1 to 20	t=2 to 20	t=3 to 20	t=4 to 20	t=5 to 20	t=6 to 20	t=7 to 20
Price	-0.46***	-0.41***	-0.38***	-0.35***	-0.32***	-0.26***	-0.24***
Reminder	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Period	-0.038***	-0.04***	-0.025***	-0.02***	-0.02***	-0.014**	-0.005
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.42)
<i>log likelihood</i>	-1,373	-1,205	-1,067	-968	-888	-798	-712
<i>Number of observations</i>	3,798	3,608	3,419	3,229	3,039	2,849	2,659

NB: p-values into brackets

Finally, the learning effect, captured by the ‘period’ variable, becomes insignificant (p-value=0.42) if we exclude the first six periods, whereas the negative effect of the price reminder treatment on consumption remains significant at the 1% level with a corresponding estimate of approximately -0.24. The next subsection focuses on behavioral inattention to examine whether the effects of our price reminder treatment help participants increase their attention level.

3.3. Measures of behavioral inattention

Behavioral inattention has gained some interest in recent years, a milestone being DellaVigna [15]. The idea is straightforward: If a behavioral agent bears some cognitive costs to obtain some information about his complex environment or to determine what would be the optimal choice given constraints, there is room for price or quantity misperception⁵. Gabaix [16] conducted an extensive review of the behavioral inattention literature and proposed a formal theoretical framework compatible with the main behavioral deviations. In the particular case of deterministic action and attention, a behavioral agent maximizes his “attention-augmented decision utility” depending on the different attributes of his consumption bundle, each attribute being weighted by a parameter measuring the degree of attention, θ , that is, between 0 (no attention for the corresponding attribute) and 1 (full attention). Attribute variables may have default values, “the value that spontaneously comes to mind with no thinking”⁶. This implies that the value x_i of attribute i is subjectively perceived as:

$$x_i^s := \theta_i x_i + (1 - \theta_i) x_i^d \quad (4)$$

⁵ This is consistent with the framework used by, among others, Alcott and Kessler [9] or Brent and Ward [8] that distinguish an internality parameter (a factor that affects choice but not experienced utility, e.g., mistake in evaluation due to inattention) from the moral cost of choice (coming for instance from consumption comparison to peers).

⁶ Gabaix [16], p. 268.

where x_i^s is the subjective value of variable x_i , θ_i is the attention level regarding attribute i , and x_i^d is the default value for variable x_i .

In what follows, we measure inattention at the individual level by considering the quantity and then by using deviation from optimal choice to tackle price misperception. To give a formal microeconomic background to behavioral inattention, we follow DellaVigna [15] by considering the value of the bundle of goods for a behavioral agent (Gabaix [16]) as:

$$V = v + o \quad (5)$$

where v is the visible component and o the opaque component.

In our design, choosing a consumption level for q implies a composite-good consumption choice of an amount l . Assume that the opaque component relates only to the unit price p for q consumption (as in Sexton [36]) and that budget constraint is:

$$Y = l + \theta pq \quad (6)$$

where θ is the attention level (between 0 and 1), or equivalently, the ratio between perceived price \tilde{p} and actual price p , as $\tilde{p} = \theta p$.

Attention may be measured in two ways in this framework:

- (a) Either by considering some reference point of consumption that is revealed at the first consumption choice (default value, see 3.3.1),
- (b) Or by considering the difference between actual and optimal consumption choices due to price misperception (see 3.3.2).

3.3.1 Attention and default consumption level

Assume that a given participant is confused by all the information that is given during the instructions, especially the price information, and that the choice is, to use the expression by DellaVigna [15], *opaque* at the beginning of the experiment. The first choice and its deviation from the optimal choice is an indirect measure of this opacity. Moreover, as choice is repeated for 20 periods under the same economic environment, participants' information feedback about payoff given at the end of each period should increase the salience of the incentive structure. Then, as a consequence, if we consider only participants who do not get any information reminder, confusion should decrease over time, therefore attention should grow.

To measure attention level, we use equation (4) above by assuming that value q_i is the optimal consumption choice for a particular individual, i.e., q_i^* . For the default value, as we did not elicit any prior during the experiment, we conjecture that this prior value of consumption quantity might be captured by the first initial choice made by each participant. Therefore, our estimations are based on:

$$q_i^t = \theta_i q_i^* + (1 - \theta_i) q_i^1 \quad (7)$$

where q_i^t is the observed consumption choice for individual i at period t , q_i^* her optimal consumption choice (constant across t) and q_i^1 , the observed consumption choice in $t=1$.

To capture the attention level and its change across t , we consider only the observations where no price reminder occurred. Using a nonlinear least-squares estimation procedure to address the nonlinearity of parameters in equation (7), estimations about the attention parameter give the following results:

Table 8. Attention level estimates (no price reminder), all sessions

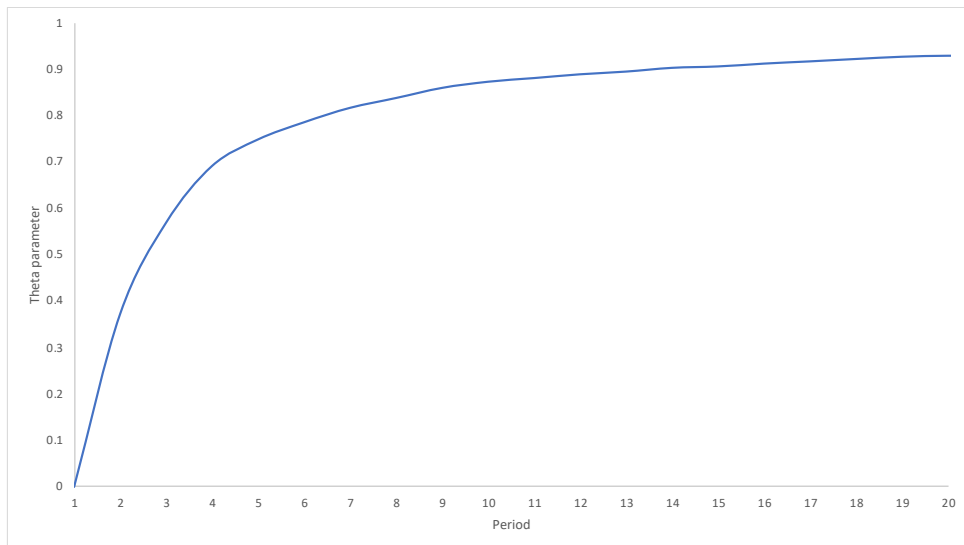
	Pooled data (no price reminder)	CBR tariff scheme	IBR tariff scheme
θ parameter	0.927***	0.828***	0.940***
p-values	(0.00)	(0.00)	(0.00)
Adj R ²	0.88	0.87	0.90
Number of obs.	2,400	960	1,440

NB: p-values into brackets

The results are consistent with summary statistics about relative deviations to optimal quantity choice described in Table 3. Indeed, the attention level is quite high (approximately 0.93 considering all data) and higher under the IBR tariff scheme than under the CBR tariff scheme.

An interesting feature to be observed is the evolution of attention with choice repetition, obtained with successive econometric regressions dropping each period, one by one. The following figure illustrates the pattern.

Figure 6: Evolution of the theta parameter through choice situation repetition



The figure above shows how theta evolves over repetition, first very quickly during the first periods as participants receive feedback about the difference between their actual payoff and the highest possible payoff for them. The convergence to almost perfect attention (i.e., a theta parameter higher than 0.9) is ensured after period 10.

3.3.2 Attention as price misperception

Following Sexton [36], we use equation (5) to define an individual's objective function as:

$$U(l, q) = l + \alpha V(q) \quad (8)$$

Where α is a taste parameter. Maximizing (8) subject to (6) gives:

$$V'(q) = \frac{\theta p}{\alpha} \quad (9)$$

Greater inattention reduces the right-hand side of equation (9), causing higher consumption of q at equilibrium as $V'(q)$ is positive and $V''(q) < 0$.

An inattentive individual perceives the budget constraint incorrectly and maximizes utility by considering a lower price, which would be consistent with a bundle (l^*, q^*) , infeasible. Having committed to consuming q^* , the individual can only consume $\hat{l} < l^*$, which yields less utility than the optimal bundle (l^{**}, q^{**}) chosen by a fully attentive individual.

Using equation (6), we can write:

$$Y = l + \theta pq \leftrightarrow \theta = \frac{Y - l}{pq} \quad (10)$$

Which amount of l should be used? If the actual one was used, the attention parameter would be equal to 1, and as actual consumption differs from optimal consumption, it is not possible. To follow Sexton's [36] theoretical model, if excess consumption would increase (denoting a decrease in attention level), the slope of the budget constraint that would figure a lower price tangential to the initial utility level would also decrease, which is precisely the effect of the inattention parameter (the perceived marginal price is lower than the actual price). As a consequence, we measure θ as:

$$\theta = \frac{Y - l^*}{pq} \quad (11)$$

where l^* is the amount of numeraire that would have been chosen for the optimal bundle.

Computing the value of attention parameters under each treatment gives the following aggregated results (see Table 9).

Table 9: Descriptive statistics for attention parameter Theta

Information Nudge Tarif Scheme	No Price Reminder	Price Reminder	Total
CBR	0.8666 (0.2408)	0.9035 (0.2100)	0.8846 (0.2266)
IBR	0.9347 (0.1980)	0.9365 (0.1881)	0.9356 (0.1931)
Total	0.9068 (0.2189)	0.9233 (0.1978)	0.9151 (0.2087)

NB: Standard deviation into brackets

These figures complement the previous estimates (Table 8) by comparing the level of attention during periods with and without price reminders. Corresponding results confirm that price reminder treatment improves the attention of the participants. To complete the analysis, we develop an econometric model to identify theta determinants. As our dependent variable attention has values between 0 and 1, we retain an estimation method based on a fractional probit model (Wooldridge [37], see Table 10).

Table 10: Attention level determinants, fractional probit model

Treatment variables	(a) attention as a deviation from optimal bundle
Tariff scheme (=1 for CBR)	-0.325*** (0.040)
Price Reminder (=1 if Yes)	0.104*** (0.040)
Period	0.0217** (0.036)
Constant	1.252*** (0.049)
N. obs	4,624
R squared	0.0231

NB: p-values into brackets

In the case of attention measured by deviation from the optimal consumption bundle, we identify the following determinants for the attention parameter. Attention is reduced in the CBR tariff scheme compared to the IBR scheme, which is the strongest effect (-0.325) and is increased when controlling for the existence of reminders (+0.104) and the possible learning effect (+0.0217). More precisely, facing a CBR tariff scheme reduces attention by 0.32 points. Moreover, the attention level is the highest under IBR with a price reminder, as observed in the table above. These results are in accordance with econometric analyses implemented to explain deviation from the optimum ratio and thus confirm that price reminder treatment works by improving the attention of participants, allowing them to better understand the pricing scheme, particularly when they face an IBR scheme.

4. Conclusion

In the public utilities domain (water, energy, transportation, etc.), numerous economists advocate for increasing monetary incentives for consumers of these facilities by implementing pricing structures where the marginal price is to increase with consumption. However, the implicit assumption is that consumers do not experience any pervasive difficulty in “thinking on the margin” (Rees-Jones and Taubinsky [4]).

In this study, we argue that these economic efficiency benefits should be compared to the possible cognitive costs of these complex tariff schemes for consumers. In particular, if attention is a scarce resource for consumers (Gabaix [16]), consumers might use heuristics to simplify the choice problem, potentially rendering them more inattentive to the marginal price signal. Finally, it will result in more costly deviations to the optimal consumption level for consumers.

Our experimental results show that when facing a complex tariff scheme of increasing unit price (like IBR), consumers' deviations to optimal consumption choice tend to decrease compared to the flat pricing scheme (CBR). On the one hand, the complexity of the increasing tariff scheme might trigger more errors for consumers, on the other hand, the greater saliency of the incentive effect makes consumers more attentive to the price signal compared to a simple scheme. Moreover, we also observe that a simple permanent price reminder might be of great help to make price signals more salient for consumers, as behavioral deviations are less frequent in the case of an increasing unit price scheme.

Our experimental results are also helpful in capturing inattention levels and their evolution over time for our participants. We observe that attention levels in our experiment are high, even if differences between experimental treatments clearly exist. In particular, assuming the first choice as an individual benchmark for attention level at the beginning of the choice sequence, we observe a concave evolution of attention level for subjects.

Our findings, therefore, have some important implications for public utilities management: To make progressive pricing efficient, consumers must fully understand the structure of the tariff schedule. For instance, describing the details of the tariff scheme on the bill is not sufficient to give consumers a clear perception of the marginal price, and a possible improvement could be to provide them with a permanent reminder of the marginal price when making decisions.

To go further, future research based on behavioral economics (lab or field) could provide more insight into the issues of the persistence of price information recall on essential good consumption – such as water and energy -- behavior. In addition, future experiments should also address the full incentives of tariffs, including the thresholds, and compare various tariff schemes and their effect on consumption, depending on the number of block rates and on their progressivity.

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APPENDIX – Instructions for IBR scheme with No Information Reminder + IBR with Information Reminder (translated from French)

Welcome,

Thanks for participating to this experimental session. If you make your choices carefully, you will be able to obtain a considerable amount of money, with the amount depending on your choices.

More precisely, during this experiment, you will have to make 40 choices during 40 periods, with 2 steps, each step being made of 20 periods. During each of these period choices, you will be able to obtain a certain amount of points. At the end of the session, the computer will randomly choose for each participant 2 period choices made during the first step and 2 period choice made during the second step. The computer will add all the points the participant gained during these 4 periods randomly chosen and will convert the total number of points in euros according to the following rate: 1 euro per 20 points.

Main principle of the experiment

During each period, you will have to choose a certain amount of goods to purchase given a personal endowment (in points, displayed on your computer screen in your personal choice computer interface) that you have and for a given unit price for this good. It is not possible to have expenditures that are higher than your personal endowment. The unit price of the good to purchase will be given in the following instructions for each step, and this price may change between the first and the second step. The more units you will buy, the more points you will gain. However, you will have to deduct from this gain the amount you should pay for these units + a certain amount of administrative charges.

Your net gain will be computed in the following way by the computer:

$$\text{Your net payoff} = \text{Gross Payoff} - \text{Administrative Charges} - \text{Total price for goods}$$

The total price for the goods purchased will simply be the number of units you bought multiplied by the unit price. For instance, if the unit price equals 1 and if you choose to buy 7 units, the computer will deduct 7 points (1*7) for the total price + a certain amount of administrative charges for buying 7 unit.

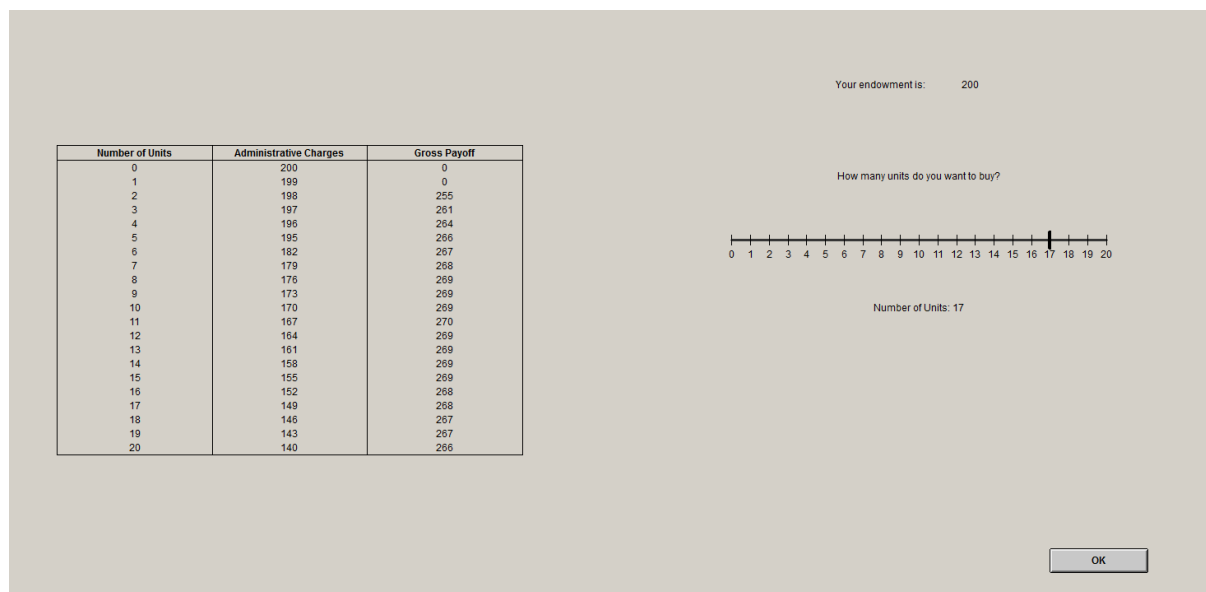
When you make your choice, the computer screen will display some information that will help you to compute your possible payoffs, namely, gains in points depending on the number of units you purchase and administrative charges.

The first step

This step will last 20 periods. During this first step, the unit price for the good will be 1 point per unit if you purchase strictly less than 6 units and 3 points per unit if you purchase 6 units or more (up to 20). Depending on the number of units you purchase, the gross gains and the administrative charges will stay the same for each period.

The computer interface for making your choice during the first step will be as follows:

Figure 8. Screen capture of Z-Tree + no price information recall (translated from French)



(Attention please! The figures that you see in this screen capture are not necessarily the same as the ones that will be displayed when you will actually have to choose.)

Here, choosing to purchase will consist of moving the cursor to a given number of units you want to purchase, from 0 to a maximum of 20 units. In the screen capture, this fictitious participant receives an endowment of 200 points. If he chooses to buy 10 units, as this number is higher than 6, the unit price equals 3. The purchasing price would be therefore $10 \times 3 = 30$ points. As a consequence, this participant would receive 269 points as her gross payoff and would be charged 170 points for administrative charges. Finally, her net payoff for purchasing 10 units would be computed as follows:

$$\text{Net payoff} = 269 - 170 - 30 = 69 \text{ points}$$

As a consequence, her net payoff in the first step would be the following:

$$\text{Net payoff} = \text{Gross Gain} - \text{Administrative Charges} - (1 \text{ point} \times \text{number of purchased units IF the number of purchased units is strictly less than 6})$$

OR

$Net\ payoff = Gross\ Gain - Administrative\ Charges - (3\ points \times number\ of\ purchased\ units)$ IF the number of purchased units is equal to or more than 6)

At the end of each period, the computer will display a screen that will recall your personal endowment, the number of units you chose to purchase, the amount of administrative charges for your purchase, the total purchasing price, your gross payoff and finally your net payoff.

These period choices will be repeated 20 times during this first step.

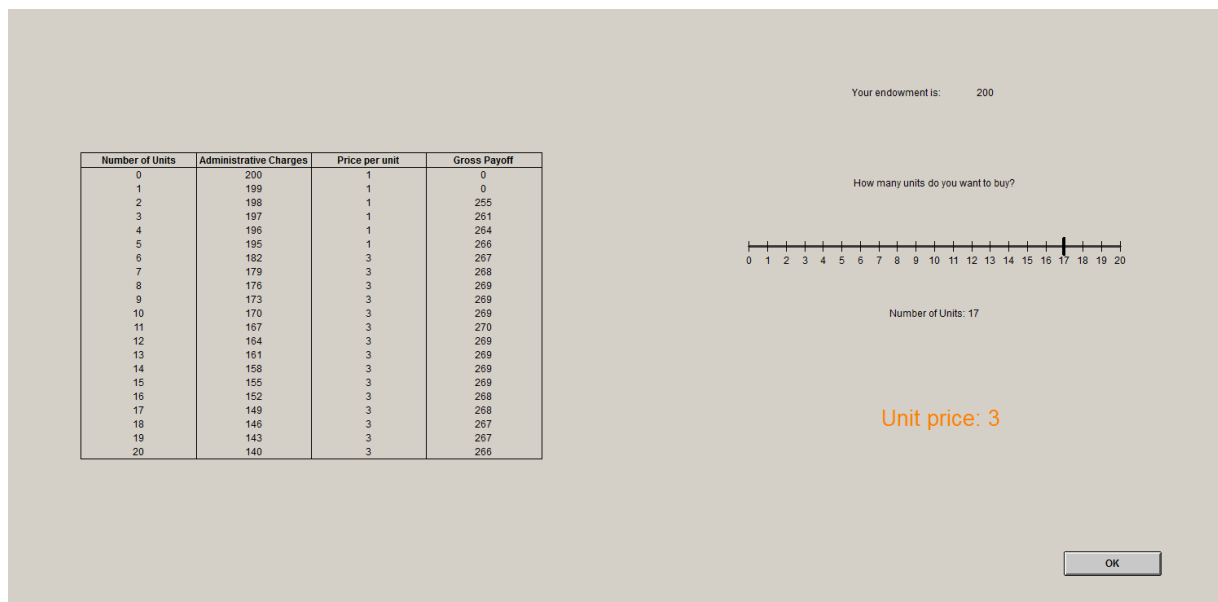
Second step

For this step, the unit price for the good will be 1 point per unit strictly less than 6 units and 3 points per unit if you purchase 6 units or more (up to 20). Depending on the number of units you may purchase, you will obtain, similar to the first step, gross payoffs and you will be charged administrative charges.

Gross gains and administrative charges during this second period will be the same as in the first period.

The computer interface for making your choice during the second step will be as follows:

Figure 9. Screen capture of Z-Tree + price information recall (translated from French)



(Attention please! The figures that you see in this screen capture are not necessarily the same as the ones that will be displayed when you will actually have to choose.)

Here, choosing to purchase will consist of moving the cursor to a given number of units you want to purchase, from 0 to a maximum of 20 units. *Differently from the first step, the unit price will be displayed on the screen below the cursor (here, as the number of units selected is 17, the unit price is recalled to be 3 points per unit).*

In the screen capture, this fictitious participant receives an endowment of 200 points. If she chooses to buy 10 units, as this number is strictly higher than 5, the unit price equals 3. The purchasing price would therefore be $10 \times 3 = 30$ points. As a consequence, this participant would receive 269 points as her gross payoff and would be charged 170 points in administrative charges. Finally, her net payoff for purchasing 10 units would be computed as follows:

$$\text{Net payoff} = 269 - 170 - 30 = 69 \text{ points}$$

As a consequence, her net payoff in the first step would be the following:

$$\text{Net payoff} = \text{Gross Gain} - \text{Administrative Charges} - (1 \text{ point} \times \text{number of purchased units IF the number of purchased units is strictly less than 6})$$

OR

$$\text{Net payoff} = \text{Gross Gain} - \text{Administrative Charges} - (3 \text{ points} \times \text{number of purchased units IF the number of purchased units is equal to or more than 6})$$

At the end of each period, the computer will display a screen that will recall your personal endowment, the number of units you chose to purchase, the amount of administrative charges for your purchase, the total purchasing price, your gross payoff and finally your net payoff.

These period choices will be repeated 20 times during this second step.

Your final payoff

When each participant completed the 40 period choices, the computer would randomly draw 4 periods for each participant as described earlier, and would display your total payoff both in points and in Euros.

Good luck!