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Temptation and Commitment in the Laboratory

Daniel Houser, Daniel Schunk, Joachim Winter and Erte Xiao

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Daniel Houser

George Mason University
dhouser@gmu.edu

Daniel Schunk

University of Zurich
dschunk@iew.uzh.ch

Joachim Winter

University of Munich
winter@lmu.de

Erte Xiao

Carnegie Mellon University
exiao@andrew.cmu.edu

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Abstract: Temptation and self-control in intertemporal choice environments are receiving increasing attention in the theoretical economics literature. Nevertheless, there remains a scarcity of empirical evidence from controlled environments informing behavior under repeated temptations. This is unfortunate in light of the fact that in many natural environments, the same temptation must be repeatedly resisted. This paper fills that gap by reporting data from a novel laboratory study of economic decisions under repeat temptations. Subjects are repeatedly offered an option with instantaneous benefit that also entails a substantial reduction to overall earnings. We show that this option is “tempting” in the sense that a substantial fraction of our subjects incur pecuniary costs to eliminate the choice, and thus commit to not choosing the tempting alternative. We compare the timing and price-elasticity of these commitment decisions to predictions from existing theoretical models of decision under temptation. Our data are broadly consistent with theory, with the notable exception that commitment often occurs with delay rather than at the first opportunity. Moreover, the timing of commitment is significantly impacted by the cost of the commitment device. The patterns we report have direct implications for economic theory, and are a first step toward designing mechanisms that promote prudent economic decisions under temptation.

Keywords: self-control; willpower; temptation; commitment; laboratory experiment

JEL classification: D11; C91

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1. Introduction

When temptation and immediate desires interfere with the attainment of long-term goals, the ability to resist them is a necessary skill. Very often, temptation appears not just once, but repeatedly. Thus, resisting repeated temptation requires repeated exercise of self-control. For example, saving money for the future requires consistently controlling the impulse to consume immediately. Common experience reveals that even one-time self-control is difficult, and, as a result, people frequently turn to external devices to assist them in resisting temptation. One common device is to intentionally exclude the tempting good from the choice set. Again, take saving for an example: each month, a person may be tempted to consume a larger fraction of his/her income than planned, but this temptation can be removed by committing to a saving plan.

The question of whether people delay their choice of commitment when facing repeated temptation is clearly of significant economic importance. Nevertheless, we are aware of no direct evidence on this issue. Our study investigates this question while taking into account the fact that using commitment devices can be costly. For example, a saving plan may involve a cost since it restricts adjustment of saving in reaction to shocks. How does the timing of commitment choices vary with either commitment costs or the relative benefit of resisting temptation? This paper informs these questions by reporting data from a novel laboratory study of economic decisions under repeat temptations.

How people make decisions under temptation has long been a topic of interest in both psychology and economics (e.g., Thaler and Shefrin, 1981; Tversky and Shafir, 1992; O'Donoghue and Rabin, 1999, 2000; Prelec, 1989; Benabou and Tirole, 2004; McClure, et al. 2004; Heidhues and Köszegi, 2009; Hare, et al., 2009). A large literature, going back to Strotz (1955), develops theoretical explanations for time-inconsistent decision-making (also see, Laibson, 1997, and the survey by Caillaud and Jullien, 2000). In the last decade, it has been shown that temptation can be modeled in a fully time-consistent manner (e.g., Gul and Pesendorfer, 2001, 2004, 2005; Miao, 2008). In addition, many have made efforts to formally model the role of commitment in environments with tempting goods (e.g., Noor, 2007; Ozdenoren, et al., 2008).

These and related theoretical developments are grounded in a broad empirical literature demonstrating that humans are affected by temptation and sometimes succumb to it (e.g., Mischel, et al., 1989; Hoch and Loewenstein, 1991; Ainslie, 1992; Loewenstein and Prelec, 1992; Baumeister, et al., 1994; Metcalfe and Mischel, 1999; Charness and Gneezy, 2009; see

also Bryan, et al., 2010, for a survey). Data from natural and field experiments provide evidence for the importance of temptation in real economic choices. For example, Della Vigna and Malmendier (2006) highlight that temptation preferences can lead people to pay not to go to the gym, while Houser, et al. (2008) take advantage of a natural experiment to demonstrate that “tempting” goods are more likely to be purchased from the checkout aisle when the wait-time is longer (see also Burger, et al., 2009, and Bucciol, et al., 2009, for results from field experiments on temptation with adults and children, respectively). Moreover, experiments in psychology provide evidence that cognitive load (often interpreted as reducing one’s ability to exercise “willpower”) leaves subjects more likely to choose tempting goods (e.g., Shiv and Fedorikin, 1999; Baumeister, et al., 1994; Baumeister and Vohs, 2003; Hinson et al., 2003; Dewitte, et al., 2005; Vohs and Faber, 2007).

Difficulties in exercising self-control motivate people to pursue alternative methods for resisting temptation. These commitment devices include restricting choices, for instance, by going to a restaurant with less tempting food (Wertenbroch, 1998), by using specific ordering strategies to pre-commit to watching “high-brow” movies (Read, et al., 1999), or committing to saving plans (Ashraf, et al., 2006; Benartzi and Thaler, 2004). People also increase the cost of succumbing to temptation (e.g. Gine, et al., 2009; Schelling, 1992; <http://www.stickk.com/>¹), distract themselves from temptation, or impose personal rules of conduct on themselves (see Baron, 2000; Elster, 2000, Ariely and Wertenbroch, 2002).

Given the vast empirical evidence on people’s difficulties to resist temptation and their willingness to use commitment devices, an important open question for economists is the extent to which the demand for commitment is price elastic. In particular, when temptation appears repeatedly, when do people succumb to temptations, when do they decide to adopt commitment devices, and how is the timing of their use affected by cost? While these questions can be difficult to investigate using a field experiment, we design a controlled laboratory environment where the cost of commitment and the cost of succumbing to a temptation can be manipulated exogenously and independently of each other. Thus, the controlled environment is specifically designed to allow us to discover systematic dynamic patterns in commitment choices under temptation that might otherwise be difficult to uncover using field data.

¹ This is a webpage launched by Ian Ayres and Dean Karlan. A participant signs a contract requiring him/her to donate a self-specified amount of money to charity if he/she fails to achieve a self-specified goal.

Participants in our laboratory environment are exposed to the same tempting stimulus multiple times. On each exposure, they can either: (i) succumb to the temptation; (ii) make a (perhaps costly) commitment decision that removes any future exposures to the temptation; or (iii) resist the temptation without choosing to commit, thus being exposed to it again in the future. We compare individual decision-making in randomized treatments in which the commitment device is either free or associated with a small cost.

Importantly, we structure our environment such that hyperbolic discounting models, and especially Fudenberg and Levine (2006), predict that a person will not change her decisions when the exposure to the tempting stimulus is repeated. For example, a person who resists temptation but does not make the possibly costly commitment decision (to remove the temptation from her choice set) should resist without commitment at the next exposure as well.

Our main finding is that the general patterns of behavior observed in our data are well in line with the predictions of the model introduced by Fudenberg and Levine (2006). But specific and important behavioral patterns related to the timing of commitment are not captured in existing theoretical models. In particular, a sizeable fraction of subjects in our data do change their decision with repeated exposure. After initially resisting without commitment, they either succumb or commit. We thus provide evidence that some subjects delay their commitment decisions when facing temptations². Furthermore, we show that under costly commitment, subjects are less likely to commit at the first opportunity. The fact that commitment costs matter both for commitment decisions as well as for the timing of commitment constitutes novel empirical evidence that commitment devices are (at least sometimes) normal goods.

Our findings stress the behavioral relevance of commitment costs, and may also provide convergent evidence that self-control (or willpower) is an “exhaustible resource” in the sense that it becomes more difficult over time (see, e.g., Hoch and Loewenstein, 1991; Shiv and Fedorikin, 1999; Baumeister, et al., 1994; Baumeister and Vohs, 2003; Hinson, et al., 2003; Dewitte, et al., 2005; Vohs and Faber, 2007). This study therefore highlights the value of adding features such as ego depletion to formal models of decisions in tempting environments (e.g., Ozdenoren, et al. 2008).

The remainder of this paper is organized as follows. Section 2 describes the design of our experiment. In Section 3, we use the framework of Fudenberg and Levine (2006) to derive

² Returning to the consumption example, people who find themselves increasingly in debt might initially delay the decision to eliminate their credit cards, but eventually experience a change of heart and do so.

hypotheses for the behavior of the subjects in our experiment. Sections 4 and 5 contain results and discussion, respectively. The last section of the paper is devoted to a summary, conclusions, and suggestions for future research.

2. Experiment design

The primary requirement of our design is a laboratory environment that contains a tempting good and the option to commit to not choosing this tempting good. Further, our design allows for the ability to manipulate exogenously both the commitment cost as well as the benefits of resisting temptation. Finally, in order to test directly specific predictions of hyperbolic discounting models (e.g., Fudenberg and Levine, 2006), it is necessary to observe subjects' decisions over a sequence of repeated temptation exposures. To implement these features, we use the context of a simple repeated counting task that is designed to be boring.

The counting task

In each repetition of the counting task, subjects are asked to count the number of ones in a series of nine digits, either zeros or ones, that are displayed on the computer screen for 15 seconds (see Figure A.1 for a screenshot). Counting tasks are displayed at random time intervals. Between counting tasks, subjects face an otherwise empty screen with a digital clock that displays the elapsed time of the experiment (see Figure A.2 for a screenshot).

The time between counting screens is either 1 minute, 2 minutes, or 3 minutes. To ensure that subjects focus their attention on the computer screen (and hence not get involved in other activities), they are informed that the lengths of these waiting periods are drawn randomly such that each of these time spells occurs, on average, equally often during the counting task (i.e., the waiting time can be considered as being drawn from a uniform distribution over the time spells).

At the beginning of each session, participants are informed that the experiment will last for 120 minutes and that they have to remain in the laboratory for the entire duration of the experiment. Then, the counting task and the random nature of the waiting periods between counting tasks are explained and participants are informed that they earn a maximum of \$15 in addition to their show-up fee if they provide the correct answer (i.e., the correct number of ones) in at least 70% of all counting tasks, and that they earn only \$3 in addition to their show-up fee if they provide less than 70% of correct responses. Their payoff is greatly increased if they perform

the counting task for the full two hours with an accuracy rate of 70% or greater.³ Hence, participants face a strong monetary incentive to perform the repetitive and boring counting task.

The tempting good and the temptation screen

In our experiment, the tempting good is the option to stop doing the counting task and obtain internet access. We refer to this temptation as “surfing the internet” in the sequel. The reason we chose this good is that we expected it to have positive utility for all subjects⁴: with internet access one can check e-mail, chat, visit social networks, read the news, or even study. This tempting good is offered to subjects during the two-hour counting task at random points in time. In this context, it is important to stress the following two details of our design. First, when subjects succumb to the temptation of surfing the internet, they lose the possibility of going back to the counting task during the entire remaining time of the experiment. Second, whenever subjects are offered the tempting good, they are simultaneously offered the option to commit to counting for the *entire* two hours. In particular, the use of this commitment device eliminates one’s ability to surf the internet during the *entire* remaining time of the experiment.

We operationalize temptation in our experiment by showing to the subjects an internet browser window, henceforth referred to as the “temptation screen” (for a screenshot see Figure A.3). This screen displays the payoff the subject has earned so far and offers her three choices represented by two buttons and a default option:

- *Continue*: Continue the counting task, having the chance to earn an additional payoff depending on their performance in the counting task, and keep the option to surf the internet.
- *Commit*: Continue the counting task, having the chance to earn an additional payoff depending on their performance in the counting task, but without being given the opportunity to surf the internet any more. Choosing this commitment option involves a cost that is taken from the subject’s total payoff.

³ None of our participants came close to violating this restriction, so it seems not to be binding. The reason we used this restriction is to make sure that subjects paid attention to the computer screen during the whole time of the experiment.

⁴ The utility of surfing the internet might vary between subjects, but such preference heterogeneity does not affect our revealed preference argument which, as detailed below, randomly assigns: (i) opportunity costs of surfing; and (ii) commitment costs.

- *Surf*: Surf the internet right away. This is the default if no other choice is made by the time the temptation screen disappears (after 120 or 60 seconds).⁵

Phases of the experiment

A key advantage of our environment is that it allows for a rich set of behaviors. Subjects can resist surfing the internet and then perform the counting task for the entire two hours. Alternatively, subjects can stop doing the counting task and succumb to the temptation of surfing the internet at various randomly determined points in time (which would imply strongly reduced monetary payoffs). Finally, subjects can choose to use the commitment device if they are worried that they may succumb to the surfing temptation at some point before the experiment ends. The timing of the set of possible behaviors, should they occur, is of particular interest. Our experiment design allows us to observe whether subjects change their decisions with repeated exposure to temptation.

One concern, however, is that subjects at the beginning of the experiment may not correctly anticipate how boring the counting task really is and how much disutility it provides. To avoid this, our design minimizes such “learning” as a potential explanation for changed decisions by dividing the experiment into three phases which every subject passes through in the same order. In the first phase, phase 0, subjects perform the counting task—as described above—for a full 30 minutes, and, importantly, no surf or commitment options are provided; in this “learning” phase subjects thus get a long exposure to the counting task. The subsequent two experimental phases 1 and 2 offer surf and commitment options at random points in time, with opportunity costs of surfing and commitment costs assigned randomly. By changing the payoff structure in these two phases, we are able to test the behavioral hypotheses developed in section 3. In all experimental conditions that we consider, payoffs are structured such that the total amount earned by a subject who performs the counting task successfully for the entire duration of the experiment—i.e., for all 3 phases—is \$15 (in addition to the show-up fee). This allows us to inform subjects at the beginning of phase 0 about the maximum amount they can earn without revealing to them that there will be separate phases within the experiment that involve additional decisions and different payoff structures.

⁵ When the temptation screen appears for the first time, it is shown for 120 seconds, to ensure that subjects had enough time to understand the text and the payoffs. The remaining temptation screens are only displayed for 60 seconds.

The time structure of the experiment is summarized in Table 1. Subjects are not informed about this time structure. Moreover, they are informed about the decisions they can make (in addition to the counting decisions) only at the temptation screens. We provide a description of the time structure here.

- *Phase 0* lasts for 30 minutes. In this phase, subjects are exposed to 15 counting tasks, with empty screens shown in between the counting tasks, as described to them at the beginning of the experiment.
- *Phase 1* lasts for 45 minutes (i.e., it starts at minute 31 and ends after minute 75). Subjects are exposed to another 12 counting tasks with empty screens appearing in between the counting tasks as described above. Additionally, in this phase there are six instances at which subjects are shown the temptation screen (described above). On this screen, subjects can choose whether they would like to continue performing the counting task, surf the internet, or use a commitment device that removes the opportunity to surf the internet for the remainder of the experiment.
- *Phase 2* lasts for another 45 minutes (i.e., it starts at minute 76 and ends after minute 120). As in phase 1, up to 12 counting tasks, separated by empty screens, are displayed. Additionally, subjects are shown the temptation screen at six instances. The temptation screen is identical with the temptation screen shown in phase 1, only the payoffs differ (see Tables 1 and 2).

**** Include table 1 here ****

When a subject enters a new phase, the payoff structure of the task changes according to the description in Tables 1 and 2; this enables us to test the behavioral hypotheses developed in section 3. This change in the payoff structure, of course, only concerns those subjects, who have not yet decided to surf the internet or use the commitment option. If a subject had already chosen to surf the internet at one of the temptation screens in the previous phase, she would have to continue surfing the internet for the entire remaining time of the experiment, without possibility to do the counting task or use the commitment option any more. Similarly, if a subject had already chosen the commitment option at one of the temptation screens in a previous phase, she would have be doing the counting task for the remaining time of the experiment, without any being shown the temptation screen any more.

Experiment Conditions

At the beginning of the experiment, each subject is randomly assigned to one of 12 experimental conditions, denoted by G1 through G12. The condition determines the values of three design parameters—commitment cost, P_1 , and P_2 —which in turn determine the payoff a subject can achieve conditional on her performance in the counting task and additional decisions made during the experiment. Subjects are not aware that there are multiple experiment conditions. The values of the design parameters are listed in Table 2.

**** Include table 2 here ****

Having multiple experiment conditions serves two purposes: First, they demonstrate that the observed behavior is robust to differences in the parameterization. Second, they demonstrate that the surfing option is really a temptation and that the subjects understand the structure of the task: Specifically, in conditions G2, G5, G8, and G11, subjects already receive the maximum payoff of \$15 if they successfully complete the counting tasks through phase 1. That is, in those conditions, all subjects for whom surfing has more utility than counting should stop counting at beginning of phase 2. Indeed, all subjects in these treatments did this.

Exit questionnaire, show-up fee, total payments, and sample

At the conclusion of the counting experiment, all subjects participated in a questionnaire study. The exit questionnaire collected basic demographic data as well as responses on three established psychometric instruments that have been shown to capture important dispositional differences in individual decision behavior. The most widely accepted taxonomy of personality traits is the Big Five (Costa and McCrae, 1988). We also use two established scales that are more targeted to the temptation problem that we study, the “consideration of future consequences” (CFC) scale (Strathman, et al., 1994), and the “need for cognition” (NFC) scale (Cacioppo and Petty, 1982). Descriptive statistics of these measures are contained in Table 3b. Subjects received an additional \$3 for the questionnaire task. All subjects also received a show-up fee of \$5. Thus, the maximum amount that a subject could earn (by performing the counting task for the entire two hours with more than 70% correct answers and filling in the questionnaire) was \$22. The entire amount was paid in cash at the end of the experiment.

The experiment was conducted in the experimental laboratory of the Interdisciplinary Center for Economic Science (ICES) at George Mason University. A total of 88 subjects participated in 8 sessions; the corresponding descriptive statistics are reported in Table 3a. The

number of subjects within sessions was kept small to minimize potential distractions by other subjects in the laboratory.

**** Include tables 3a and 3b here ****

3. Hypotheses

In this section, we connect decisions by subjects in our experiment to a theory of decision under temptation suggested by Fudenberg and Levine (2006, henceforth FL). Our goal is to motivate our hypotheses, and our brief outline of FL below is sufficient for this purpose.

FL developed a dual-self model. There is a single patient long-run self along with a sequence of myopic short-run selves. The long and short-run selves share the same preferences over stage outcomes, but differ in how they view the future. In particular, the short-run selves are perfectly myopic in the sense that they care only about stage-game outcomes.

FL model multi-period games, with each period consisting of two phases. In the first phase of each period, the long-run self can exert self-control to affect the preferences (thus choices) of the short-run self. Exerting self-control is costly for both parties. In the second phase, after preferences have been chosen, the short-run player makes the period's final decision. In FL's framework: (i) the long-run self cannot pre-commit for the entire dynamic game, but instead begins each new period needing to make a (costly) self-control decision; and (ii) the long-run self has the same stage-game preferences as the short-run selves, and so wishes to serve the interests of future short-run selves.

To connect this to our environment, note first that our game includes a finite number of periods, where each period includes either a "counting" task or a "temptation" task, but not both. Players do not know the number or distribution over periods of the two tasks. It is important to emphasize that players are aware that the number of periods is finite, that the duration of the experiment is two hours, and that a clock on their computer screen makes them aware of the amount of time that has passed. Recall at this point that all subjects have already been exposed to the 30-minute phase 0 consisting of repeated counting tasks before they see the first temptation screen and that all subjects have experience with surfing the internet. Hence, subjects know what utility they would get from counting, or from surfing. Players also know that if they finish all of the counting (with some easy-to-obtain level of accuracy), they earn $W_H > 0$ at the end of the

experiment, but if they choose instead to enjoy the internet, they earn $W_L < W_H$. Players evaluate payoffs according to the strictly monotonically increasing and concave utility function $U(\cdot)$.

Participating in the counting task is the only alternative during a “counting” period. Denote the utility of counting in period t by $U(\text{count}_t)$. Without loss of generality, assume $U(\text{count}_t) = 0$ for all t .

Players have several choices during a “temptation” period. The temptation screen informs them that they may: (i) stop counting and surf the internet for the duration of the experiment; (ii) pay a one-time non-negative amount to make a commitment to count for the duration of the experiment; or (iii) continue counting without committing. Players’ decisions during a temptation period are modeled as follows.

Following FL, the short-run self evaluates the temptation period perfectly myopically. It considers only the period utility of surfing the internet, in comparison to the period utility of deciding to count in the future (which they will not experience). Denote the utility of surfing in period t as $V_t(\text{surf})$. Because the utility of counting is zero, the short-run player will prefer to surf whenever $V_t(\text{surf}) > 0$. If surfing carries negative utility (is less enjoyable than counting), the short-run player is indifferent between continuing and committing when commitment cost is zero, and otherwise strictly prefers to continue without cost.

Still following FL, the long-run self uses all short-run selves’ period-utilities to evaluate decisions in this game. In any period t , the long-run value to finishing the counting task is equal to $U(W_H)$, the amount earned by the period t short-run player, plus $\tau(t)U(\text{count})$, where $\tau(t)$ is the number of counting periods a subject believes remain in the experiment at period t . However, because of the normalization $U(\text{count})=0$, the expectation term can be dropped and the long-run value of finishing the counting task reduces to $U(W_H)$. The long-run value of surfing is $U(W_L) + V_t(\text{surf})$, where $V_t(\text{surf})$ is the expected value of surfing from period t to the end of the experiment.

Thus, the long-run self compares $U(W_H)$ to $U(W_L) + V_t(\text{surf})$. If the value of surfing exceeds $U(W_H)$, then the long-run and short-run selves have aligned interests and the subject chooses to surf. However, if $U(W_H) > U(W_L) + V_t(\text{surf})$ then the long-run and short-run selves prefer different alternatives, and the long-run self might exercise self-control, at some utility

(psychic) cost $C \geq 0$, in order to ensure that the short-run player does not surf. In particular, FL assumes that by exercising self-control, the long-run self can change the short-run self's choice set, in our case to ensure that surfing is viewed as less attractive than counting, so that $V_t(\text{surf}) < 0$.⁶ The long-run self is willing to use self-control if $U(W_H) - C \geq U(W_L) + V_t(\text{surf})$.

During a temptation period, the long-run self might also prefer to commit. Let $\tau'(t)$ denote the expected remaining number of temptation screens in period t . Because self-control must be exercised at each temptation screen, and assuming additive separability and no time-discounting, the expected utility cost of exercising self-control each time it is necessary to do so throughout the remainder of the experiment is $\tau'(t)C$. Thus, the long-run self is willing to choose commitment preferences for the short-run self whenever one of the two following conditions hold:

$$U(W_H - P) - C \geq U(W_H) - \tau'(t)C \geq U(W_L) + V_t(\text{surf}) \quad (1)$$

or

$$U(W_H - P) - C \geq U(W_L) + V_t(\text{surf}) \geq U(W_H) - \tau'(t)C \quad (2)$$

where $P \geq 0$ is the pecuniary price of the commitment device. People who satisfy (1) will count without surfing if the cost of commitment is sufficiently high, while people with preferences satisfying (2) will surf if the cost of commitment is sufficiently high.

Finally, in order to obtain a precise hypotheses, let us assume that the expected number of remaining temptation screens decreases (at an arbitrarily small but positive rate) as the experiment proceeds, so that $\tau'(t)$ is strictly monotonically decreasing in t . Similarly, let us assume that $V_t(\text{surf})$ is strictly monotonically decreasing in t , meaning that surfing for a shorter amount of time is less valuable (by some arbitrarily small amount) than surfing for a longer amount of time.

We are now in a position to state our main hypotheses.

Hypothesis 0: Surfing is a tempting good for at least some people.

While we cannot observe individuals' preferences, evidence in support of this hypothesis can be obtained from commitment behavior. In particular, it follows from (1) that any person who pays a strictly positive price P to commit has preferences that satisfy:

⁶ This is an application of assumption 2 in FL.

$$U(W_H) - C > U(W_H - P) - C \geq U(W_L) + V_t(\text{surf})$$

and thus, by definition, surfing is a tempting good for such a person.

Hypothesis 1: If one prefers to commit, commitment occurs at the first opportunity.

To see this, suppose a person does not commit at period t . Then from (1) and the fact that $\tau'(t)$ is strictly decreasing we have:

$$U(W_H - P) - C \leq U(W_H) - \tau'(t)C < U(W_H) - \tau'(t+1)C$$

Thus, commitment cannot be preferred in period $t+1$ if it was not chosen in period t . A similar argument can be made from (2).

Hypothesis 2: If one prefers surfing over counting, surfing occurs at the first opportunity.

This follows by reasoning exactly analogous to that above, and our assumption that $V_t(\text{surf})$ is strictly decreasing in t .

Hypothesis 3: The frequency of commitment (weakly) monotonically decreases as its price increases:

$$U(W_H - P) - C \geq U(W_H) - \tau'(t)C \geq U(W_L) + V_t(\text{surf})$$

This simple comparative static follows directly from (1) or (2). If people are heterogeneous with respect to their utility function, and in light of our assumption that utility is strictly increasing in its arguments, the fraction of the population for whom (1) or (2) is satisfied decreases monotonically as P increases. Of course, from Hypothesis 1, those who do commit will do so at the first opportunity.

Hypothesis 4: The number of people who choose to surf will not decrease as commitment costs increase.

It is easy to see that commitment costs can only affect surfing behavior when the following holds. Let commitment costs be ordered according to $P < P'$. Then,

$$U(W_H - P) - C \geq U(W_L) + V_t(\text{surf}) > U(W_H) - \tau'(t)C$$

$$U(W_H - P') - C < U(W_L) + V_t(\text{surf})$$

Subjects with such preferences avoid surfing by committing, because the cost to them of expending willpower is very high. However, when commitment becomes sufficiently expensive, it is no longer an attractive option, and the subject surfs.

Note that the “temptation” screen could be perceived as an annoyance people will pay to remove. In contrast with Hypothesis 1, this would suggest that commitment decisions should monotonically increase with the number of exposures to the temptation screen. It turns out that commitment decisions do not increase over time, and thus “annoyance” does not seem to be a reasonable explanation for our data.

Hypothesis 5: The number of people who choose to commit will not decrease as the value of finishing the task (W_H) increases.

To see this, first let $W_H^1 < W_H^2$. Because $U(\cdot)$ is strictly concave, we have $U(W_H^2 - P) - U(W_H^1 - P) > U(W_H^2) - U(W_H^1)$. Consequently, it is easy to verify that if commitment is chosen under W_H^1 — that is, if given all else, (1) or (2) above hold under W_H^1 — then commitment must also be chosen ((1) or (2) must also hold) under the higher value W_H^2 . Moreover, it is easy to see that there can be cases where neither (1) nor (2) will hold under the lower completion value W_H^1 , but they will hold under a higher value W_H^2 . For example, inequality (1) can hold under W_H^2 , and yet the first two terms can be reversed under the smaller value W_H^1 .

4. Results

In order to structure the discussion of our results, we classify subjects according to seven stylized behavioral types. We should point out that these stylized behaviors arise naturally given the structure of our experiment, so this is not an *ad hoc* classification of behavioral types. The key question that guides our first analysis is whether our treatments had a significant effect on the distribution of these seven behavioral types. We then return to the hypothesis discussed in the previous section.

Table 4 shows that upon seeing the temptation screen for the first time, 12.5% of the subjects started to surf (*type 1*) while 20.5% used the commitment device (*type 2*). Together, 33% of the subjects made one of these two decisions at the first temptation screen. The next two lines of the table refer to subjects who used the commitment device (*type 3*, 13.6% of all

subjects) or started to surf (*type 4*, 19.3%) later during phase 1 at one of the temptation screens 2 through 6. The fourth and fifth lines of the table list the subjects who used the commitment device in phase 2 (*type 5*, 2.3%), and the subjects (*type 6*, 11.4%) who started to surf in phase 2. These two groups are small, indicating that only a very minor fraction of decisions were made in phase 2. The remaining 18 subjects (*type 7*, 20.5%) never used a commitment device and resisted the temptation of surfing at all screens. For these subjects, utility from counting was not so low relative to that of surfing the internet to justify the lower payoff at the end of the experiment.

** Include table 4 here **

Table 4 also contains the test statistics and p -values for χ^2 -tests for the effects of the randomly assigned treatments on the distribution of stylized behaviors. There are statistically significant differences for the contrast between zero vs. positive commitment cost ($p=0.024$) and for the size of the additional payoff for counting to the end of phase 1 ($p=0.042$). Even if we only look at phase 2, we see that for the small sample of subjects who were still counting, there is also a significant effect ($p<0.000$) of the additional payoff for counting to the end of phase 2. From the findings in table 4, we conclude that our treatment manipulations have significant effects on the behavior of the subjects. In particular, an increase in commitment costs decreases the frequency of commitment, while an increase in the value of using the commitment device (i.e., an increase in W_1) strongly increases the frequency of commitment. Thus, even small modifications to the decision environment have a fundamental impact on observed behavior.

Since the vast majority of the decisions are made in phase 1 of the experiment, we now analyze the behavior in this first phase in more detail. Figure 1 shows, by the temptation screen, the *shares* of subjects that decided to commit or surf, respectively, during phase 1 of the experiment. Figure 2 shows, by the temptation screen, the *hazard rates* of subjects who committed and began surfing, respectively. Both figures are stratified by commitment cost (C) and the value of counting (WI). These figures already convey the five key findings that emerge from our data.

First, the two top panels of Figures 1 and 2 show that a substantial fraction of subjects paid the commitment costs and hence were willing to pay to remove the surfing option from their choice set. This confirms hypothesis 0. Second, the majority of commitment decisions were taken at the first opportunity (in temptation screen 1); the increase in the share of commitment on screens 2 to 6 is only minor, compared to the large fraction of commitment decisions at screen 1. This result generally confirms Hypothesis 1. Third, surfing decisions are also mostly taken at the

first opportunity, thus confirming Hypothesis 2. However, figures 2 and 3 further indicate that a certain fraction of subjects does not behave consistently with the model outlined in section 3. The reason is that those subjects' commitment and surfing decisions were made at later temptation screens—an important observation which we will address in more detail later in the paper. Fourth, in agreement with Hypothesis 3, we observe that the frequency of commitment decreases with an increase in commitment cost. Finally, we observe that the fraction of people who choose to surf decreases with an increase in commitment cost. This effect, however, is very weak, and we will later see that it is not statistically significant, making it consistent with Hypothesis 4.

** Include figure 1 here **

** Include figure 2 here **

In Table 5, we present results from six multivariate Probit regressions that corroborate all our findings above. They include as independent variables a set of dummies for the randomly assigned treatments, as well as controls for the socio-demographic and psychometric characteristics of the subject. The dependent variables are binary and capture the decisions to surf and commit at three different points in the experiment: (i) At the first temptation screen; (ii) at one of the other five temptation screens in phase 1; and (iii) by the end of the experiment (i.e., after Phase 2). Personal characteristics are represented by dummy variables for being female, being older than 20 years, and for the major subject (natural sciences, economics or business, and social sciences, with reference category “other”). Psychometric scores have been computed from the responses to the exit questionnaires: (i) consideration for future consequences (CFC); (ii) need for cognition (NFC); and (iii) the five personality dimensions of extraversion, agreeableness, conscientiousness, neuroticism, and openness. All psychometric scores have been standardized. The table reports marginal effects, so that the coefficients of the psychological scores can be interpreted as the effect of a change by one standard deviation on the probability of the binary outcome, measured in percentage points. The personal characteristics are all expressed as dummy variables, so that their coefficients correspond to the effect of a change of the dummy from zero to one, again expressed in percentage points. Finally, the commitment cost and value variables are expressed in dollars, so their coefficients measure the percentage-point effect of a one-unit change.

The first row in Table 5 shows that the commitment cost dummy is statistically significant in two regressions with committing as the dependent variable. Commitment is less

likely when there are positive costs associated with it. The impact is sizeable; changing commitment costs from zero to one dollar reduces the probability of *committing* by about 27 percentage points. Commitment costs are not statistically significant predictors at the first temptation screen. This could be due to our relatively small sample. In the other three regressions, commitment costs have no significant effect on the likelihood of *succumbing to temptation*; this is what we would expect since the wish to surf rather than count depends on subjects' preferences but not on whether commitment is costly or not. The regression results with respect to commitment costs are thus in line with hypotheses 3 and 4, derived in section 3, confirming the predictions of the FL-model.

** Include table 5 here **

Interestingly, the remaining value of counting (*additional payoff for counting to end*) is a powerful and statistically significant predictor of the decision of whether to commit in all six regressions. This is consistent with our Hypothesis 5 as derived from the FL-model. The higher the remaining value of resisting the temptation, the more subjects are likely to commit. Importantly, our results emphasize that even very mild environmental modifications—such as small changes in commitment cost—can have strong effects on behavior in tempting situations.

The experimental manipulations of the decision environment seem to have a stronger explanatory power for behavior than the personality characteristics and the dispositional personality measures that we have included in our analyses. This result changes little when we look at the coefficients of the probit regressions rather than the marginal effects. One might argue that this finding is due to our small sample size. Nevertheless, even with this small sample, we do find significant effects on commitment decisions of the economic incentive variables (commitment costs and value of resisting the temptation).

5. Discussion

We begin by discussing subjects' behavior at the first temptation screen as opposed to behavior at later screens. Note that at the first temptation screen, subjects have already been exposed to the counting task for 30 minutes; hence, they know their benefit from counting (i.e., their opportunity cost) and their benefit from surfing the internet. Consequently, surfing at the first occasion is a rational decision and does not necessarily provide any information on temptation preferences. Some subjects may just prefer surfing over counting even though this means a

substantially lower payoff at the end of the experiment. Nevertheless, the decision to commit is informative, especially when there is a positive commitment cost. Indeed, when it is fully free, 26.1% of subjects choose to eliminate the surfing option at the first opportunity. The fraction of commitment decisions made at the first opportunity, however, decreases to 14.3% when a small cost (\$1) is present.

While the general behavioral patterns observed in our data are well in line with the Fudenberg and Levine (2006) model, the choices related to the *timing* of commitment and succumbing to temptation cannot be captured by existing economic models. We see from Table 5 and that a considerable fraction of people deliberately delay commitment decisions as well as the decision to surf the internet. Figures 1 and 2 provide further details on the patterns of delayed decisions and reveals that they are not strongly affected by the level of commitment costs. In this context, it is also interesting to note that although the cost of commitment significantly decreases the demand for commitment, such cost does not seem to affect the number of subjects who finish the task and earn the maximum amount. This suggests that when commitment is free, subjects prefer to use commitment instead of expending their willpower, which is psychologically costly. However, when the commitment has a monetary cost, these subjects will choose to exercise willpower to save \$1. In both cases, however, they are able to resist temptation and increase earnings.

It is worth emphasizing that subjects were engaged in the experiment for 30 minutes prior to making a decision under temptation, so it seems implausible that the decision to delay commitment (or succumb to temptation) could be explained by “learning” about the nature of the experiment’s (counting) task. On the other hand, from repeated exposure to temptation one might be able to “learn” about one’s own psychic cost to resisting temptation. If so, then in the face of costly commitment it might be optimal to experience multiple temptations, thus informing whether one should incur the pecuniary commitment cost⁷. This reasoning cannot, however, explain the 18% of decisions to delay zero-cost commitment, and neither can it explain delays in the decision to surf. Moreover, it is worth noting that a simple error-rate explanation for our data cannot account for the substantial differences we find between frequencies of delayed decisions to surf and commit.

Finally, note that we are able, based on data from our exit questionnaire, to relate the behavior observed in the experiment to dispositional characteristics of the subjects, thus

⁷ We thank David Levine for this observation.

shedding light on psychological determinants of behavior in tempting situations. This is important for two reasons. First, the theoretical analysis study of behavior in tempting situations has been strongly inspired by psychology research (see e.g. Bryan, et al., 2010). Second, the knowledge of who (e.g., the naïve or the sophisticated) takes up commitment devices would take us a step closer to being able to assess welfare implications associated with making commitment devices available. Table 4 shows two findings in this respect.

First, we observe that most dispositional measures are not associated with behavior in the experiment. However, the CFC score, a measure for the extent of forward-looking behavior, is significantly related to the surfing decision: The more forward-looking the subject, as measured by this scale, the less likely they are to succumb to the temptation of surfing. It thus seems that the CFC score is able to predict whether a person will succumb to temptations. This instrument has already proven valuable in studies on tobacco and alcohol usage (Strathman, et al., 1994), aggression (Joireman, et al., 2003), and health behaviors (Ouellette, et al., 2005). We speculate that the short CFC instrument could also be valuable in classifying types of people in natural choice situations, i.e, saving and retirement decisions. Doing so could prove useful in tailoring individual-specific interventions to promote prudent economic decision-making.

Second, we observe that the environmental variables—commitment cost and remaining payoff from surfing—seem to override the behavioral variance explained by the dispositional type measures, despite being small in monetary magnitude. For example, an increase in commitment costs by only 1 dollar reduces the likelihood of having used the commitment device by the end of the experiment by 27 percentage points. In contrast, variations of the psychometric scales by one standard deviation do not predict changes in decisions to surf or commit.

We can conclude that individual personality types do not explain decision heterogeneity in tempting situations, while salient features of the decision environment, particularly commitment cost and the compensation for resisting a temptation, are relevant. These economic incentives are clearly important for modeling behavior in tempting environments. Nevertheless, other individual characteristics, e.g., cognitive skills, might help to explain commitment behavior and should be explored in future studies.

6. Conclusion

In this paper, we presented results from a novel laboratory experimental design involving repeated temptations: Subjects were paid to pursue a boring counting task, and tempted by the alternative to forgo their wage for counting and instead surf the internet. Subjects were also offered the option to commit to counting by choosing to remove the tempting option to surf. Our findings are broadly consistent with predictions derived from a model of decisions under temptation (Fudenberg and Levine, 2006), and they shed light on the determinants of individual behavior in tempting situations. In particular, we first show that the opportunity cost of succumbing to temptation has an economically and statistically significant positive impact on the decision to commit. Next we show that the willingness to commit is sensitive to even small changes in its cost. Both factors play an important role in Fudenberg and Levine's (2006) model.

However, while consistent in broad brushstroke, we discovered that for a sizeable fraction of the subjects in our experiment, the dynamics of decision-making departed in important ways from theoretical predictions and also interacted with the commitment costs. Specifically, some of our subjects delayed their commitment decisions when facing repeated temptations. In future research, we plan to further investigate the determinants of the dynamics of commitment decisions, with special emphasis on whether decision heterogeneity in this respect might be explained by individual "traits," including gender. The laboratory tool developed in this paper can facilitate these and other related studies of decision under temptation. As a result, it will help develop theory that can handle environments involving repeated temptations, which are so common in our everyday life.

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Table 1: Phases of the experiment and design parameters characterizing each phase.

Phase	Duration	Number of counting tasks	Number of temptation screens	Commitment cost [in \$]	Final payoff if surfing [in \$]	Additional payoff for counting to end of experiment [in \$]
0	30 min	15	0			
1	45 min	12	6	C	P_1	$W_1 = 15 - P_1$
2	45 min	12	6	C	P_2	$W_2 = 15 - P_2$

Note: C , P_1 , and P_2 are design parameters whose values are randomly assigned to the 12 experimental conditions. In all experimental conditions, the total payoff for subjects who count until the end of the experiment is \$15 (less any commitment cost).

Table 2: Experimental design: values of design parameters by experimental condition

Experimental condition G	Commitment cost (C)	Payoff if surfing in phase 1 (P_1)	Payoff if surfing in phase 2 (P_2)	N
1	\$ 0	\$ 10	\$ 10	8
2	\$ 0	\$ 10	\$ 15	8
3	\$ 0	\$ 8	\$ 12	8
4	\$ 1	\$ 10	\$ 10	8
5	\$ 1	\$ 10	\$ 15	8
6	\$ 1	\$ 8	\$ 12	8
7	\$ 0	\$ 8	\$ 10	9
8	\$ 0	\$ 8	\$ 15	6
9	\$ 0	\$ 10	\$ 12	5
10	\$ 1	\$ 8	\$ 10	3
11	\$ 1	\$ 8	\$ 15	8
12	\$ 1	\$ 10	\$ 12	9

Note: The total number of subjects is 88.

Table 3a: Descriptive statistics on subjects' characteristics

Variable	Value	<i>N</i>	%
Age	18–20	52	59.1
	21–29	36	40.9
Sex	Male	51	58.0
	Female	37	42.0
Major subject	Economics or business	31	35.2
	Natural sciences or mathematics	15	17.1
	Social sciences	33	37.5
	Other	9	10.2

Note: The total number of subjects is 88.

Table 3b: Descriptive statistics on psychometric scores

Scale	Mean	St. dev.	Min	Median	Max
Consideration for future consequences	0.69	0.14	0.33	0.70	0.95
Need for cognition	0.70	0.14	0.24	0.72	0.98
Machiavelli scale	0.56	0.10	0.26	0.56	0.87
Big 5 extraversion	0.61	0.20	0.21	0.64	1.00
Big 5 agreeableness	0.67	0.15	0.29	0.64	1.00
Big 5 conscientiousness	0.74	0.19	0.21	0.79	1.00
Big 5 neuroticism	0.69	0.21	0.14	0.71	1.00
Big 5 openness	0.79	0.16	0.29	0.79	1.00

Note: The total number of subjects is 88.

Table 4: Stylized behaviors, overall and by values of treatment variables

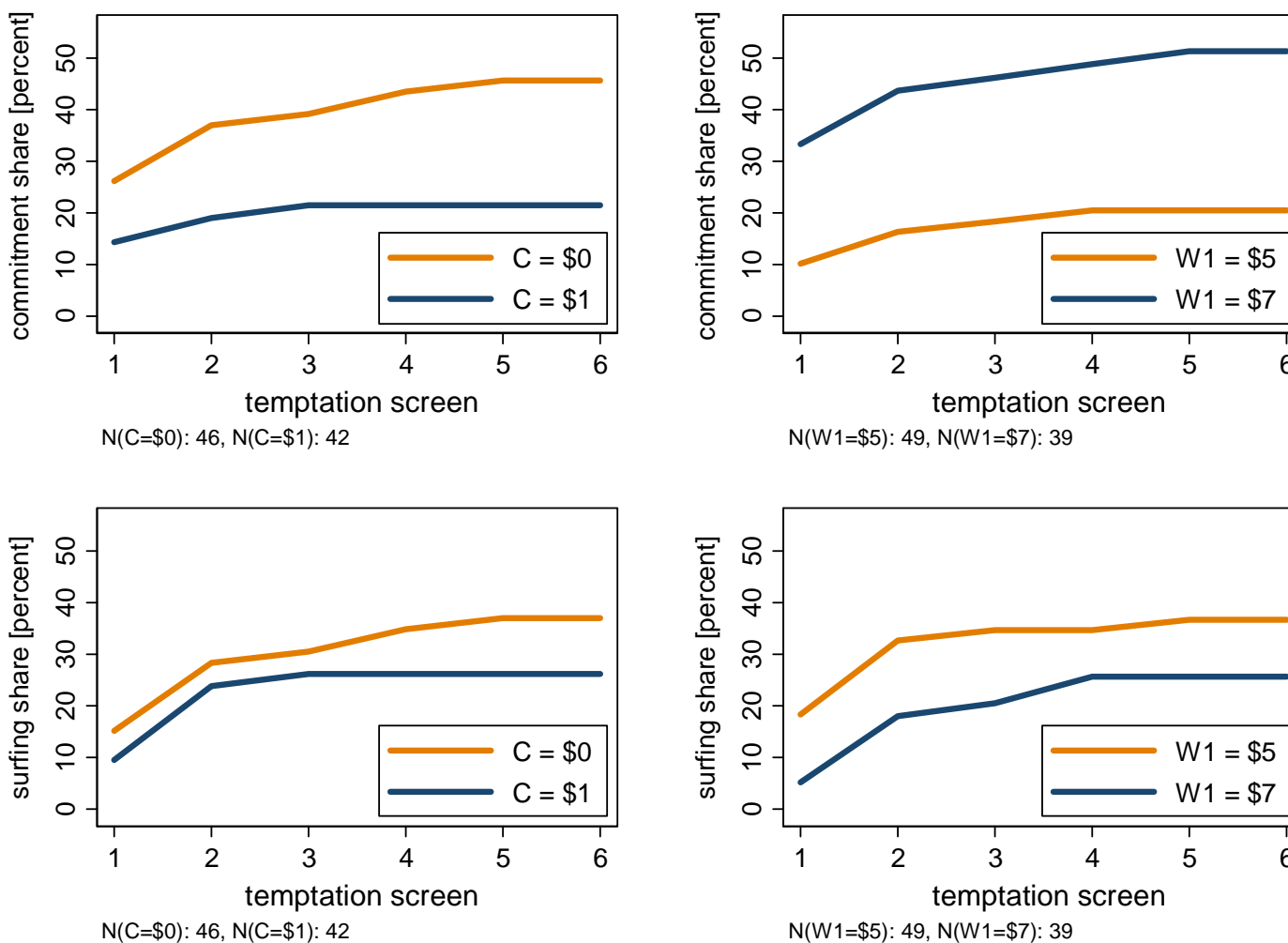
				Commitment cost (C)				Additional payoff in phase 1 (W ₁) for counting to end of experiment				Additional payoff in phase 2 (W ₂) for counting to end of experiment					
				\$ 0		\$ 1		\$ 5		\$ 7		\$ 0		\$ 3		\$ 5	
Type	Stylized behavior	N	%	N	%	N	%	N	%	N	%	N	%	N	%		
1	Used commitment device at first temptation screen	18	20.5	12	26.1	6	14.3	5	10.2	13	33.3						
2	Succumbed to temptation at first temptation screen	11	12.5	7	15.2	4	9.5	9	18.4	2	5.1						
3	Used commitment device at later screen in phase 1	12	13.6	9	19.6	3	7.1	5	10.2	7	18.0						
4	Succumbed to temptation at later screen in phase 1	17	19.3	10	21.7	7	16.7	9	18.4	8	20.5						
5	Used commitment device in phase 2	2	2.3	1	2.2	1	2.4	1	2.0	1	2.6	0	0.0	1	7.1		
6	Succumbed to temptation in phase 2	10	11.4	4	8.7	6	14.3	8	16.3	2	5.1	8	100.0	1	7.1		
7	Never used commitment device and resisted the temptation at all screens	18	20.5	3	6.5	15	35.7	12	24.5	6	15.4	0	0.0	12	85.7		
Column total		88		46		42		49		39		8		14		8	
Test for independence of columns				$\chi^2(6) = 14.6, p = 0.024$				$\chi^2(6) = 13.0, p = 0.042$				$\chi^2(4) = 22.2, p < 0.000$					

Table 5: Probit regressions of the decision to surf or commit

	Surfing 1 st screen	Surfing screens 2-6	Surfing at end	Committed 1 st screen	Committed screen 2-6	Committed at end
Commitment cost (C)	-0.0370 (0.0272)	-0.111 (0.102)	-0.0758 (0.113)	-0.0899 (0.0672)	-0.265** (0.104)	-0.273** (0.110)
Additional payoff for counting to end (W_1)	-0.0514 (0.0345)	-0.0947 (0.0584)	-0.161** (0.0654)	0.165*** (0.0405)	0.241*** (0.0668)	0.263*** (0.0670)
Additional payoff for counting to end (W_2)			-0.0249 (0.0309)			-0.0261 (0.0284)
Female	-0.0201 (0.0193)	-0.174 (0.115)	-0.265** (0.126)	0.120 (0.0864)	0.161 (0.125)	0.288** (0.132)
Age: older than 20	0.0677 (0.0432)	0.158 (0.103)	0.0202 (0.117)	-0.106 (0.0660)	-0.122 (0.108)	-0.0464 (0.111)
Natural sciences	-0.0291 (0.0210)	-0.219 (0.139)	-0.0307 (0.202)	-0.0994 (0.0756)	-0.0873 (0.190)	-0.204 (0.159)
Economics or business	-0.0428 (0.0351)	-0.161 (0.159)	0.101 (0.188)	-0.0694 (0.103)	0.170 (0.209)	0.113 (0.202)
Social sciences	-0.0933* (0.0533)	-0.0323 (0.173)	0.0951 (0.187)	0.0798 (0.128)	0.273 (0.205)	0.134 (0.201)
“Consideration future consequences” score	-0.0217 (0.0147)	-0.148** (0.0618)	-0.105 (0.0680)	0.0345 (0.0331)	0.0714 (0.0586)	0.0730 (0.0600)
“Need for cognition” score	0.00330 (0.00834)	-0.00288 (0.0599)	-0.0522 (0.0713)	-0.00989 (0.0408)	0.0182 (0.0691)	0.0228 (0.0707)
Big 5 extraversion	0.0142 (0.0122)	-0.0292 (0.0575)	0.0296 (0.0635)	-0.111*** (0.0407)	-0.0585 (0.0598)	-0.0896 (0.0624)
Big 5 agreeableness	-0.000318 (0.00744)	0.00802 (0.0560)	0.0618 (0.0645)	0.0235 (0.0382)	0.0164 (0.0567)	0.0209 (0.0592)
Big 5 conscientiousness	0.0147 (0.0122)	0.0322 (0.0521)	0.0919 (0.0614)	-0.0172 (0.0353)	-0.0339 (0.0565)	-0.0722 (0.0607)
Big 5 neuroticism	-0.0187 (0.0123)	-0.0282 (0.0545)	-0.111* (0.0644)	-0.00140 (0.0368)	0.0324 (0.0629)	0.0698 (0.0670)
Big 5 openness	-1.73e-05 (0.00796)	-0.0484 (0.0575)	-0.0106 (0.0657)	0.0187 (0.0373)	-0.00743 (0.0586)	-0.0208 (0.0642)
p value for $\chi^2(5)$ test for joint significance of demographic characteristics	0.0125**	0.3097	0.4734	0.0189**	0.1711	0.1168
p value for $\chi^2(7)$ test for joint significance of psychometric scores	0.0585	0.4191	0.2224	0.3222	0.8431	0.5845
Constant	12.80*** (3.229)	2.273 (1.749)	3.667** (1.660)	-8.621*** (2.220)	-6.702*** (1.856)	-6.574*** (1.807)
Observations	88	88	88	88	88	88

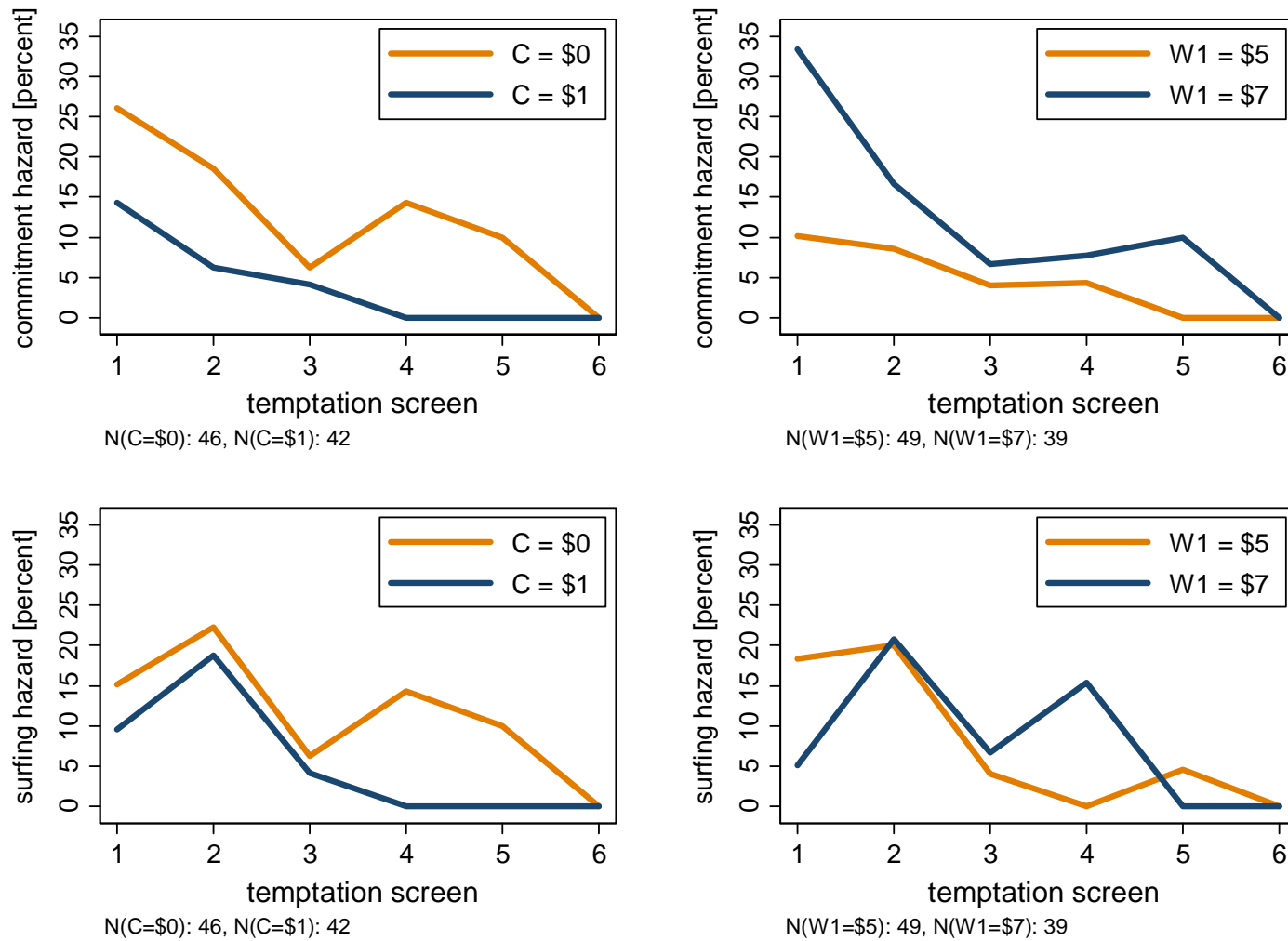
Notes: Coefficients are expressed as marginal effects, evaluated at the mean of the covariates. The psychometric scores are standardized. The symbol * denotes statistical significance at the 10% level; ** at the 5% level; and *** at the 1% level.

Figure 1: Shares of commitment and surfing in phase 1, by commitment cost and additional payoff for counting to end.



Legend: C = Commitment costs [in \$]; W1 = *Additional* payoff gained from counting to the end of the experiment [in \$].

Figure 2: Hazard rates of commitment and surfing in phase 1, by commitment cost and additional payoff for counting to end.



Legend: C = Commitment costs [in \$]; W1 = *Additional* payoff gained from counting to the end of the experiment [in \$].

Appendix

A.1 Instructions provided at the beginning of the experiment

Thank you for coming. You have already earned five dollars for arriving on time. These instructions explain how you can earn more money during the experiment.

Today's experiment involves counting. From time to time you will see displayed on your computer screen nine digits, either zeros or ones. Your task is to count the number of ones, and report that number in a box provided. You will have 15 seconds to provide an answer. Not providing an answer, or providing an incorrect answer, is counted as a mistake. If at the end of the experiment you have made mistakes on less than 30% of the counting tasks, then you earn \$15 in addition to your show-up fee. If at the end of the experiment you have made mistakes on more than 30% of the counting tasks, then you earn \$3 in addition to your show-up fee.

This experiment will end at different times for different participants. Please do not leave the room, talk or otherwise distract other participants in any way until you are told that all participants have completed the experiment and you have exited the laboratory.

A.2 Instructions provided on each of the temptation screens in phase 1⁸

Thank you for participating in today's experiment. You have earned \$ X^9 .

You will now be given access to the internet, so that you can pass time until the experiment ends for all participants. If you like, you can also continue the counting experiment. If you continue in the counting experiment you can earn up to an additional \$ $15 - X^8$. You will be given access to the internet unless you press the "Continue Counting" button.

Continue Counting

Click here if you want to continue counting without any more opportunities to access the internet. There is a \$ C^{10} charge for clicking this button. You will continue counting until the experiment ends. You can earn up to $[15 - X^8 - C^9]$ in addition your earnings.

Continue Counting and Remove Internet Option
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⁸ The temptation screens in phase 2 are identical, and only differ with respect to the treatment variables, as described in table 2. For a screenshot of the temptation screen, please see figure A.3.

⁹ This variable X is either P_1 or P_2 (depending on the particular phase), and its value is described in Tables 1 and 2.

¹⁰ The value of the commitment cost C is described in Table 2.

Figure A.1: Counting screen

<p>Count the number of ones:</p> <p>101000010</p> <p><input type="checkbox"/></p> <p>Submit</p> <p>Time left for decision: 10 s</p>	<p>Status</p> <p>Total time elapsed:</p> <p>0:03:05</p>
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Figure A.2: Empty screen



Figure A.3: Temptation screen

Time remaining in the experiment: 1:28:43

Thank you for participating in today's experiment. **You have earned \$10.00.**

You will now be given access to the internet, so that you can pass the time until the experiment ends for all participants. If you like, you can also continue in the counting experiment. If you continue in the counting experiment you can earn up to an additional \$5.00. You will be given access to the internet unless you press the "Continue Counting" button.

Continue Counting

Click here if you want to continue counting without any more opportunities to access the internet. There is a \$1.00 charge for clicking this button. You will continue counting until the experiment ends. You can earn up to \$4.00 in addition to your earnings.

Continue Counting and Remove Internet-Option

Done Local intranet

Time left for decision: 102 s

Status
Total time elapsed:
0:31:16