Demand for a Commitment Device in Online Gaming

Vinci Y.C. Chow*

The Chinese University of Hong Kong

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Abstract

To investigate the self-control of video-game players, I implemented a field experiment on popular multiplayer online games. Undergraduates in the treatment group were given software that could limit their duration of play. I found that the demand for commitment appears limited, with usage declining from 79% percent at the beginning to 5% towards the end. The difference is driven by a reduction among heavy players, and persists even after most subjects stopped using the devices. 10.4% of treatment subjects had a positive willingness-to-pay for the software. Lastly, I find that players on average overestimated how long they would play.

Keywords: Time-inconsistency, hyperbolic discounting, cues, commitment, gaming

JEL classifications: C93, D03, J22

*Department of Economics, The Chinese University of Hong Kong, Hong Kong. Email: vincichow@cuhk.edu.hk. I am grateful to my advisor in UC Berkeley, Stefano DellaVigna, as well as Botond Kőszegi, Ulrike Malmendier, Robert MacCoun, Matthew Rabin, Dan Acland, Mike Urbancic, Eva Vivalt and Varian Wrynn for their invaluable comments and discussions. I thank Burkhard Schipper, Gary Charness, Dan Friedman and Uri Gneezy for being the relay principle investigators of the experiment and their generous help in recruitment. Funding is generously provided by the UC Berkeley Population Center, the Russell Sage Foundation and the UC Berkeley Institute for Business Research. All errors are mine.

1 Introduction

Video gaming is a major form of entertainment nowadays. The video game industry generates sales over $30 billion, comparable to tobacco. The industry is expected to grow strongly for the next few years, with most of the growth coming from the online games sector (Gamasutra, 2008). This paper investigates whether players of a genre of popular online games overplay and how well they can predict how much they play. I define "overplaying" as the amount of leisure that the subjects would prefer not to consume from an *ex ante* perspective.

There are three reasons why overplaying in online games is an interesting topic. First, it is a major leisure activity among younger generations. Teenagers surveyed by the Bureau of Labor Statistics in the most recent American Time Use Survey spent an average of 0.84 hours per day on "playing games and computer use for leisure", more than any other form of leisure besides watching television (Bureau of Labor Statistics, 2010). Second, in the midst of gaming's rapid growth comes an increasing concern on overplaying. A number of Asian countries with large gaming populations have instated policies with the aim of reining in game-playing behavior, such as shutting off internet connection to game servers late at night (The Korean Herald, 2010), limiting sales of games to minors (Businessweek, 2010) and introducing in-game disadvantages after prolonged play (The Korean Times, 2010). Medical clinics targeting video gamers have also started to appear (Computer Addiction Services, 2010; Smith and Jones Clinic, 2010). The third reason why online games are interesting to study is that since their functionality depends on communicating with online servers, the investigator can collect data on individual players' actual time of play instead of relying on aggregated or self-reported data. Furthermore, depending on the type of data sought, an experiment on online-gaming can be effectively implemented over a large number of subjects for relatively low cost.

To illustrate how players might have demand for commitment, I present a model with a simple binary consumption setting with constant marginal utility and increasing marginal cost. Existing theoretical literature has so far only investigated utilization of a single simple commitment mechanism.[1] Building on their insights, my model investigates the timing of commitment usage as well as the usage of multiple commitment devices. I argue that by providing different types of commitment devices, one can differentiate between different causes of overplay.

Two possible sources of time-inconsistency are incorporated in the model to allow for the possibility of overplaying. First, the player can be *present-biased*, in that she values the current period over future periods more than she would have in previous periods. Second, the player can be *cue sensitive*, such that in certain states her ability to make rational decisions is impaired—for example, if the player happens to see an advertisement of the game, she might be cued and sense a strong desire to play the game at that moment. Psychology and economics research in present-biasedness (see for example Loewenstein and Prelec, 1992) has argued for hyperbolic discount rates instead of a single constant discount rate. For analytical tractability, this model adopts the quasi-hyperbolic discounting structure proposed by Laibson (1997b), which captures the essential features of true hyperbolic discounting. As for cue-sensitivity, I incorporate a simplified version of the structure proposed by Bernheim and Rangel (2004)—in each period there is a random chance that the player would always play, regardless of the cost involved. Lastly, following O'Donoghue and Rabin (2001), the player is allowed to be fully aware, partially aware or completely unaware of her time-inconsistency.

The model results in four predictions. First, players who are aware of their time-inconsistency play weakly shorter and weakly fewer sessions. Second, only players aware of their time-inconsistency would use a commitment device. Third, when commitment is available, sophisticated players play weakly shorter but weakly more sessions. Fourth, the model predicts that only cue-sensitive players would use multiple commitment devices during the same game session.

[1] Theories that predict demand for commitment include hyperbolic discounting and its variants (Laibson, 1997b; O'Donoghue and Rabin, 1999; Frederick et al., 2002), temptation utility (Gul and Pesendorfer, 2001, 2007) and cue-theories (Laibson, 1997a; Bernheim and Rangel, 2004).

A field experiment was carried out from February 2010 to July 2010 on players of a popular genre of online games called Massively Multi-player Online Role-Playing Games (MMORPGs), recruited from the undergraduate population of five University of California campuses.[2] The experiment consisted of three parts. First, all subjects installed a piece of software logging their duration of play and, via the software, treatment subjects were additionally provided with commitment devices that allowed them to limit their duration of play. The software sent logged information back to a data server between February 27th 2010 and June 20th 2010. Second, all subjects were asked to make a prediction on the duration they would play in a specific week. Their predictions were then compared to the actual logged hours of play. Third, treatment subjects' willingness-to-pay for the software were solicited via an incentive-compatible mechanism.

This paper has four goals, the first three of which concern time-inconsistency. The first is to investigate experimentally whether players have demand for commitment devices in a field setting. By providing subjects with software devices that arguably have no use other than to restrain one's own duration of play, I can estimate a lower bound on the fraction of subjects who were aware of their time-inconsistency in game-playing. In the experiment, 79 percent of the treatment subjects used one or more of the provided commitment devices voluntarily, though usage dropped significantly after the fourth week.[3] Through a Becker-DeGroot-Marschak mechanism, I find that 10.4 percent of the subjects have a positive willingness-to-pay for the commitment devices I designed, at an average of \$4.90.[4] To my knowledge, this is the first study to report an actual willingness-to-pay for a commitment device.

The second goal is to measure the effect commitment has on players' behavior, with emphasis on controlling for self-selection. Without controlling for self-selection, correlation between commitment device usage and reduced gameplay is not necessarily evidence for an effective commitment device, as it could be due to those who do not play much self-selecting

[2] The five campuses were Berkeley, Davis, Santa Barbara, Santa Cruz and San Diego.

[3] All treatment subjects were required to use the commitment devices once. The percentage quoted above excludes these very first usages.

[4] So the overall average willingness-to-pay is 50 cents.

into using the commitment device via attrition. To that end, a 2x2 experimental design was implemented. During sign-up, potential subjects' preference for receiving the commitment devices were solicited using an incentivized method. After the sign-up deadline had passed, half of the potential subjects who expressed a preference for receiving the commitment devices were assigned to the treatment group, along with half of the potential subjects who did not express such a preference. This assignment procedure minimized the chance that the treatment group would receive a disproportionate share of subjects who wanted the commitment devices.

There is evidence that players who used the commitment devices were concerned with suboptimal length of playing. The average total hours played by the subjects in the treatment group was 52.3, compared to 85.8 in the control group, a difference of 39 percent. Controlling for preference for being in treatment, self-reported experience of play and campus-affiliation, the estimated difference in the number of hours played between the treatment and control groups is statistically significant. There is, on the other hand, little evidence concerning suboptimal frequency of play, for the decrease in how often subjects started playing is insignificant. Treatment subjects played an average of 51.1 sessions throughout the experiment, while the control subjects played 67.5, both with standard deviations of over 100 sessions.[5]

Third, I attempt to distinguish between the different models that could potentially explain overplaying behavior. According to the model's hypothesis that only cue-sensitive players would use multiple commitment devices on the same game session, 29.2 percent of treatment subjects could potentially be categorized as cue-sensitive as opposed to being purely present-biased, though the evidence is largely suggestive.

The fourth goal is to investigate the accuracy of beliefs—can players accurately predict how much they would play in the future, or are there systematic biases in their projections? The existence of biases would call into doubt the optimality of players' actions, including the setup of commitment. This investigation also acts as a test of the reliability of self-

[5]A session is defined as a period of continuous game-play. A session is started by either launching a game or returning from a period computer inactivity.

reported duration of play, which the existing literature on video-gaming has been relying on. Comparing the predictions reported by subjects and the actual logged durations of play, I find that subjects in the experiment significantly overestimated how long they would play by 50.1 percent. This finding is inconsistent with the hypothesis that players are naïve about their self-control problem, because naïvete should have resulted in underestimation. A shortcoming with how this was investigated is that subjects were not provided with incentives to accurately report their predictions about their future behavior.

Lastly, I was able to obtain the academic records of a substantial sub-sample of the subjects in the experiment. Subjects did relatively well in school, as measured by mean cumulative grade-point-average (GPA) of 3.22 within the treatment group and 3.12 within the control group. Compared to campus-wide averages of 2.9 to 3.03, the figures challenge the notion that gameplaying is necessarily associated with lower academic performances.

Before turning to the model a brief summary on the existing literature on commitment and on video-game overplaying is warranted. Despite advancement in theories that predict individuals have demand for commitment devices, studies on the usage of commitment devices are relatively sparse. See Bryan et al. (2010) for an overview of theories and evidence on demand for commitment. Laboratory experiments include Read et al. (1999), in which subjects were provided with the choice of "highbrow" and "lowbrow" movies. The study finds that subjects who were being asked to choose ahead of the time were more likely to pick "highbrow" movies. Ariely and Wertenbroch (2002) assigned subjects proofreading tasks and provided commitment devices in the form of deadlines. They find that involuntary deadlines gave rise to the highest productivity in terms of proofreading accuracy, followed by voluntary deadlines and no deadlines. As for field experiments, Thaler and Benartzi (2004) allowed employees in three companies to commit to a higher retirement contribution when a pay raise arrives. They found saving rates increased by as much as 10.1 percentage points with commitment. Ashraf et al. (2006) offered a commitment savings product through a Filipino bank. They find 28.4 percent of those offered the commitment device utilized it, with utilization correlated with a lower discount rate. Gine et al. (2010) offered smokers a commitment savings account that confiscated their savings if they tested positive for nicotine and cotinine six months after opening the account. They found that smokers being offered the commitment device were 3 percentage points more likely to pass the nicotine and cotinine test.

I am aware of two studies in this area that have utilized games as the activity of interest. Millar and Navarick (1984) conducted perhaps the earliest laboratory study that used a video game in a test of preference for immediate gratification. In another laboratory study, Fernandez-Villaverde and Mukherji (2006) explicitly test hyperbolic discounting through providing a commitment device on duration of game play. The present study is the first, to my knowledge, to carry out an experiment on actual game platforms with real players, rather than using experimental subjects who are not necessarily players of the game in question outside the experiment.

Psychologists have studied video game and media addiction more extensively. Studies have shown that video game usage is correlated with lower academic performance (Anand, 2007; Skoric et al., 2009), higher hostility (Chiu et al., 2004) and lower social support (Longman et al., 2009). In a national study, Gentile (2009) puts the percentage of pathological video-game players at 8 percent. He demonstrates that players who meet clinical criteria for pathological gaming had poorer school performance after controlling for demographics and that pathological gaming is not identical to a high amount of play. One potential drawback of these studies, however, is that all of them relied on self-reported duration of play, and a legitimate concern would be that players may have reported their durations of play with bias. By designing commitment devices, this study contributes to a very small literature on treatment for video-game addiction. Griffiths and Meredith (2009) review existing treatment methods. Very few empirical studies of treatment exist (see for example Kuczmierczyk et al., 1987 and Keepers, 1990), and I am unaware of any of experimental study of treatment.

The remainder of this paper is organized as follows. Section 2 presents a simple model of overplaying and usage of commitment devices. The results of the experiment are discussed in Section 3. Section 4 concludes the paper.

2 Model

To motivate the model, consider the case in which a certain period of time before an important assignment is due, a student is deciding whether and when to play a game. Playing brings the student immediate enjoyment, with the tradeoff that the student is able to spend less time on the assignment. Being able to spend less time on the assignment imposes a future cost, for example in the form of a lower end-of-term grade.

The game takes time to initialize before playing is possible. There are a variety of reasons why this could be the case. First, launching a game is not an instant process. Most online games require their players to log in and establish a connection with a game server before any playing is possible. Graphic-intensive games additionally have loading processes that take up a noticeable amount of time. Second and perhaps more importantly, the player might need to seek out other players so as to play together.[6] After the game is initialized, at various moments in time before the assignment is due the student faces the decision of whether to play.

If the student believes she is capable of choosing the optimal amount of play at any given moment, intuitively she should initialize the game at the earliest possible moment. First, it allows playing sooner. Second, it allows for flexibility in duration of play in response to how fun the game turns out to be. If the player is aware of her self-control problem, however, she might consider alternative actions. Perhaps she would work on her assignment first before initializing the game or, if her self-control problem is severe enough, not initialize at all. She

[6]The prime reason why games are brought online is to give players the option to play with others. To facilitate matching between players with different levels of experience and skill, most online games feature some form of ranking system. Since most players prefer playing with others who are at a similar level, but it can be hard to find others who are at approximately the same level at any given point in time, the matching process is non-trivial. For games with a small player base, finding a player who would be an appropriate match is often a particularly time-consuming task.

might also find the use of commitment, such as having friends over for a group study session the night before the assignment is due, an attractive option.

I shall now set up a model that stylizes such scenarios. The model captures the tradeoffs between the instantaneous benefit and the future cost of playing. The player's choice set includes when to initialize the game, when to play, and, if commitment devices are available, when to use the commitment devices.

2.1 Setup

A player faces a finite dynamic optimization problem of 4 periods, from $t = 0$ to $t = 3$. At each period, if playing has not been initiated, the player first decides whether to initiate playing. I denote initializing the game in Period t as $z_t = 1$ and not initializing in Period t as $z_t = 0$. The game only needs to be initialized once. For clarity, let $z_t = \varnothing$ indicate that the game has been initialized before Period t. If the player chooses not to initiate playing the period ends, giving her a utility of zero for that period.

If the player chooses to initiate playing, in each *subsequent* period she faces the choice of whether to play in that particular period. Denote playing in Period t by $a_t = 1$ and not playing by $a_t = 0$. In every Period t, $a_t = 0$ if $z_t \in \{0, 1\}$ and $a_t \in \{0, 1\}$ if $z_t = \varnothing$. The assumption that no actual playing can occur in the period of initialization represents the time it takes to set the game up for playing. Because the earliest period the player can initialize the game is Period 0, the assumption implies there are at most three periods of actual gameplay in the model.

The instantaneous utility from playing in period t is

$$u_t(a_t) = (\eta_t + \epsilon) \cdot a_t \tag{2.1}$$

η_t is a non-random process depending only on t. ϵ is a mean-zero random variable with cumulative distribution $F(\epsilon)$, realized immediately after the player decides to initiate play and does not change in subsequent periods. This formulation captures in the simplest form a situation where instantaneous utility is random.[7]

Playing incurs a cost in the future. This is captured by a single cost paid after the very last period, $C(n)$, where n is the number of periods played. I assume there is increasing marginal cost, so $\forall n\, c(n) = C(n) - C(n-1) > 0$ and $c(n) > c(n-1)$. Let $C(0) = 0$.

I assume that the player's welfare is the sum of all instantaneous utilities minus cost,[8]

$$U_w = \beta \left[\sum_{\tau=1}^{3} u_\tau(a_\tau) - C\left(\sum_{i=1}^{3} a_i \right) \right] \tag{2.2}$$

where β is assumed to be equal to or less than one. In any given period t, however, the player is potentially present-biased (Laibson, 1997b). Let $\mathbf{s}_{-t} \equiv [(a_0, z_0),...,(a_{t-1}, z_{t-1})]$ represents the player's actions before Period t and $\mathbf{s}_t \equiv [(a_{t+1}, z_{t+1}),...,(a_3, z_3)]$ represents her actions after Period t. The player's utility function in Period t is

$$U_t(a_t, z_t, \mathbf{s}_{-t}, \mathbf{s}_t | \beta) = u_t(a_t) + \beta \left[\sum_{\tau=t+1}^{3} u_\tau(a_\tau) - C\left(\sum_{i=1}^{3} a_i \right) \right] \tag{2.3}$$

When $\beta < 1$ the player is present-biased, because she has a time-inconsistent preference for immediate consumption. I allow for the possibility that the player holds wrong belief about her inconsistency in the future. The player believes that her utility function in Period $t' > t$ is

$$\hat{U}_{t'}(a_{t'}, z_{t'}, \mathbf{s}_{-t'}, \mathbf{s}_{t'} | \beta) = u_{t'}(a_{t'}) + \hat{\beta} \left[\sum_{\tau=t'+1}^{3} u_\tau(a_\tau) - C\left(\sum_{i=1}^{3} a_i \right) \right] \tag{2.4}$$

where $\beta \leq \hat{\beta} \leq 1$. The player is *$\beta$-naïve* if $\hat{\beta} = 1$, *partially β-sophisticated* if $\beta < \hat{\beta} < 1$ and

[7] If the the random component of instantaneous utility is not fixed after game initialization, the player generally has an additional incentive to play, as a positive realization of the component can be taken advantage of by playing longer. Because this additional incentive is not central to the psychological phenomenon I am exploring, I assume the random component is only realized once. An exception is the special case where noises are independent across time periods, bounded by the increase in marginal cost and can only be learnt by the player through playing. Under those three conditions, it can be shown that the additional incentive to play does not exist.

[8] (2.2) in effect assumes there is no exponential discounting, which is reasonable given gameplay mostly occur in relatively short time-frame.

fullyβ-sophisticated if $\hat{\beta} = \beta$ (O'Donoghue and Rabin, 2001).

To capture the effects of cues I assume that once the game is initialized, in every period the player receives a cue with probability p and enters a *hot* mode. When in hot mode the player plays for sure in that period, even if playing is not optimal. Furthermore she will not be able to initiate any of the commitment devices I introduce later on. If the player does not enter the hot mode she is in the *cold* mode, in which she chooses her action optimally. Let $\hat{p}$ be the player's belief about the value of p. Similar to present-biasedness, the player is *p-naïve* if $\hat{p} = 0$, partially *p-sophisticated* if $0 < \hat{p} < p$ and *fully p-sophisticated* if $\hat{p} = p$.[9] Because the player is always playing in the hot mode, throughout this paper I use "choose to play" or "willing to play" to denote gameplaying in the cold mode.

Because ϵ and the hot or cold modes are random, at every period t the player maximizes the expected value of U_t, given her past actions and her beliefs. Notice that by (2.3), U_t does not directly depend on the beliefs $\hat{\beta}$ and $\hat{p}$. The two affect U_t indirectly through the player's beliefs about what her future actions $a_{t+1}, ...$ and $z_{t+1}, ...$ would be. Letting $\hat{\mathbf{s}}_t(a_t, z_t, \mathbf{s}_{-t}, \epsilon, \hat{\beta}, \hat{p}) = [(\hat{a}^t_{t+1}, \hat{z}^t_{t+1}), ..., (\hat{a}^t_3, \hat{z}^t_3)]$ be her Period-t belief about $\mathbf{s}_t$,[10] the player maximizes

$$V_t(a_t, z_t) \equiv E_t[U_t(a_t, z_t, \mathbf{s}_{-t}, \hat{\mathbf{s}}_t | \beta)] \tag{2.5}$$

If the game has not been initialized, the player solves

$$\max_{z_t} V_t(0, z_t) \tag{2.6}$$

After the game has been initialized, she solves instead

$$\max_{a_t} V_t(a_t, \varnothing) \tag{2.7}$$

[9]This definition of sophistication ignores the possibility that $\hat{p}$ is bigger than p, which can be interpreted as the player being pessimistic about her chance of being cued. Removing this limitation would not alter any of the results.

[10]Note that $\hat{a}^t_{t'}$, $t' > t$ is a random variable.

Let $V_t^*(a_t, z_t) \equiv E_t[U_t(a_t, z_t, \mathbf{s}_{-t}, \hat{\mathbf{s}}_t(\cdot, \hat{\beta}, \hat{p})|1)]$ be the time-consistent objective function *given the player's beliefs.*[11] Overplaying is defined as the player choosing to play despite the time-consistent expected utility of playing in a period being smaller than the time-consistent expected utility of not playing under the player's beliefs:

Definition 1. The player is *overplaying* if $a_t = 1$ and $\arg\max_{a_t} V_t^*(a_t, \varnothing) \neq 1$.

By comparing expected utilities, overplaying is not limited to the periods where playing is actually suboptimal—a player is also considered to be overplaying if she plays with the expectation that she will play sub-optimally in the future.[12]

To ensure that cue-triggered overplaying could happen over all game-playing strategies the player might choose, I also make the following modeling assumption:

Assumption 1. $\eta_3 + \epsilon < \beta c(1)$.

Assumption 1 bounds instantaneous utility in Period 3 from above, guaranteeing that playing in the last period will not be chosen even by a present-biased player:

Lemma 1. *The player never chooses to play in Period 3.*

Proof. See Appendix. □

Given Assumption 1, Period 3 should be viewed as an additional period (beyond Period 1 and Period 2) when playing can only be suboptimal, regardless of how fun the game is. For example, it could represent the night before an assignment is due, when playing could mean the player would miss the deadline for the assignment because she would wake up late.

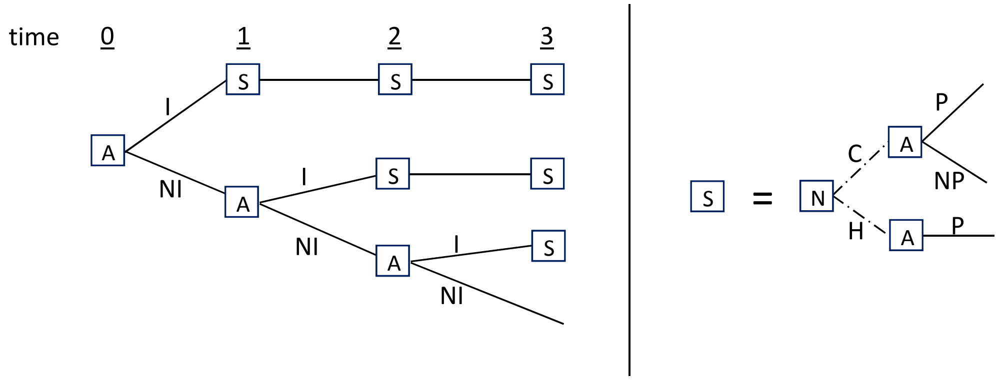
Lastly to simplify, I assume that instantaneous utility is identical in earlier periods:

Assumption 2. $\eta_1 = \eta_2$.

[11] Note that V_t^* is *not* the objective function of a time-consistent player because it allows for incorrect beliefs. The objective function of a time-consistent player is $E_t[U_t(a_t, z_t, \mathbf{s}_{-t}, \hat{\mathbf{s}}_t(\cdot, 1, 0)|1)]$.

[12] A simple example to illustrate the definition: suppose the time-consistent optimal duration of play is one period, but a naïve and a sophisticated player would each play for two periods. The first period of play for the naïve player is not overplaying under the definition, because the player believes that she is not going to play in the future. The same period of play is overplaying under the definition for the sophisticated player, because she knew she would overplay in the next period and could have avoided it had she chosen not to play in this period.

Figure 2.1: Game Diagram



Captions: A – Agent/Player. N – Nature. S – Sub-Tree. I – Initiate. NI – Not Initiate.
C – Cold Mode. H – Hot Mode. P – Play. NP – Not Play.

2.2 Strategy without Commitment

The solution to the model involves a series of thresholds for ϵ, one for each possible state, above which the player chooses to play in that state. The thresholds are solved in the appendix. The following proposition summarizes the main predictions of the model:

Proposition 1. *(Strategy without Commitment)*

1. *Holding the initialization period fixed, the number of periods the player chooses to play and the expected number of periods the player actually plays are weakly decreasing in* β, *weakly decreasing in* $\hat{\beta}$ *and weakly decreasing in* $\hat{p}$.

2. *Suppose the player currently only chooses to play in Period 1. As* $\hat{p}$ *increases, she is weakly more likely to choose to only play in a later period or to choose not playing. As* $\hat{\beta}$ *increases, there exists an* $\tilde{\epsilon}$ *where she would also do so if* $\epsilon < \tilde{\epsilon}$, *but would keep choosing to play in Period 1 if* $\epsilon \geq \tilde{\epsilon}$.

3. *The player initializes the game weakly later as* $\hat{p}$ *increases or as*$\hat{\beta}$ *decreases, and she might not initialize if* $\hat{p}$ *is large enough or* $\hat{\beta}$ *is small enough.* β *has no effect on the initialization decision.*

Proof. See Appendix. □

It is intuitive that a more time-consistent or more cue-aware player will choose to play fewer sessions, but that naïve over present-biasedness *delays* playing might perhaps be surprising. The latter is a manifestation of the "preproperation effect" explored in O'Donoghue and Rabin (1999). When the game is not very fun (low ϵ), the naïve player erroneously believes that she would be able to refrain from playing in the future. This gives her the incentive not to play in the current period, because she thinks she would be able to completely avoid the negative consequence of playing. A sophisticated player, on the other hand, realizes that she would play in the next period if and only if she refrains in the current period, and as such sees no reason to delay playing. When the game is fun (high ϵ), sophistication makes no difference because the instantaneous utility from playing is high enough to induce even a naïve player to believe that she is always going to play in Period 2.

The third point follows from the observation that a sophisticated player initializes late when the expected benefit from playing a second period optimally is less than the expected cost from overplaying, which is more likely to be the case as $\hat{p}$ increases or as $\hat{\beta}$ decreases. Further, when the expected cost of overplaying exceeds the expected benefit of playing of even one period, the player would choose not to initiate playing, even if playing is optimal for some realizations of ϵ.

2.3 Strategy with Commitment

In Proposition 1, the restriction that playing has to end after Period 3 is in essence being used by the player as a commitment device. This strategy has several drawbacks, however. First, the player does not observe the realized value of ϵ when she picks an initiating period, when a more ideal commitment device would instead allow for a longer duration of play when ϵ turns out to be high. Second, in many instances starting late might not be feasible, for example when there is no binding end to game-play. Lastly, it imposes a delay in game-play, which is costly if the exponential discount factor is not assumed to be one.

Because of the these reasons, an overplaying player has demand for commitment devices other than starting late. Suppose the player is offered one or both of the following two types of commitment devices: an *ex ante* device (X) in which she can commit to a definite duration of play before initiating the game, and an in-game device (I), in which, *if she is in cold mode,* she can commit to end the game after the current period. With either device, once the designated last period of game-play has elapsed $a_t = 0$ for all subsequent periods. Denote $X_t = 0$ and $I_t = 0$ as not using the respective commitment devices, $X_t = x$, $x > 0$ as using Device X to set a limit of x periods, and $I_t = 1$ as using Device I in Period t. By construction, $X_t = 0$ if $z_{t-1} = \varnothing$ and $I_t = 0$ if $z_{t-1} = 0$. The player now maximizes

$$V_t(a_t, z_t, I_t, X_t) = E_t[U_t | a_t, z_t, I_t, X_t, \mathbf{s}_t = \hat{\mathbf{s}}_t]. \tag{2.8}$$

where $\hat{\mathbf{s}}_t(a_t, z_t, \epsilon, \hat{\beta}, \hat{p}, I_t, X_t) = [(\hat{a}^t_{t+1}, \hat{z}^t_{t+1}, \hat{I}^t_{t+1}, \hat{X}^t_{t+1}), ..., (\hat{a}^t_3, \hat{z}^t_3, \hat{I}^t_3, \hat{X}^t_3)]$ now depends on I_t and X_t in addition to a_t, z_t, ϵ, $\hat{\beta}$ and $\hat{p}$. I assume that if the player is indifferent between using a device or not she would not use it—this could be justified by assuming that there is a small cost involved in using any of the devices.

The two devices each have their advantages and disadvantages. X is always available but cannot be adjusted with respect to realization of ϵ, while I can be adjusted but may not be available if the player falls prey to cues. Moreover, neither device prevents overplaying in Period 1.

Let $n_t \equiv a_1 + ... + a_t$ be the total number of periods played on or before Period t. The following proposition characterizes the usage of commitment:

Proposition 2. *(Usage of Commitment)*

1. *A naïve player never uses a commitment device.*

2. *A β-sophisticated player would use I in Period t if I is available, $a_{t+1} \in \{0, 1\}$ and $\hat{\beta} \leq \frac{u_{t+1}(1)}{c(n_t+1)} < 1$. She would use X in Period t if X is the only commitment device available, $z_{t'} = 0 \; \forall \, t' < t$ and $\exists \, x > 0$ s.t. $(1, x)$ is the unique solution to $\max_{z_t, X_t} V_t(0, z_t, 0, X_t)$.*

3. *A p-sophisticated player would always use X if available. She would use I in Period t if she is in cold mode, $a_{t+1} \in \{0,1\}$ and $\exists\, a_t^*$ s.t. $(a_t^*, 1)$ is the unique solution to $\max_{a_t, I_t} V_t(a_t, \varnothing, I_t, 0)$.*

Proof. See Appendix. □

Whether a p-sophisticated player would use both X and I depends on the parameters of the model and the realization of ϵ. The following corollary provides sufficient conditions for the player to use both commitment devices:

Corollary 4. *A p-sophisticated player would use both X and I if*

1. $a_{t+1} \in \{0,1\}$ *and* $u_{t+1}(1) < c(n_{t-1}+1)$*, or*

2. $a_{t+j} \in \{0,1\}$ *for* $j = 1, 2$*,* $u_{t+1}(1) \geq c(n_{t-1}+1)$ *and* $u_{t+1}(1) < c(n_{t-1}+2)$*.*

Proof. See Appendix. □

3 Field Experiment

3.1 Design

The core idea was to design a controlled experiment in which treatment subjects receive commitment devices, with an emphasis on controlling for self-selection among players. Multiple commitment devices were provided, first for testing whether subjects have demand for multiple devices for the same occasion, and second to reduce the artificial limitation on when blocks have to be set up. Furthermore to increase the likelihood that self-control is indeed a problem, I chose to recruit players from a genre of games that is known to be time consuming.

World of Warcraft® is a Massively-Multiplayer Online Role-Playing Game (*MMORPG*). The game is set in a fantasy world, where players interact with the world via customizable avatars—a human warrior or a dwarf hunter for instance—and can engage in a variety of activities. While combating computer-controlled characters or other human players is a prominent feature of the game, it is entirely possible for a player to engage only in "civic" activities such as tailoring or auctioneering. Playing World of Warcraft requires a paid subscription, which costs $15.99 per month in the United States. The price is substantially lower in countries like China. The maker of the game, Blizzard Entertainment, claims eleven million subscribers, making it one of the most popular, if not the most popular, subscription-based MMORPG (Guinness World Records, n.d.). To enlarge our potential subject pool I also recruited subjects playing MMORPGs that are similar to World of Warcraft in nature, such as Everquest®, Maplestory® and Star Wars: Galaxy®. In our final subject pool 75 percent of the subjects played World of Warcraft.

I programmed a Windows®-based commitment software, which I named *BlokSet*, that allows a user to limit when, or for how long, she can play MMORPGs. BlokSet allows the user to set blocks, which are time periods during which BlokSet prevents her from playing MMORPGs. Blocks work in two ways. If the user try to launch a game software during a block that she had set, BlokSet will prevent the software from launching. If the user was playing when a block is scheduled to begin, BlokSet will terminate the game software at the beginning of the block. Before that happens, BlokSet gives verbal reminders and shows a countdown timer so that the user can wrap up the game session before the block begins. BlokSet consists of three different devices, each allowing the user to set blocks in a different way. The *Calendar Blocker* allows the user to schedule blocks on a calendar, for all or part of any day. The *Pre-Game Blocker* gives the user the option to set a block for that session at the beginning of a game-session. The user chooses how long to play, and when that time is up the game-session ends and the block begins. In addition, the Pre-Game device allows the user to display a timer indicating how long she has been playing. The timer can be displayed with or without setting a block. Lastly, the *In-Game Blocker* allows the user to set a block in the middle of a game session, in a very similar fashion to the Pre-Game Blocker. There is a “settings” page where the user can select default options for how the three devices work. Figure 3.1 on page 19 demonstrates the interfaces of the three different blockers.

The provision of multiple devices allows for a flexible representation of the theoretical devices in the previous section. Available for setup far ahead of actual gameplay, the Calendar Blocker is an implementation of the ex-ante device (X), while the In-Game Blocker, available only while playing, is an implementation of the in-game device (I). The remaining device, the Pre-Game Blocker, can be interpreted as either an implementation of X or I, depending on how far in the future does β comes into effect.

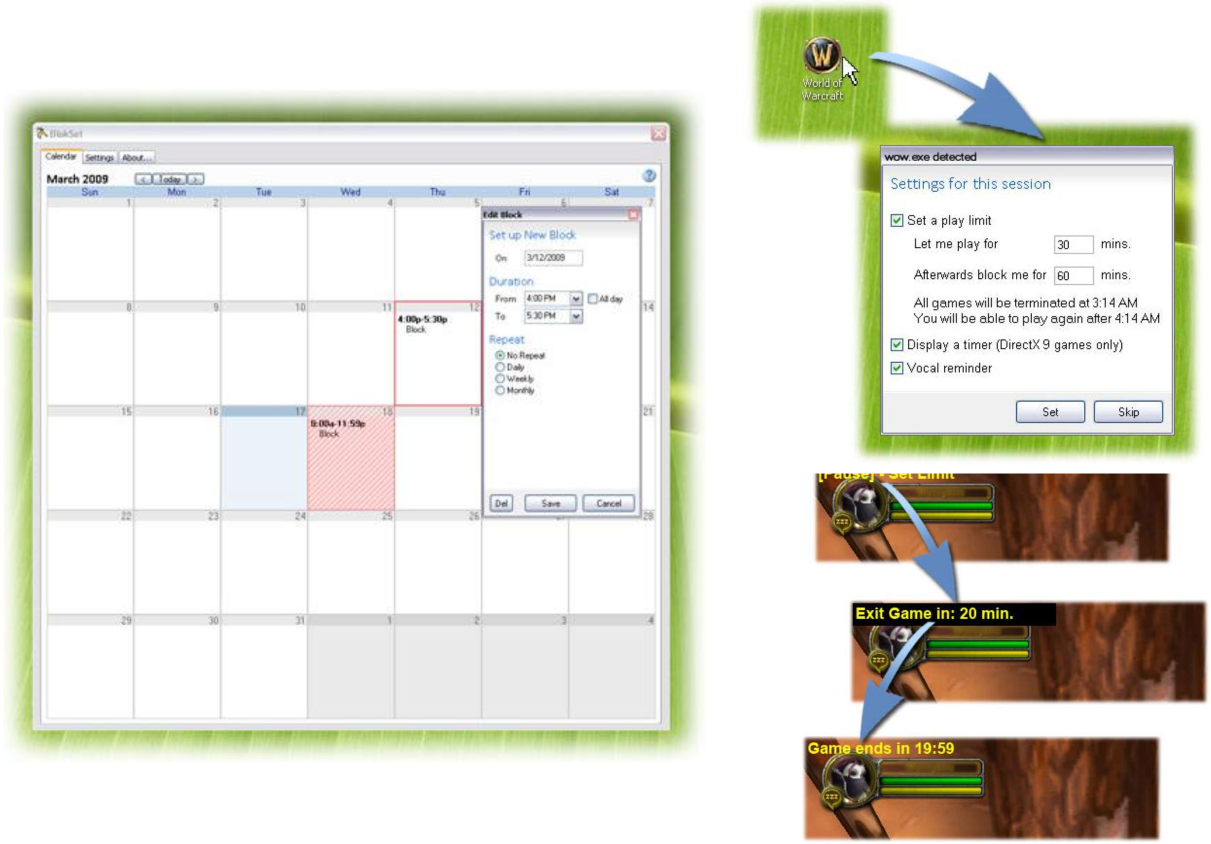
Subjects were recruited via two channels between mid-January to mid-February 2010—recruitment postings on Facebook, as well as fliers posted throughout five campuses of the University of California: Berkeley, Davis, Santa Cruz, Santa Barbara and San Diego.[13] The recruitment materials included a link to a sign-up website and clearly described the criteria for getting into the experiment: potential subjects must be a UC undergraduate, a player of a supported MMORPG game and a user of any version of the Windows operating system. In practice the last requirement was largely redundant since very few games support alternative operating systems, and virtually all players use Windows due to the fact that most games are optimized for that platform.

During sign-up, potential subjects were informed of how they would be paid if they were accepted into the experiment: a first payment of up to \$15 after they installed a software package, and a second payment up to \$25 at the end of the experiment. They were also told that their payments would be \$15 and \$25 unless they chose to give up some of the payments as part of the experiment.[14] They were then given a tour of the features of Blokset, and were asked of whether they would be willing to pay \$1 to try the software during the experimental period. This question allowed us to separate potential subjects

[13]A small scale pilot experiment on 40 subjects was carried out in Spring 2008 on the Berkeley campus alone, following largely the same experimental design. The results from the pilot were statistically insignificant but qualitatively similar.

[14]The framing of the experimental tasks as involving giving up part of their subject payment might result in a reference effect, reducing the subjects’ willingness to choose options that reduce their payments. This works against demand for commitment devices.

Figure 3.1: Interface of BlokSet



Top: Calendar Blocker. A grid representing the days in a given month. Clicking on a cell brings up a dialog box, allowing the user to set up blocks. BlokSet prevents any monitored games from being launched when a block is in effect. *Bottom-left:* Pre-Game Blocker. Whenever the user launches a monitored game, BlokSet freezes the game and pops up a dialog box, giving the user the option to set a limit and a block. In addition, the user can opt to display a timer and activate vocal reminders. *Bottom-right:* In-Game Blocker. While in-game, the user can click on a pre-assigned key to bring up a dialog on screen, allowing her to enter a limit. When the limit is reached, the game terminates.

who had an interest in the commitment software from those who did not. I describe these subjects as having a *willingness-to-try*. To avoid subjects strategically selecting an answer with the intention to increase their chance of entering the experiment, it was made clear in the description that I were looking for both subjects who answered "yes" and answered "no", and that acceptance would not be announced until sign up was over.

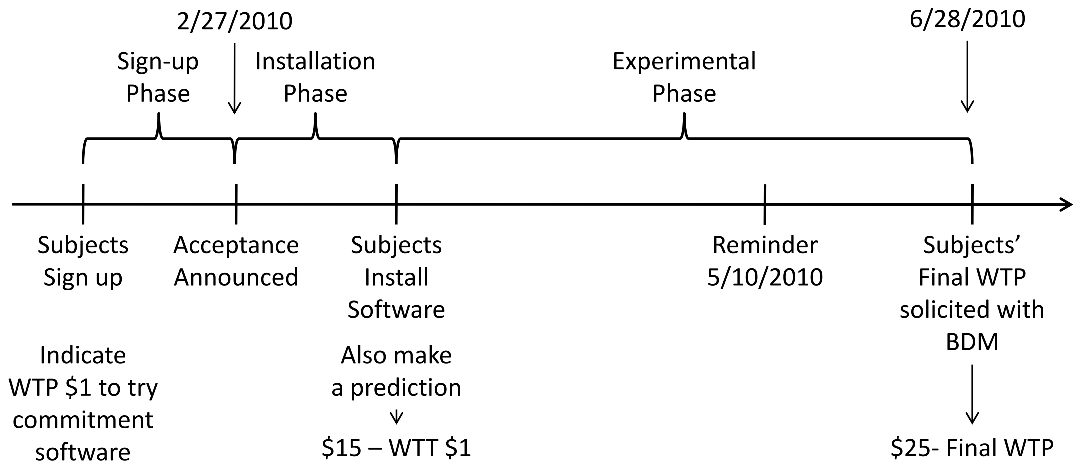
With the information on the subjects' interest in BlokSet I implemented a 2x2 experimental design. Half of the subjects who were willing to pay $1 to try the BlokSet were assigned to the treatment, as were half of the subjects who indicated otherwise. This minimizes the confound that could arise if awareness of a self-control problem is correlated with less playing. All subjects were assigned monitoring software that monitored their computer usage, with treatment subjects receiving BlokSet in addition.

Acceptance was announced via email between February 27th and March 2nd, 2010, in which subjects were instructed to download and install their assigned software packages from the experiment's website. Subjects were *not* told which package they were assigned with in the email. This was done so as to not affect their prediction on duration of play, which I solicited in the next step. When the subjects logged in to the experiment's website they were first asked to complete a pre-treatment survey, followed by making a prediction about how many hours they would play in the week of March 7th to March 13th, *before* they were informed on which package they would receive.[15] After making the prediction, subjects were told of which package they were assigned to, and a link to download the package was provided. I mailed subjects their first payment in checks after I confirmed that the monitoring software was installed on their computer and sending data. A $1 payment was deduced from the first payment to those who indicated a willingness-to-pay and were assigned the BlokSet.

To avoid complications in soliciting willingness-to-try I did not implement a passive

[15]This created a potential complication, as subjects might have different expectations on how much they would play depending on the availability of commitment devices. Section 3.9 shows that this issue does not seem to be significant.

Figure 3.2: Experiment Timeline



observation period, so subjects assigned with BlokSet were able to access its feature the moment they installed the software. For the following 16 weeks I monitored when and for how long they played MMORPGs, and for treatment subjects I also monitored their usage of the three commitment devices. Data collection was disabled on the servers on June 20th.

An email was sent on May 10th (Week 10) to treatment subjects reminding them of the availability of the commitment devices. This investigates whether there was any reduction in commitment usage due to subjects forgetting about the availability of the devices. Control subjects received an email simply notifying them of the time till the end of the experiment.

On June 28th subjects were instructed via email to complete a final step on the experiment's website, before July 5th, in order to obtain their second payment of up to $25. On the website they were informed that BlokSet would cease to function on July 31st, and were offered the chance to forfeit a part of their second payment for the right to keep using BlokSet after July 31st. I used a Becker-DeGroot-Marschak mechanism (Becker et al., 1964). To make the randomness credible, subjects were informed that the threshold used would be a transformation of the closing price of Dow Jones Industrial Average on July 5th. The transformation formula was shown on the same screen. At July 5th I provided subjects who indicated a willingness-to-pay higher that the random threshold with a code to activate

BlokSet permanently. A second payment of \$25, minus the randomly generated threshold for subjects who indicated a willingness-to-pay greater than or equal it, was mailed to subjects subsequently.

3.2 Subject Selection and Attrition

Table I summarizes the characteristics of the data. 299 students signed up for the experiment, of which 119 were rejected due to not reporting themselves as a MMORPG player or not being a Windows user. Of the remaining 180 students, 27 indicated a willingness-to-try. Our initial assignment allocated 14 potential subjects with willingness-to-try to the treatment group and 13 to control, and 76/77 potential subjects with no willingness-to-try to each of the groups. 75 potential subjects never responded to the acceptance email, which left us with the final subject count of 105, of which 48 were in the treatment group. Attribution ratio was similar across willingness-to-try in the treatment group, with 6 out of 14 (42.9%) from those with willingness-to-try not responding, versus 36 out of 76 (47.3%) from those without. The ratio was lower among potential subjects in the control group—2 out of 13 (25.4%) potential subjects with willingness-to-try and 31 out of 77 (40.3%) without willingness-to-try never responded. Table II reports the OLS coefficients and average logit marginal effects from regressing the attrition dummy on the treatment-group dummy and the willingness-to-try dummy. Neither dummy has a significant effect on the attrition rate.

3.3 Subject Demographics

Within the 105 subjects, there is little difference over self-reported survey attributes between treatment and control. Treatment subjects were slightly more experienced players and played more, having spent an average of 13.38 years playing video games instead of 11.02 years, and played 15.61 hours per week versus 14.53 per week. They also reported themselves to be less happy and less healthy (5.36 versus 5.58 and 5.27 versus 5.58 respectively, out of 7). Only the difference in years playing video games is statistically significant.

TABLE I

SUMMARY STATISTICS

Time Period Covered		3/7/2010-6/20/2010			
Total Sign-up		299			
Valid Sign-up		180			
w/ Willingness-To-Try		27			
Attrition		75			
	Treatment		**Control**		**Pr(|T|>|t|)**
No. of Subjects	48		57		
w/ Willingness-To-Try	8		11		
Total Hours Played, Avg. Across Players	52.32	(119.67)	85.83	(164.87)	0.2440
Avg. Hrs. Per Session, Avg. Across Players	0.74	(0.53)	1.20	(0.74)	0.0058
No. of Sessions, Average Across Players	51.10	(107.75)	67.53	(127.98)	0.4834
Self-Reported Survey Data					
Yrs. Playing MMORPG	5.91	(3.15)	5.65	(2.81)	0.6714
Yrs. Playing Video Games	13.38	(4.56)	11.02	(3.48)	0.0048
Hours Played per Week	15.61	(10.93)	14.53	(9.20)	0.5977
Happiness	5.36	(1.00)	5.58	(0.94)	0.2641
Playing makes School Work Harder	2.24	(0.74)	2.40	(0.87)	0.3381
Health	5.27	(1.39)	5.58	(1.13)	0.2275
Academic Performance (GPA)					
Fall 2009	3.23	(0.60)	3.14	(0.52)	0.5675
Spring 2010	3.19	(0.73)	3.17	(0.49)	0.8893
Cumulative in August 2010	3.22	(0.49)	3.12	(0.39)	0.4189

Standard deviations in parentheses. GPA based on a sub-sample of 51 students (26 treatment, 25 control) whom we were able to obtain data. Playing Makes School Harder is ranked from 1-4, 1 being "rarely" and 4 being "always". Happiness and Health are ranked from 1-7, 7 being the highest.

TABLE II

Attrition Rate – Variation across 2x2 Groups

	Attrition Dummy		
	(OLS)		(Logistic)
Treatment Dummy	0.102		0.103
	(0.073)		(0.073)
WTT Dummy	-0.144		-0.145
	(0.103)		(0.097)
Constant	0.387	***	
	(0.539)		
N	180		180

*Significant at 10%, **Significant at 5%, ***Significant at 1%.

Table II regresses attrition on the 2x2 group assignments. *Attrition Dummy* = 1 if the potential subject never responded, = 0 otherwise. *Treatment Dummy* = 1 if the potential subject was assigned to the treatment group, = 0 if assigned to control group. *WTT Dummy* = 1 if the potential subject expressed a willingness-to-pay of $1 to try out the commitment devices during sign-up, = 0 otherwise. Coefficients in the logit regression are average marginal effects.

I was able to obtain the academic records of a substantial subsample of subjects. Within these 51 subjects—26 in treatment, 25 in control—there was no statistically-significant difference in academic performances. The average GPA in the Fall quarter of 2009 was 3.23 within the treatment group, versus 3.14 within the control group. In the Spring semester/quarter of 2010 it was 3.19 versus 3.17. Based on data provided by campus registrars, the average cumulative GPA in University of California campuses varies from 2.9 to 3.03.

The relatively high average academic performance suggests that gaming is not necessarily correlated with low academic achievement. One might argue that truly heavy players might not have seen our recruitment fliers on campus, which could give rise to self-selection bias. It would be difficult, however, to make the parallel argument regarding Facebook advertisements. Another concern is the University of California student population being a biased sample of game players. As a preeminent university system, University of California admits students who performed well in high school. Students who struggled academically due to excessive gameplaying are unlikely to be admitted, yet they might well be the ones who could benefit the most from the availability of commitment devices. This issue weakens the representativeness, but not the validity, of any observed relationship between academic performance and gameplaying in this experiment.

3.4 Correlates of Willingness-to-Try

Table III regresses willingness-to-try on subjects' academic performance immediately before the experiment. Grade-point-average in Fall 2009 is negatively correlated with willingness-to-try. A negative relationship between past GPA and willingness-to-try for a new commitment device is intuitive—attaining high academic performance usually requires a high degree of self-control. Subjects with high GPA therefore either had an inherently high degree of self-control, or they might have access to other forms of commitment. The relationship between GPA and willingness-to-try is insignificant after controlling for gameplay experience. This suggests that the observed relationship between GPA and willingness-to-try is at least partially due to experience in gameplay.

3.5 Demand for the Commitment Devices

To ensure that treatment subjects understand the functionality of the devices, they were required to use each type of device at least once. I drop these first usages in my analysis.[16] Overall 38 out of the 48 treatment subjects (79%) used one of the three devices. Take-up rate is similar across willingness-to-try—of the 38, 6 indicated a willingness-to-try during sign-up, out of a total of 8 assigned to the treatment group (75%). Figure 3.3 plots throughout time the usage of each device as a percentage of the total number of treatment subjects. Usage are heavily concentrated between Week 3 and 4, and dropped off significantly by Week 6. It is possible that this reflects the faltering of initial curiosity. The drop also coincides with the end of spring break, when the combination of returning to school and heavy playing during the break might have made self-control easier even without commitment. The reminder at

[16]Specifically, the first observed usage of each device within each subject is dropped.

TABLE III

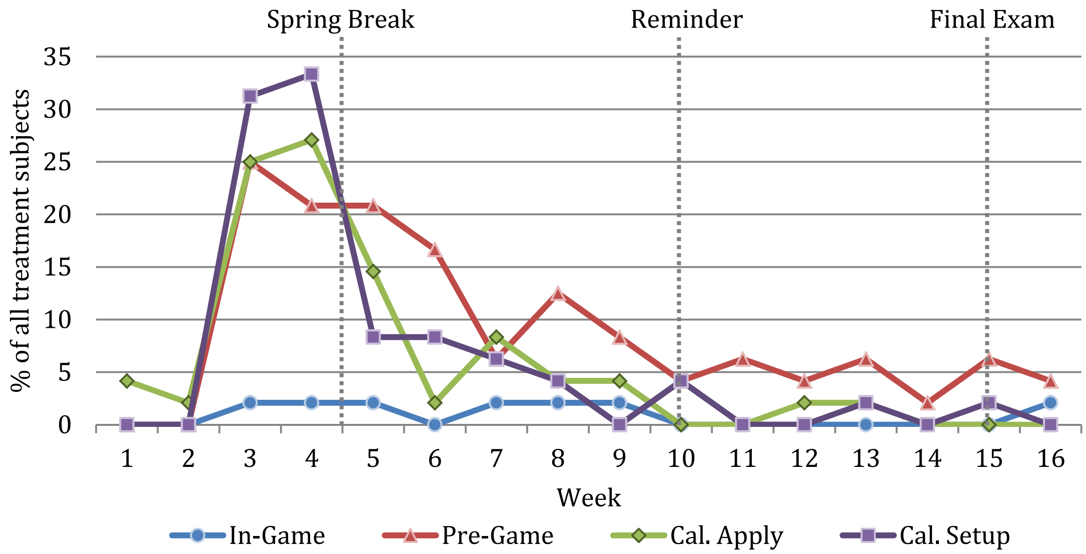
Willingness-to-Try and Grades

	WTT Dummy			
	(1)		(2)	
Fall 09 GPA	-0.200	**	-0.114	
	(0.096)		(0.082)	
Self-Reported Survey Data				
Academic Performance	0.025		-0.004	
	(0.040)		(0.049)	
Playing makes School Work Harder	-0.070		0.080	
	0.099)		(0.089)	
Social Life - In-Game	-0.011		0.053	
	(0.028)		(0.032)	
Social Life - Out of Game	0.033		-0.059	
	(0.041)		(0.040)	
Health	-0.044		0.050	
	(0.039)		(0.040)	
Happiness			0.102	
			(0.051)	
Yrs. Playing MMORPG			0.052	**
			(0.022)	
Yrs. Playing Video Games			-0.017	
			(0.013)	
Hours Played per Week			-0.012	**
			(0.005)	
N	51		51	

*Significant at 10%, **Significant at 5%, ***Significant at 1%. All regressions controlled for campus fixed-effects and standard errors are robust.

This table regresses the Willingness-to-Try dummy on subjects' fall 2009 grade-point-average. *WTT Dummy* = 1 if the potential subject expressed a willingness-to-pay of $1 to try out the commitment devices during sign-up, = 0 otherwise. *Playing Makes Sch. Harder* is ranked from 1-4, 1 being "rarely" and 4 being "always". *Social life*, *Happiness* and *Health* are ranked from 1-7, 7 being the highest.

Figure 3.3: Individual Device Take-Up Rate



This figure plots throughout time the usage of each device as a percentage of the total number of treatment subjects. *In-Game* represents usage of the In-Game Blocker while *Pre-Game* represents that of the Pre-Game Blocker. *Cal. Setup* represents the number of Calendar Blocks being set up, while *Cal. Apply* represents the number of Calendar Blocks that went into effect in the given week.

Week 10 has no discernible effect on commitment usage.

30 subjects voluntarily used the Calendar Blocker at least once, setting a median of 3 blocks and an average of 4.83. The number of calendar blocks in effect in each week is also shown in Figure 2 as *Cal. Apply*. 8 subjects had set up blocks that have effective dates before the time of setting. Since these blocks serve no functional purposes they are excluded from subsequent analysis. Among the remaining blocks, 35.1 percent of were set to be in effect within the same 24-hour period, while the rest were set to be effective by a median of 5.02 days and an average of 14.32 days later. Since calendar blocks need to be set up in advance, their usage might suggest that the decisions to launch a game were already time-inconsistent. For example, subjects might have anticipated cuing from friends or forum browsing. Habit formation could also be a contributing factor, as subjects could reduce their current play by making future playing prohibitively costly.

24 subjects voluntarily used the Pre-Game Blocker at least once, setting a median of 4 blocks and an average of 8.25. The median limit is 1.92 hours while the median block is

TABLE IV

COMMITMENT USAGE - STATISTICS

Calendar Blocker		
No. of Users	30	
No. of Uses	164	
Median Duration: Setup to Target (days)	0.9	
Median Block Duration (days)	1	
Pre-Game Blocker		
No. of Users	24	
No. of Uses	171	
Limit - Average. Within Subject		
Median, Across Subjects (hrs.)	1.92	
Average, Across Subjects (hrs.)	17.39	(50.94)
Block - Average Within Subject		
Median, Across Subjects (hrs.)	0.82	
Average, Across Subjects (hrs.)	0.89	(0.68)
In-Game Blocker		
No. of Users	10	
No. of Uses	15	
Limit - Average Within Subject		
Median, Across Subjects (hrs.)	2.5	
Average, Across Subjects (hrs.)	5.05	(7.20)

Standard deviations in parentheses.

0.79 hours. While the numbers of users and uses are both lower than those of the Calendar Blocker, they were more spread-out through time—in the second half of the experiment an average of 4.9 percent of treatment subjects used the Pre-Game Blocker, while only 0.9 percent of subjects used the Calendar Blocker. This difference was perhaps due to the prompt display of the Pre-Game Blocker every time the game started, which served as a form of reminder that the Calendar Blocker lacked in the later stages of the experiment.

10 subjects voluntarily used the In-Game Blocker at least once. All 10 subjects have also used another device voluntarily—all 10 used the Pre-Game Blocker, and 8 used the Calendar Blocker also. In all there were only 15 uses of the In-Game Device. The low utilization of In-Game Blocker was perhaps due to the continuous play-style of MMORPGs, as the constant attention required made triggering the device costly.

The evidence on overlapping commitment usage is not strong. Among the 38 subjects, 8 used all three devices and another 10 used two. 7 of the 18 have set up blocks that have potentially overlapping effects, defined as two different types of blocks coming into effect within 12 hours of each other, and both allowed for game-play before the sooner of the two blocks.[17] The mean number of overlaps is 2.7 while median number of overlaps is 1. While these subjects used the commitment devices more often than the average subject (mean= 17.1, median= 15), the mean and median percentages of total usage the overlaps represent still stood at 41.9 percent and 40 percent, largely due to the high ratio of overlaps-to-usage among light users. The model in the previous section proposes that these 7 subjects, representing 14.6 percent of the treatment group, might have believed that they were vulnerable to cues. There are two alternative explanations to the behavior. First, it is possible that the subjects had simply forgotten that they had previously set up a block, though the software was designed to reduce the chance of such incidents by reminding the player of any blocks coming into effect within the same day. Second, given that the average session in the treatment group was only 0.74 hours long, a block set to be in effect 12 hours away might

[17] The number of subjects with overlaps is fairly stable to the bound on time difference—6 subjects if I lower the bound to 6 hours and 8 subjects if I raise the bound to 24 hours.

not be an effective one. One could argue, however, that this is effectively the same argument as cue-sensitivity. For the player to have set up ahead of time the block that came into effect later, she must have anticipated a positive chance that she would not be able to set up the block that would eventually come into effect earlier.

3.6 Correlates of Demand for the Commitment Devices

Table V-A predicts total device usage by subject characteristics available at the beginning of the experiment. Only self-reported happiness is significantly correlated with number of uses in the ordinary least-square regression, with subjects who had reported they were happier before the experiment began being less likely to use the devices. This observation supports the theory that usage of commitment devices was a response to perceived sub-optimal playing. Moreover if overplaying decreases happiness, subjects being happier would indicate that they were indeed playing optimally rather than being naïve about their time-inconsistency.

The willingness-to-try dummy has negative coefficients in all three regressions, indicating that subjects with preference for being in treatment ended up using fewer commitments. This might be the result of these subjects having lower demand for gameplay, as well as some other subjects having developed a high demand for the commitment devices after being mandated to try them.

Table V-B regresses the mean difference between the effective date and the setting date of Calendar Blocks for each subject on subject characteristics available at the beginning of the experiment. Subjects who had expressed a willingness-to-try for the commitment devices, as well as subjects with a higher Fall 2009 GPA, are estimated to have set up Calendar Blocks further ahead in time. Statistical significance, however, depends on the number of self-reported attributes included in the regressions. The estimated effect of willingness-to-pay is insignificant once experience of play is controlled for.

TABLE V-A

PREDICTING DEVICE USAGE

	Number of Uses	Usage Dummy	
	(OLS)	(OLS)	(Logistic)
WTT Dummy	-4.910	-0.398 **	-0.329
	(4.112)	(0.152)	(0.231)
Predicted Hours Played 3/07-3/13	0.042	0.001	0.007
	(0.269)	(0.010)	(0.009)
Self-Reported Survey Data			
Playing makes Sch. Work Harder	0.766	-0.027	-0.029
	(2.356)	(0.087)	(0.060)
Health	0.600	0.041	0.044
	(1.176)	(0.043)	(0.034)
Happiness	-3.414 **	-0.017	-0.048
	(1.636)	(0.061)	(0.069)
Yrs. Playing MMORPG	0.157	-0.008	-0.009
	(0.523)	(0.019)	(0.017)
Yrs. Playing Video Games	-0.031	0.011	0.013
	(0.383)	(0.014)	(0.012)
Hours Played per Week	-0.078	0.004	-0.001
	(0.273)	(0.010)	(0.008)
Constant	22.370	0.695	
	(13.233)	(0.489)	
N	45	45	45

*Significant at 10%, **Significant at 5%, ***Significant at 1%. Coefficients in the logistic regression are average marginal effects.

This table regresses two measures of device usage on information available before 3/7. *Number of Uses* is a player's total voluntarily usage of all three devices. Usage Dummy = 1 if the player voluntarily used any of the three devices at least once, = 0 otherwise. *WTT Dummy* = 1 if the potential subject expressed a willingness-to-pay of $1 to try out the commitment devices during sign-up, = 0 otherwise. *Playing Makes Sch. Harder* is ranked from 1-4, 1 being "rarely" and 4 being "always". *Happiness* and *Health* are ranked from 1-7, 7 being the highest. Three subjects were dropped from the regressions because they did not submit a prediction, resulting in the final observation count of 45 subjects.

TABLE V-B

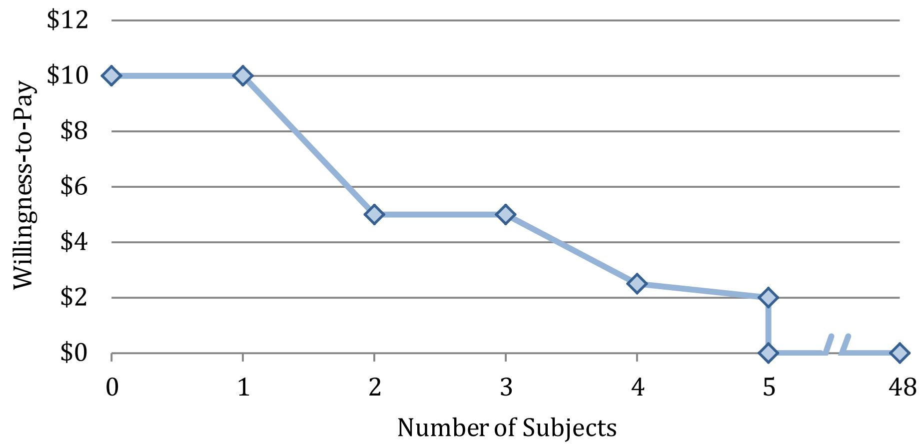
CALENDAR BLOCK SETUP ON WILLINGNESS-TO-TRY AND GRADES

	Mean(Apply Date – Setup Date)			
	(1)	(2)	(3)	(4)
WTT Dummy	0.285	8.854 **	6.763	2.447
	(1.383)	(3.491)	(3.984)	(19.689)
Fall 09 GPA	2.465	1.713 **	4.690 **	
	(1.672)	(1.169)	(2.008)	
Self-Reported Survey Data				
Academic Performance		1.713		-4.367
		(1.169)		(7.560)
Playing makes School Work Harder		1.837		3.713
		(1.047)		(10.022)
Social Life - In-Game		1.160		1.699
		(1.058)		(6.891)
Social Life - Out of Game		-0.743		7.281
		(0.555)		(8.119)
Health		2.221 ***	-1.501 **	5.185
		(0.609)	(0.517)	(5.415)
Happiness		-0.349 **	-0.535	-4.038
		(0.457)	(0.672)	(8.106)
Yrs. Playing MMORPG			-0.082	5.779
			(0.228)	(2.251)
Yrs. Playing Video Games			0.226	3.672
			(0.270)	(1.929)
Hours Played per Week			0.044	-0.887
			(0.087)	(1.057)
N	16	16	16	30

*Significant at 10%, **Significant at 5%, ***Significant at 1%. Standard errors are robust.

This table regresses the mean difference between apply date and setup date of Calendar Blocks for each subject on Willingness-to-Try dummy and subjects' fall 2009 GPA. *WTT Dummy* = 1 if the potential subject expressed a willingness-to-pay of \$1 to try out the commitment devices during sign-up, = 0 otherwise. *Playing Makes Sch. Harder* is ranked from 1-4, 1 being "rarely" and 4 being "always". *Social life*, *Happiness* and *Health* are ranked from 1-7, 7 being the highest.

Figure 3.4: Willingness-to-Pay for BlokSet



This figure plots the number of treatment subjects with a demand for BlokSet at a given price, according to the willingness-to-pay solicited with a Becker-DeGroot-Marschak mechanism at the end of the experiment.

3.7 Willingness-to-Pay for Commitment

Five treatment subjects indicated a positive willingness-to-pay under the Becker-DeGroot-Marschak mechanism (Becker et al., 1964) conducted at the end of the experiment, for an average of $4.90.[18] Given that BlokSet has no other use other than to block oneself from launching games, the positive willingness-to-pay manifested by these subjects suggests that they desired to use the BlokSet to limit their duration of play, which in turn implies that they believed they were suffering from overplaying. The small number of subjects (10.4 percent) with willingness-to-pay indicates that most subjects did not perceive the commitment devices to be useful.[19]

Figure 3.4 plots the willingness-to-pay for subjects with positive willingness-to-pay. Of the five subjects, two indicated a willingness-to-try during sign up. Thus 25 percent of the subjects with a willingness-to-try had a positive final willingness-to-pay, versus 7.5 percent among those without. While the sample size is too small to draw a statistically meaningful

[18]In comparison, Microsoft's newest operating system, Windows 7, had a student price tag of $29.99, while the average price of a newly released computer game is $40. Windows 7 price as quoted on http://www.win741.com. Computer game prices are based on author's survey of Amazon.com listing of newly released game in November.

[19]Subjects who did not provide a valid response are categorized as having a willingness-to-pay of zero, which gives the most conservative estimate of willingness-to-pay.

inference, this is suggestive evidence that while most players could be correct on whether they need commitment, a non-trivial sub-population might be not.

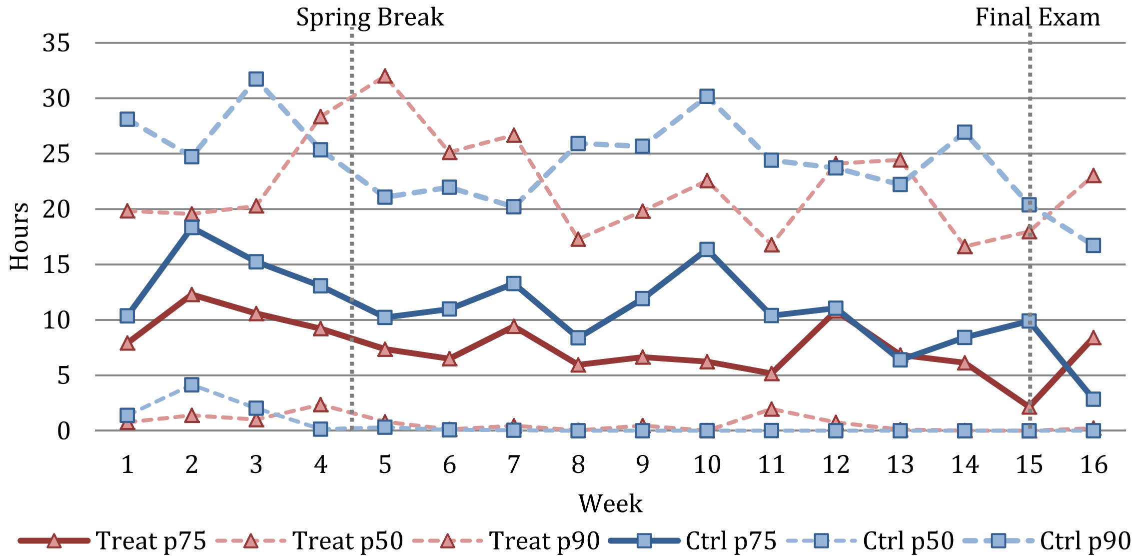
3.8 Effects on Duration of Play

Overall, treatment subjects played less as measured by three different methods—total hours played, session length and number of sessions. Throughout the three-and-a-half month period, subjects in the treatment group played an average total of 52.32 hours, versus 85.83 hours in control. The average session length was 0.74 hours versus 1.2 hours, while the average number of sessions was 51.10 versus 67.53.

Figure 3.5 plots the weekly hours played by the median, the 75th percentile and the 90th percentile subject in each group. It shows that the difference in duration of play across treatment and control was largely driven by the heavier players. The 75th percentile treatment subject played on average 7.65 hours per week, while the equivalent control subject played 11.13. Although treatment subjects played less than control in all three percentiles, the differences between the median and 90th percentiles within each group (22.33 and 24.13 respectively) indicate a high degree of variance. There is a general decline in hours played throughout the experiment. "Loss of interest" is the most common explanation being given by subjects when surveyed on why they stopped playing.

Table VI-A and Table VI-B compares duration-of-play measurements of the treatment group versus the control group, controlling for self-reported experience in game-play and campus affiliation. Subjects in the treatment group played significantly shorter duration, as measured by either total number of hours played (column 1) or hours played in a session (column 5). In Table VI-A, the estimated reduction in total hours played is 66.4 percent of the average figure of control subjects, while the reduction in mean session length is 44.2 percent. The change in number of sessions played (column 3), on the other hand, is not significant. Consistent with the model in the previous section, this suggests that players who used the commitment devices believed that they might play with suboptimal duration, but

Figure 3.5: Weekly Hours Played



This figures plots throughout time the average number of hours played in a given week. *Treat* represents the treatment group while *Ctrl* represents the control group. pN is the Nth percentile.

not suboptimal frequency. The estimated treatment effects are larger than the differences in simple mean because treatment subjects on average reported themselves to be heavier players and more experienced in playing, both of which are positively correlated with duration of play.

Given that the distribution of hours played was heavily skewed, another way of looking at the treatment effect is to ask how much less control subjects needed to play in order to match the mean duration played by the treatment subjects. The difference between the mean total duration played by the treatment group and by the control group could have been eliminated if either all control subjects played 39.04 precent less, the top half played 39.11 percent less, the top quartile played 46.62 percent less, or the top decile played 74.93 percent less.

The second set of regressions breaks up the effects according to willingness-to-try. Control subjects without willingness-to-try serves as the baseline case. *Treatment Dummy* now captures the average difference being a treatment subject without willingness-to-try, while *WTT Dummy* captures the difference as a control subject with willingness-to-try. Adding

TABLE VI-A

EFFECTS OF AVAILABILITY OF COMMITMENT ON DURATION-OF-PLAY

	Total Hrs. Played		Session Count		Mean Session Length (hrs.)	
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment Dummy	-56.990 **	-78.742 **	-25.552	-44.175 *	-0.530 ***	-0.550 ***
	(27.927)	(32.820)	(19.852)	(23.649)	(0.168)	(0.181)
WTT Dummy		-71.788 ***		-64.419 **		-0.206
		(25.582)		(25.068)		(0.686)
Treatment Dummy		111.303 ***		95.481 ***		0.171
* WTT Dummy		(37.367)		(32.156)		(0.765)
Self-Reported Survey Data						
Yrs. Playing MMORPG	-4.363	-4.867	-3.789	-4.149	-0.039	-0.037
	(6.423)	(6.671)	(3.916)	(4.105)	(0.033)	(0.035)
Yrs. Playing Video Games	3.801	4.465	0.302	0.843	0.045 *	0.046 *
	(3.971)	(3.997)	(3.277)	(3.338)	(0.024)	(0.024)
Hours Played per Week	4.387 ***	4.159 ***	2.853 ***	2.643 ***	0.022 ***	0.021 **
	(1.405)	(1.393)	(0.945)	(0.960)	(0.008)	(0.009)
N	105	105	105	105	66	66
Mean – Treatment	52.32		51.10		0.74	
Mean – Control	85.83		67.53		1.20	

*Significant at 10%, **Significant at 5%, ***Significant at 1%. All regressions are ordinary least-square, controlled for campus fixed-effects. Robust standard errors in parentheses.

Table VI regresses three measures of duration-of-play on 2x2 group assignments, interactions and self-reported survey data. *Treatment Dummy* = 1 if the potential subject was assigned to the treatment group, = 0 if assigned to control group. *WTT Dummy* = 1 if the potential subject expressed a willingness-to-pay of $1 to try out the commitment devices during sign-up, = 0 otherwise.

TABLE VI-B

EFFECTS OF AVAILABILITY OF COMMITMENT ON DURATION-OF-PLAY - LOG

	log(1+Total Hrs. Played)		log(1+Session Count)		log(1+Mean Session Length)	
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment Dummy	-0.904 **	-1.422 ***	-0.587	-1.022 **	-0.251 ***	-0.251 ***
	(0.423)	(0.468)	(0.401)	(0.444)	(0.084)	(0.088)
WTT Dummy		-2.165 ***		-2.026 ***		-0.017
		(0.503)		(0.461)		(0.400)
Treatment Dummy		2.678 ***		2.253 **		0.005
* WTT Dummy		(0.884)		(0.915)		(0.448)
Self-Reported Survey Data						
log(1+yrs. - MMO)	-0.634	-0.617	-0.539	-0.494	-0.093	-0.091
	(0.440)	(0.471)	(0.434)	(0.463)	(0.072)	(0.075)
log(1+yrs. - video games)	1.159 *	1.285 **	0.998 *	1.092 *	0.222 **	0.223 **
	(0.601)	(0.576)	(0.584)	(0.577)	(0.104)	(0.102)
log(1+hrs. played/week)	1.566 ***	1.439 ***	1.324 ***	1.200 ***	0.210 ***	0.209 ***
	(0.252)	(0.274)	(0.251)	(0.271)	(0.056)	(0.064)
N	105	105	105	105	86	86
Mean – Treatment	52.32		51.10		0.74	
Mean – Control	85.83		67.53		1.20	

*Significant at 10%, **Significant at 5%, ***Significant at 1%. All regressions are ordinary least-square, controlled for campus fixed-effects. Robust standard errors in parentheses.

Table VI regresses measures of duration-of-play under an expanded game list on group assignments, interactions and self-reported survey data. *Treatment Dummy* = 1 if the potential subject was assigned to the treatment group, = 0 if assigned to control group. *WTT Dummy* = 1 if the potential subject expressed a willingness-to-pay of $1 to try out the commitment devices during sign-up, = 0 otherwise.

the two dummies with the interaction term gives us the difference for treatment subjects with willingness-to-try. Just as one would expect, the estimated coefficients suggest that all three on average played less than control subjects without willingness-to-try. What is perhaps more surprising though is that the estimated difference is smallest for treatment subjects with willingness-to-try. Estimated reduction in total number of hours played (column 2) is 78.7 for treatment subjects without willingness-to-try, 71.8 for control subjects with willingness-to-try, but only 39.2 for treatment subjects with willingness-to-try. While the hypothesis that the estimated differences are identical cannot be rejected at the 5 percent confidence interval ($F = 4.34$, $p = 0.081$), treatment subjects with willingness-to-try having the smallest difference is consistent with the story that willingness-to-try is a proxy for sophisticated players, who voluntarily play less in the absence of a commitment device. This is supported by the estimated differences in number of sessions played (column 4)—the hypothesis that treatment subjects with willingness-to-try were playing an equal number of sessions as control subjects with willingness-to-try is rejected ($F = 26.72$, $p = 0.004$). Thus treatment subjects with willingness-to-try might be playing shorter sessions, but they were certainly playing more sessions. This is what one would expect from sophisticated players—with commitment, overplaying is no longer a threat, which allows these players to play on occasions which they believe they would otherwise overplay.

While the treatment effect is significant, it is unclear what portion of it can be attributed to the availability of commitment devices. From Figure 3.5, it is apparent that the effect persisted after most subjects stopped using commitment. The difference could be due the 2x2 design not being able to completely control for self-selection. It is also possible that the availability of commitment devices cued the subjects into believing that they had played too much in the past, and as such voluntarily chose to play less during the experiment.

Two questions regarding the results are addressed in the appendix. The first question is whether there is substitution towards other forms of consumption. Section A.1 addresses one particular aspect of this issue—whether subjects were substituting towards other games. It demonstrates that while mean duration of play increases when one considers the expanded list of games, the estimated treatment effect remains. The second is whether the same treatment effect is observed in other time-consuming computer activities. Section A.2 shows that there is no significant difference in time spent on internet browsing.

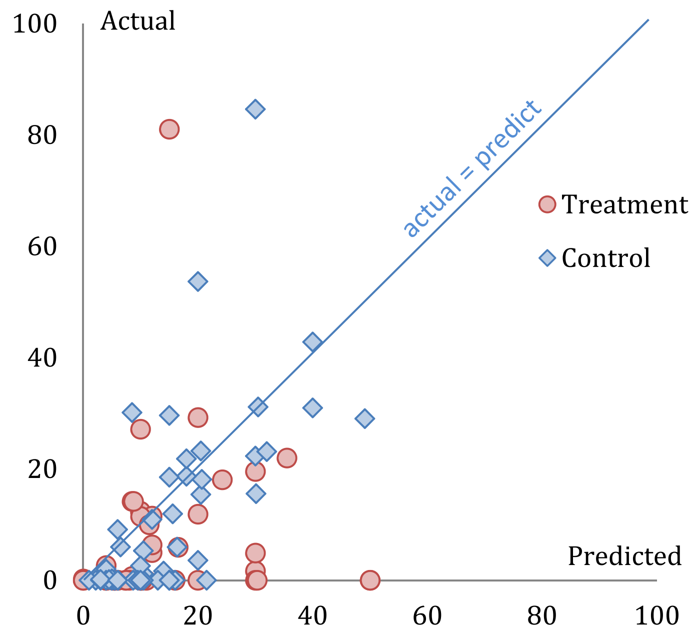
3.9 Prediction

Nine subjects had not yet installed their assigned software package for the week they were told to predict hours of play and are thus excluded. Figure 3.6 plots subjects' self-predicted durations of play against their actual durations of play. There was significant overestimation. The mean difference between predicted and actual durations is 4.72 hours ($T = 3.34$, $p = 0.001$). Given the average actual duration of play is 9.29 hours, this represents a 50.1 percent overestimation. The overestimation was driven by a large number of subjects who had predicted positive durations of play but ended up not playing. The overestimation was insignificant without those subjects (mean$= 1.89$, $T = 0.99$, $p = 0.324$). The difference persists even if one compares the prediction with average hours played per week from March 7th–March 27th (mean$= 6.15$, $T = 4.55$, $p = 0.000$), so the overestimation does not seem to be due to subjects using average duration of play as a heuristic for prediction.

One might hypothesize that the availability of commitment devices allowed some treatment subjects to commit to not playing, thereby causing what seems to be an overestimation. On the surface this was not the case, as the difference is significant both within the control group (mean$= 3.64$, $T = 2.1$, $p = 0.041$) and the treatment group (mean$= 5.98$, $T = 2.53$, $p = 0.015$). Table VII regresses the prediction error—the absolute difference between actual and predicted hours of play—on predicted hours of play and self-reported play characteristics. The regression shows that subjects who predicted a longer duration of play made bigger errors. Furthermore, prediction error decreases with neither self-reported experience in gaming nor actual duration of play.

What could have driven the overestimation? It is possible that the subjects simply had

Figure 3.6: Total Hours Played 3/7 - 3/13



no idea how long they were going to play or were giving an answer to a different question than the one asked. Section A.1 of the appendix provides suggestive evidence that subjects might have been thinking of hours played on all games when answering the question. It is also possible that the subjects had access to more than one computer and reported their duration of play on all computers, even though I specifically asked them to predict usage on the computer I was monitoring. Finally, subjects might have reported a prediction that was larger than their actual prediction so as to avoid being observed as overplaying.

4 Conclusion

I developed a model investigating how a time-inconsistent game player would behave with and without access to commitment devices. The model makes a few predictions. First, players who are aware of their time-inconsistency play weakly shorter and weakly fewer sessions. Second, only players aware of their time-inconsistency would use a commitment device. Third, when a commitment device is available, sophisticated players play weakly

TABLE VI

PREDICTION ERROR – OLS REGRESSION

	|Actual Hrs. Played – Prediction|	
Treatment Dummy * Prediction	0.664	**
	(0.254)	
Control Dummy * Prediction	0.208	***
	(0.051)	
Treatment Dummy	-4.029	
	(3.420)	
Self-Reported Survey Data		
Yrs. Playing MMORPG	0.094	
	(0.287)	
Yrs. Playing Video Games	0.075	
	(0.262)	
Hours Played per Week	0.135	
	(0.243)	
N	97	

*Significant at 10%, **Significant at 5%, ***Significant at 1%. All regressions controlled for campus fixed-effects and all standard errors adjusted for campus clusters.

This table regresses the players' prediction error on treatment assignments, interactions with player-reported predicted hours and survey data. *Actual Hrs. Played* is the recorded number of hours the subject played in the week of 3/07-3/13. *Prediction* is predicted hours of play submitted by the subject for the same week. *Treatment Dummy* = 1 if the subject was assigned to the treatment group, = 0 if assigned to control group. *Control Dummy* = 1 – *Treatment Dummy*.

shorter but weakly more sessions. Fourth, the model predicts that only cue-sensitive players would use multiple commitment devices during the same game session.

I conducted a field experiment in which the time undergraduate players of a popular type of online game spent playing was monitored. Treatment subjects received a software that, in addition, allowed them to limit their duration of play. During recruitment, potential subjects were incentivized to report whether they would like to be assigned to the treatment group. Subjects who reported they would like to be assigned to treatment have significantly lower academic performance in the previous semester, as measured by their grade-point-average. The effect becomes insignificant after controlling for self-reported time spent in game playing, suggesting that the lower grade-point-average might have been caused by heavy playing.

The predictions of the model were consistent with the playing pattern observed in the experiment, though the relationship between the use of commitment devices and decreased playing time is only suggestive. There was a sizable usage of commitment devices during the initial month of the experiment and a statistically significant difference in the amount of time spent playing between the treatment group and the control group, but there was no statistically significant difference in the number of game sessions played.

The results suggest several extensions for future study. First, there are a number of important behavioral phenomena that are not investigated in my model. The ways in which habit formation, time-inseparability and additional sources of randomness beyond a single shock to instantaneous utility would affect the predictions of the model, and to what extent they can explain the observed behavior, remain to be explored. Second, is it unclear to what degree the decrease in duration of play was due to the framing of playing being an undesirable behavior. Future work could frame the activity more neutrally to investigate these effects. Finally, given that subjects in this study overestimated their future duration of play by more than 50 percent, it would be interesting to investigate whether a similar overestimation occurs with recalls. Almost all existing studies on the effects of video-gaming on academic performance and social outcomes have relied on non-incentivized, self-reported data from players. If players tend to under-report duration of play, the estimates in existing studies would be biased towards reporting large effects. Given the suggestive evidence that the overestimations were due to the subjects reporting the time they spent on all games, this bias is more likely to affect studies that focus on a limited set of games. Further, while incentivizing the reporting could mitigate the problem, it also has the downside of potentially being used by the subjects as a commitment device.

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A Robustness Checks

A.1 Expanding the Number of Game Titles

A natural question regarding the effectiveness of any commitment device is substitution towards other forms of consumption. This section addresses one particular aspect of this issue—whether subjects were substituting towards other games. Ideally one would compute total duration of play over a comprehensive list of all games. Unfortunately such a list does not exist to my knowledge.[20] The list of games used in this section was instead constructed based on my knowledge of existing games and an examination of the data. It includes 15 more games that were not reported by any player as being played. The majority of these games are not MMORPGs—there are poker games and strategy games, among others—which is not surprising given that the subjects were only asked of what MMORPGs they had been playing. Table VII-A demonstrates that while mean duration of play increases under the expanded list of games, the estimated treatment effect remains.

[20] More precisely, it is a comprehensive list of game *executables* that does not exist. Game executables do not always bear filenames that resemble the title of their respective games, and a single title is often comprise of multiple executables.

TABLE VII-A

EFFECTS OF AVAILABILITY OF COMMITMENT ON DURATION-OF-PLAY – EXPANDED GAME LIST

	Total Hrs. Played		Session Count		Mean Session Length (hrs.)	
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment Dummy	-60.424 *	-78.799 *	-49.147 **	-54.511	-0.293 **	-0.358 **
	(23.981)	(31.260)	(14.846)	(30.476)	(0.099)	(0.108)
WTT Dummy		-73.555 *		-43.613		-0.360 *
		(35.137)		(112.720)		(0.175)
Treatment Dummy		94.832		29.063		0.359
* WTT Dummy		(55.241)		(117.909)		(0.262)
Self-Reported Survey Data						
Yrs. Playing MMORPG	-3.754	-3.867	-8.510 *	-8.008 *	-0.002	-0.001
	(2.738)	(2.783)	(3.543)	(3.280)	(0.020)	(0.017)
Yrs. Playing Video Games	3.539 *	3.980 *	2.065	1.988	0.023	0.025 *
	(1.440)	(1.577)	(4.090)	(4.706)	(0.016)	(0.012)
Hours Played per Week	4.057	3.799	2.447	2.258	0.014	0.012
	(2.083)	(2.107)	(1.586)	(1.538)	(0.009)	(0.009)
N	105	105	105	105	86	86
Mean – Treatment	73.138		121.938		0.491	
Mean – Control	112.285		159.702		0.772	

*Significant at 10%, **Significant at 5%, ***Significant at 1%. All regressions are ordinary least-square, controlled for campus fixed-effects and all standard errors adjusted for campus clusters.

This table regresses measures of duration-of-play under an expanded game list on group assignments, interactions and self-reported survey data. *Treatment Dummy* = 1 if the potential subject was assigned to the treatment group, = 0 if assigned to control group. *WTT Dummy* = 1 if the potential subject expressed a willingness-to-pay of $1 to try out the commitment devices during sign-up, = 0 otherwise.

The expanded list of game is also a robustness check for the overestimation in self-predicted durations of play. With the expanded list control subjects were no longer overestimating how much they would play (mean= -2.39, $T = -1.35$, $p = 0.182$), while treatment subjects continue to do so (mean= -5.73, $T = -2.46$, $p = 0.018$). This could suggest that subjects were in fact accurate in their prediction on average, the overestimation observed among treatment subjects being the result of commitment usage. Nevertheless, it is arguable whether this constitutes evidence that subjects were not overestimating, as subjects were asked to predict how much time they would spend playing MMORPGs only.

A.2 Treatment Effects on Internet Browsing

To ensure the treatment effect is in fact due to the presence of commitment devices for games, this section investigates whether a similar reduction exists in another time-consuming computer activity—internet browsing. Table VII-B shows there is the estimated differences for internet browsing has the same signs, but statistically insignificant. This also implies that the use of commitment devices on games did not result in substitution towards internet browsing.

B Derivation of the Model

(Not for publication)

B.1 Setup

Lemma 1. *The player never chooses to play in Period 3.*

Proof. The player choose to play in Period 3 if

$$\eta + \epsilon - \beta C(n_2 + 1) \quad \geq \quad -\beta\delta C(n_2) \tag{B.1}$$

$$\eta + \epsilon \quad > \quad \beta c(n_2 + 1) \tag{B.2}$$

TABLE VII-B

EFFECTS OF AVAILABILITY OF COMMITMENT ON TIME SPENT ON INTERNET BROWSING

	Total Hrs. Browsed		Session Count		Mean Session Length (hrs.)	
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment Dummy	-51.542	-56.198	358.502	436.858	-0.057	-0.012
	(50.311)	(63.058)	(315.010)	(352.148)	(0.133)	(0.182)
WTT Dummy		-29.723		-35.226		0.136
		(130.461)		(304.437)		(0.249)
Treatment Dummy		24.722		-382.620		-0.237
* WTT Dummy		(151.640)		(502.342)		(0.239)
Self-Reported Survey Data						
Yrs. Playing MMORPG	-4.075	-3.835	-5.035	3.888	0.005	0.006
	(14.012)	(14.709)	(27.375)	(30.354)	(0.016)	(0.017)
Yrs. Playing Video Games	-5.957	-5.948	28.909	23.780	-0.008 **	-0.009 *
	(13.513)	(13.384)	(34.124)	(32.171)	(0.003)	(0.004)
Hours Played per Week	0.805	0.683	-5.587	-6.267	0.009	0.009
	(3.155)	(3.177)	(8.324)	(7.380)	(0.005)	(0.006)
N	105	105	105	105	96	96
Mean – Treatment	293.725		1162.354		0.436	
Mean – Control	348.338		798.877		0.507	

*Significant at 10%, **Significant at 5%, ***Significant at 1%. All regressions are ordinary least-square, controlled for campus fixed-effects and all standard errors adjusted for campus clusters.

This table regresses measures of internet browsing on group assignments, interactions and self-reported survey data. *Treatment Dummy* = 1 if the potential subject was assigned to the treatment group, = 0 if assigned to control group. *WTT Dummy* = 1 if the potential subject expressed a willingness-to-pay of $1 to try out the commitment devices during sign-up, = 0 otherwise.

Assumption 1 thus precludes the player from choosing to play in this period. □

B.2 Strategy without Commitment

Denote the threshold for Period t given β and $\hat{p}$ as $x_t(n_{t-1}, \beta, \hat{p}, \epsilon)$, the time-consistent threshold as $\bar{x}_t^{n_{t-1}} \equiv x_t(n_{t-1}, 1, \hat{p}, \epsilon)$ and the player's perceived threshold as $\hat{x}_t^{n_{t-1}} \equiv x_t(n_{t-1}, \hat{\beta}, \hat{p}, \epsilon)$, where $n_{t-1} \equiv a_1 + ... + a_{t-1}$ the total number of periods played on or before $t-1$. The threshold depends on ϵ itself because future thresholds also depend on ϵ, and they in turn affect the current threshold. Denote the player's belief of $a_{t'}$ given a_t, $t' > t$, as $\hat{a}_{t'}^t$ and the U_t-maximizing action as $\bar{a}_{t'}^t$.

Lemma 2. *x_t is strictly increasing in β.*

Proof. First solve the model with backward induction.

Period 2. Because the player would never voluntarily choose to play in Period 3, the player only needs to take into consideration the probability of overplaying due to cues, and thus

$$x_2(n_1, \beta, \hat{p}, \epsilon) = \beta \left[\hat{p}c(n_1 + 2) + (1 - \hat{p})c(n_1 + 1)\right] - \eta \tag{B.3}$$

Since the Period 2 threshold does not depend on ϵ, from now on I drop ϵ from the argument list from x_2.Taking the partial derivative with respect to β,

$$\frac{\partial x_2}{\partial \beta} = \hat{p}c(n_1 + 2) + (1 - \hat{p})c(n_1 + 1) > 0$$

Period 1. The expected utility of choosing to play is

$$\begin{aligned} V_1(1, \varnothing) = u_1(1) + \beta\{\hat{q}_2^1 \left[\hat{p}\left(u_2(1) + u_3(1) - C(3)\right) + (1 - \hat{p})\left(u_2(1) - C(2)\right)\right] \\ + (1 - \hat{q}_2^1)\left[\hat{p}\left(u_3(1) - C(2)\right) + (1 - \hat{p})\left(-C(1)\right)\right]\} \end{aligned} \tag{B.4}$$

where $\hat{q}_2^{n_1} = \mathbf{1}(\epsilon > \hat{x}_2^{n_1}) + [1 - \mathbf{1}(\epsilon > \hat{x}_2^{n_1})]\,\hat{p}$ is the perceived probability of playing in Period

2. The expected utility of not choosing to play is

$$V_1(0,\varnothing) = \beta\{\hat{q}_2^0\left[\hat{p}\left(u_2(1)+u_3(1)-C(2)\right)+(1-\hat{p})\left(u_2(1)-C(1)\right)\right] \\ +(1-\hat{q}_2^0)\hat{p}\left[u_3(1)-C(1)\right]\} \quad \text{(B.5)}$$

so

$$x_1(0,\beta,\hat{p},\epsilon) = \frac{\beta\left\{\hat{q}_2^1\left[\hat{p}c(3)+(1-\hat{p})c(2)\right]+(1-\hat{q}_2^0)\left[\hat{p}c(2)+(1-\hat{p})c(1)\right]\right\}}{1+\beta(\hat{q}_2^1-\hat{q}_2^0)} - \eta \quad \text{(B.6)}$$

Because $\hat{q}_2^{n_1}$ does not depend on β, $x_1(0,\beta,\hat{p},\epsilon)$ is differentiable over β and we can take derivative,

$$\begin{aligned}\frac{\partial x_1}{\partial \beta} &= \left\{\hat{q}_2^1\left[\hat{p}c(3)+(1-\hat{p})c(2)\right]+(1-\hat{q}_2^0)\left[\hat{p}c(2)+(1-\hat{p})c(1)\right]\right\} \\ &\quad \times\left\{\frac{1}{1+\beta(\hat{q}_2^1-\hat{q}_2^0)}-\frac{\beta(\hat{q}_2^1-\hat{q}_2^0)}{\left[1+\beta(\hat{q}_2^1-\hat{q}_2^0)\right]^2}\right\} && \text{(B.7)} \\ &= \left\{\hat{q}_2^1\left[\hat{p}c(3)+(1-\hat{p})c(2)\right]+(1-\hat{q}_2^0)\left[\hat{p}c(2)+(1-\hat{p})c(1)\right]\right\} \\ &\quad \times\left[\frac{1}{1+\beta(\hat{q}_2^1-\hat{q}_2^0)}\right]^2 && \text{(B.8)}\end{aligned}$$

The first part of (B.8) is the expected cost of playing in Period 1, which is positive, so $\partial x_1/\partial\beta > 0$. □

Lemma 3. *x_2 is strictly increasing in $\hat{p}$ and does not change with $\hat{\beta}$. For x_1, there exist an $\tilde{\epsilon}$ such that x_1 is strictly increasing in $\hat{p}$ and weakly increasing in $\hat{\beta}$ if $\epsilon \le \tilde{\epsilon}$. If $\epsilon > \tilde{\epsilon}$, x_1 is strictly decreasing in $\hat{p}$ and $\hat{\beta}$ at a finite set of points for every ϵ, but is strictly increasing in $\hat{p}$ and invariant in $\hat{\beta}$ otherwise. The finite set of points is given by $\left\{(\hat{p},\hat{\beta})|\epsilon = \hat{x}_2^0 \text{ or } \epsilon = \hat{x}_2^1\right\}$.*

Proof. For x_2, (B.3) does not depend on $\hat{\beta}$. As for $\hat{p}$, take the partial derivative of (B.3),

$$\frac{\partial x_2}{\partial \hat{p}} = \beta\left[c(n_1+2)-c(n_1+1)\right] > 0$$

For x_1, because $\hat{q}_2^{n_1}$ depends on $\hat{p}$ and $\hat{\beta}$, it is not differentiable over the two and the analysis has to be done piecewise. Suppose $\epsilon > \hat{x}_2^1$ and denote this set of ϵ as $\epsilon_{\mathbf{h}}$. Since $\hat{x}_2^n > \hat{x}_2^{n'}$ for $n > n'$, $q_2^n \leq q_2^{n'}$ and $\hat{q}_2^1 = 1$, $\hat{q}_2^0 = 1$. (B.6) becomes

$$x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{h}}) = \beta \left[\hat{p}c(3) + (1-\hat{p})c(2)\right] - \eta \tag{B.9}$$

It is apparent that $\partial x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{h}})/\partial\hat{p} > 0$ and $\partial x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{h}})/\partial\hat{\beta} = 0$.

If the player believes instead she is going to choose to play in Period 2 only if she has not played in Period 1, then $\hat{x}_2^0 < \epsilon < \hat{x}_2^1$. Denote this set of ϵ as $\epsilon_{\mathbf{m}}$. Because $\hat{q}_2^0 = 1$ and $\hat{q}_2^1 = \hat{p}$, (B.6) becomes

$$x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{m}}) = \frac{\hat{p}}{1+\beta(\hat{p}-1)}\beta \left[\hat{p}c(3) + (1-\hat{p})c(2)\right] - \eta \tag{B.10}$$

Again it is apparent that $\partial x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{m}})/\partial\hat{p} > 0$ and $\partial x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{l}})/\partial\hat{\beta} = 0$. However since $\frac{\hat{p}}{1+\beta(\hat{p}-1)} \leq 1$, $x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{h}}) \geq x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{m}})$. So if $\epsilon = \hat{x}_2^1$ and $\hat{\beta}$ or $\hat{p}$ increases, x_1 weakly decreases.

$x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{m}}) > x_2(0, \beta', \hat{p})$ gives

$$\frac{\hat{p}\cdot\beta/\beta'}{1+\beta(\hat{p}-1)} > \frac{\hat{p}c(2) + (1-\hat{p})c(1)}{\hat{p}c(3) + (1-\hat{p})c(2)} \tag{B.11}$$

Notice that (B.11) always holds when $\beta = \beta' = 1$ and never holds when $\hat{p} = 0$.

Lastly, denote the set of $\epsilon < \hat{x}_2$ as $\epsilon_{\mathbf{l}}$. Because $q_2^{n_1} = \hat{p}\,\forall\, n_1$,

$$x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{l}}) = \beta \left\{\hat{p}\left[\hat{p}c(3) + (1-\hat{p})c(2)\right] + (1-\hat{p})\left[\hat{p}c(2) + (1-\hat{p})c(1)\right]\right\} - \eta \tag{B.12}$$

Once again it is apparent that $\partial x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{l}})/\partial\hat{p} > 0$ and $\partial x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{l}})/\partial\hat{\beta} = 0$. Furthermore it is easy to see that $x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{h}}) \geq x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{l}})$ and $x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{l}}) \geq x_2(0, \beta, \hat{p})$.

$x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{l}}) > x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{m}})$ gives

$$\frac{\beta \hat{p}}{1 + \beta(\hat{p} - 1)} < \frac{\hat{p}c(2) + (1 - \hat{p})c(1)}{\hat{p}c(3) + (1 - \hat{p})c(2)} \tag{B.13}$$

By (B.11) $x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{l}}) < x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{m}})$ when $x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{m}}) > x_2(0, 1, \hat{p})$. Since the transition from $\epsilon_{\mathbf{m}}$ to $\epsilon_{\mathbf{l}}$ depends on $\hat{x}_2^0$, $\tilde{\epsilon}$ corresponds to $x_2(0, \tilde{\beta}, \tilde{p})$, where $\tilde{\beta}$ and $\tilde{p}$ satisfy $x_1(0, \tilde{\beta}, \tilde{p}, \epsilon_{\mathbf{l}}) = x_2(0, 1, \hat{p})$. For the same reasoning as the case of $\epsilon = \hat{x}_2^1$ above, x_1 weakly decreases if $\epsilon > \tilde{\epsilon}$ and $\epsilon = \hat{x}_2^0$. Thus only if $\epsilon < \tilde{\epsilon}$ will x_1 be weakly increasing in $\hat{\beta}$ and $\hat{p}$. □

The non-monotonic relationship between sophistication and the threshold in Period 1 is perhaps surprising. This is due to the fact that the threshold in Period 1 depends on whether the player believes she is going to play in Period 2. A change in beliefs induces discrete jumps in x_1, which is otherwise generally increasing in $\hat{p}$. When the game is fun (high ϵ), the player is likely playing in both Period 1 and 2. As $\hat{\beta}$ or $\hat{p}$ increases, she eventually believes she is not going to choose playing in Period 2, and this causes the threshold in Period 1 to discretely decrease. In contrast, when the game is not very fun (low ϵ), the player will only be playing if she believes she is not going to overplay, and she will choose to play early and only in Period 1. Because she is not expecting herself to choose playing in Period 2, an increase in $\hat{p}$ can only make her less likely to play in Period 1.

Corollary 1. *Holding the initialization period fixed, number of periods the player chooses to play as well as the expected number of periods the player actually play are weakly decreasing in $\hat{p}$ and $\hat{\beta}$.*

Proof. Lemma 3 shows that x_1 only decreases if the player goes from planning to play in Period 2 to not doing so, and thus the drop in x_1 can at most induce the same number of planned periods of play. Outside of these cases, x_1 is strictly increasing in $\hat{p}$ and weakly increasing in $\hat{\beta}$, while x_2 is strictly increasing in $\hat{p}$ and invariant in $\hat{\beta}$. The number of periods the player would choose play is therefore weakly decreasing. □

Lemma 4. *$x_1(0, \beta, \hat{p}, \epsilon) = x_2(1, \beta, \hat{p}, \epsilon)$, and if $\epsilon > x_1(0, \beta, \hat{p}, \epsilon)$ then $\epsilon > x_2(0, \beta, \hat{p}, \epsilon)$.*

Proof. When $\epsilon \in \epsilon_{\mathbf{h}}$, (B.9) gives $x_2(0, \beta, \hat{p}, \epsilon_{\mathbf{h}}) = x_3^1$. Since $x_3^1 > x_3^0$, this proves the first part of the lemma. Furthermore, $\epsilon > x_2(0, \beta, \epsilon)$ implies $\epsilon > x_3(0, \beta)$ if $\epsilon \in \epsilon_{\mathbf{h}}$.

When $\epsilon \in \epsilon_{\mathbf{m}}$, if (B.11) holds for $\beta' = \beta$ then $\epsilon > x_2(0, \beta, \hat{p}, \epsilon)$ implies $\epsilon > x_3(0, \beta, \hat{p})$. When (B.11) does not hold for $\beta' = \beta$, there exists a range of ϵ where $x_2(0, \beta, \hat{p}, \epsilon_{\mathbf{m}}) < \epsilon < x_3(0, \beta, \hat{p}, \epsilon_{\mathbf{m}})$. However, since $x_3(0, \beta, \hat{p}, \epsilon_{\mathbf{m}}) < x_3(0, \hat{\beta}, \hat{p}, \epsilon_{\mathbf{m}}) = \hat{x}_3^0$, any ϵ in this range is also smaller than $\hat{x}_3^0$, which is outside of $\epsilon_{\mathbf{m}}$.

Lastly, when $\epsilon \in \epsilon_{\mathbf{l}}$, it is easy to see from (B.12) that $x_2(0, \beta, \hat{p}, \epsilon_{\mathbf{h}}) \geq x_2(0, \beta, \hat{p}, \epsilon_{\mathbf{l}})$ and $x_2(0, \beta, \hat{p}, \epsilon_{\mathbf{l}}) \geq x_3(0, \beta, \hat{p})$. So $\epsilon > x_2(0, \beta, \hat{p}, \epsilon)$ implies $\epsilon > x_3(0, \beta, \hat{p})$ if $\epsilon \in \epsilon_{\mathbf{l}}$. This proves the second part of the lemma. □

Corollary 2. *If the player is willing to play in Period 1 but does not do so, she will be willing to play in Period 2. And if she is willing to play in Period 2 regardless of whether she has played in Period 1, she will always play in Period 1.*

Proof. The first part follows directly from second part of Lemma 4 and the second follows from the first part of Lemma 4. □

The first part of Corollary 2 says that when all else equal, the player is always more willing to play in a later period. Intuitively, the probability of cue-triggered playing is the lower in the later period, so for the same parameters the player is more willing to play. The second part says that if there is incentive to always play in the future, the same incentive would also induce playing now. This follows naturally from equal instantaneous utility in the two periods and the lack of exponential discounting.

Corollary 3. *If the player believes she is always willing to play in Period 2 regardless of whether she has played in Period 1, she will always play in Period 1.*

Proof. $\hat{x}_2^0 = x_2(0, \hat{\beta}, \hat{p}, \epsilon) \geq x_2(0, \beta, \hat{p}, \epsilon)$. The latter follows from Lemma (2). □

Corollary 3 holds because $\hat{\beta}$ is restricted to be weakly bigger than β, so the player can either believe she is equally likely to play in the future than she actually is, or believe she is less likely to do so. As a result she is more weakly more willing to play in Period 1.

Lemma 5. V_t is strictly decreasing in $\hat{p}$ and weakly increasing in $\hat{\beta}$ if $z_t \in \{1, \varnothing\}$ or $\exists\, t' > t$ s.t. $\hat{z}_{t'} = 1$. Moreover, the magnitude of change is weakly larger for $z_t = 1$ relative to $z_t = 0$.

Proof. Strictly decreasing in $\hat{p}$: $z_t \in \{1, \varnothing\}$ or $\exists\, t' > t$ s.t. $\hat{z}_{t'} = 1$ implies the player plans to play. If ϵ has not been resolved or$\epsilon \neq \hat{x}_t^{n_\tau - 1}$, by Lemma 3 the number of periods the player believes she would choose to play does not change with a small change in $\hat{p}$. Her perceived probability of overplaying, on the other hand, strictly increases with $\hat{p}$, and so V_t is strictly decreasing in $\hat{p}$. At $\epsilon = x_t^{n_\tau - 1}$, V_t does not change with a_t, so again V_t is strictly decreasing in $\hat{p}$.

W*eakly increasing in $\hat{\beta}$*: By Lemma 1 the player never chooses to play in Period 3, so V_2 does not depend on $\hat{\beta}$. For V_t where $t \in \{1, 2\}$, suppose the player currently perceive her future action to be suboptimal. As $\hat{\beta}$ increases, Corollary 1 shows that the number of periods play weakly decreases. As $\hat{\beta} = 1$ implies the the player perceive her future action to be identical to that of a time-consistent player—which is optimal for any future period—the weakly monotonic decrease in number of periods played weakly increases V_t.

Change larger for $z_t = 1$ relative to $z_t = 0$. If the player does not plan to initialize the game at any Period $\tau > t$, $V_t(0, 0) = 0$ and does not change with either $\hat{p}$ or $\hat{\beta}$, so the magnitude of change is larger for $z_t = 1$. If $z_t = 0$ but the player does plan to initialize the game in the future, she can never plan to play less when $z_t = 1$, since in the latter she can plan $a_{\tau<t} = 0$ and follow the former's plan. If $z_t = 1$, the maximum of periods the player can play is at least one more than if $z_t = 0$. An increase in $\hat{p}$ therefore decreases marginal utility in at least one more period when $z_t = 0$. Similarly for $\hat{\beta}$, with more periods the deviation from time-consistent strategy in future is weakly larger, so the magnitude of change is weakly larger when $z_t = 1$. $\square$

Proposition 1. *(Strategy without Commitment)*

1. *Holding the initialization period fixed, the number of periods the player chooses to play and the expected number of periods the player actually plays are weakly decreasing in* β*, weakly decreasing in* $\hat{\beta}$ *and weakly decreasing in* $\hat{p}$*.*

2. *Suppose the player currently only chooses to play in Period 1. As* $\hat{p}$ *increases, she is weakly more likely to choose to only play in a later period or to choose not playing. As* $\hat{\beta}$ *increases, there exists an* $\tilde{\epsilon}$ *where she would also do so if* $\epsilon < \tilde{\epsilon}$*, but would keep choosing to play in Period 1 if* $\epsilon \geq \tilde{\epsilon}$ *.*

3. *The player initializes the game weakly later as* $\hat{p}$ *increases or as* $\hat{\beta}$ *decreases, and she might not initialize if* $\hat{p}$ *is large enough or* $\hat{\beta}$ *is small enough.* β *has no effect on the initialization decision.*

Proof. (1) The first part follows from Lemma 2. The relationships are not strict due to the indivisibility of a period, meaning that small changes in x_t might not have an effect. The second part follows directly from Corollary 1.

(2) When $\epsilon < \tilde{\epsilon}$, this follows from $\epsilon > x_1(0, \beta, \hat{p}, \epsilon)$ then $\epsilon > x_2(0, \beta, \hat{p}, \epsilon)$ and x_t increasing in $\hat{p}$ and $\hat{\beta}$. When $\epsilon > \tilde{\epsilon}$, The proof of Lemma 3 shows that

$$x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{h}}) \geq x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{m}}) > x_1(0, \beta, \hat{p}, \epsilon_{\mathbf{l}}) \geq x_2(0, 1, \hat{p}) \geq x_2(0, \hat{\beta}, \hat{p}) \tag{B.14}$$

So $\epsilon > x_1(0, \beta, \hat{p}, \epsilon)$ implies that $\epsilon \neq \hat{x}_2^0$. And since it is given that the player is currently not choosing to play in Period 2, $\epsilon < \hat{x}_2^1$. By Lemma3, x_t is increasing in $\hat{p}$ and invariant in $\hat{\beta}$.

(3) The first part follows from Lemma 5. The second holds because both the benefit and cost of playing is inside β before initialization, so β is irrelevant to the decision to initialize. □

B.3 Strategy with Commitment

Proposition 2. *(Usage of Commitment)*

1. *A naïve player never uses a commitment device.*

2. *A β-sophisticated player would use I in Period t if I is available, $a_{t+1} \in \{0,1\}$ and $\hat{\beta} \leq \frac{u_{t+1}(1)}{c(n_t+1)} < 1$. She would use X in Period t if X is the only commitment device available, $z_{t'} = 0 \; \forall \, t' < t$ and $\exists \, x > 0$ s.t. $(1, x)$ is the unique solution to $\max_{z_t, X_t} V_t(0, z_t, 0, X_t)$.*

3. *A p-sophisticated player would always use X if available. She would use I in Period t if she is in cold mode, $a_{t+1} \in \{0,1\}$ and $\exists \, a_t^*$ s.t. $(a_t^*, 1)$ is the unique solution to $\max_{a_t, I_t} V_t(a_t, \varnothing, I_t, 0)$.*

Proof. (1) *Naïve player*: Since $\hat{\beta} = 1$ and $\hat{p} = 0$, $\hat{a}_{t'}^t = \bar{a}_{t'}^t$ for $t' > t$. The naïve player never forsees herself playing suboptimally in the future, so she never uses any commitment by the assumption that a player would not use a commitment if she is indifferent.

(2) *β-sophisticated player*: A β-sophisticated player would perceive herself overplaying in the next period if the marginal cost is higher than the instantaneous benefit, but the $\hat{\beta}$-discounted mariginal cost is not. Formally this is given by $(\eta_{t+1} + \epsilon)a_{t+1} - c(n_t + 1) \leq 0 < (\eta_{t+1} + \epsilon)a_{t+1} - \hat{\beta}c(n_t + 1)$, which with rearranging gives the condition stated. Since the the in-game device I blocks playing in the next period, setting $I_t = 1$ allows her to commit to the optimal duration of play after the first period of play.

By design, neither X nor I can be used to limit overplaying in Period 1. For Period $t > 1$, the player cannot use X to commit to the optimal duration of play if $\exists \epsilon, \epsilon', F(\epsilon) > 0, F(\epsilon') > 0$ s.t. $\bar{a}_t(\epsilon) \neq \bar{a}_t(\epsilon')$ and either $\hat{a}_t(\epsilon) \neq \bar{a}_t(\epsilon)$ or $\hat{a}_t(\epsilon') \neq \bar{a}_t(\epsilon')$, while I can still be used to commit in such cases. Thus the player weakly prefers I over X.

When X is the only device available, for X to be used it must be the case that the game has not been initialized, thus $z_{t'} = 0 \, \forall t' < t$. $\exists x > 0$ s.t. $(1, x) = \arg\max_{z_t, X_t} V_t(0, z_t, 0, X_t)$ says that there exists a commitment usage in which initializing the game in Period t and set

$X = x$ maximizes V_t. Since V_t is the player's objective function and z_t, X_t are the only two dimensions the player can maximize over before the game is initialized. The requirement that $(1, x)$ is the unique solution to the maximization problem guarantees that the player would set $X = x$.

(3) *p-sophisticated player:* By Lemma 1, Setting X to block playing in Period 3 is always optimal. $a_{t+1} \in \{0, 1\}$ implies that X is not blocking playing in Period $t+1$. $\exists\, a_t^*$ s.t. $(a_t^*, 1)$ uniquely maximizes $V_t(a_t, \varnothing, I_t, 0)$ is by setup the condition in which using I is optimal. □

Corollary 4. *A p-sophisticated player would use both X and I if*

1. $a_{t+1} \in \{0, 1\}$ *and* $u_{t+1}(1) < c(n_{t-1} + 1)$*, or*

2. $a_{t+j} \in \{0, 1\}$ *for* $j = 1, 2$*,* $u_{t+1}(1) \geq c(n_{t-1} + 1)$ *and* $u_{t+1}(1) < c(n_{t-1} + 2)$*.*

Proof. (1) $u_{t+1}(1) < c(n_t + 1)$ is the condition for which the marginal cost of playing is higher than the instantaneous utility of playing. It implies playing in the Period $t+1$ is suboptimal even if the player does not play in Period t. Because in Period-t the player perceives herself to overplay in Period $t+1$ with at least probability $\hat{p}$ if playing is possible, she would block future playing with I.

(2) $u_{t+1}(1) \geq c(n_{t-1} + 1)$ *and* $u_{t+1}(1) < c(n_{t-1} + 2)$ implies playing is optimal in Period $t+1$ only if the player does not play in Period t. If playing is not possible in Period $t+2$, the player can commit to the optimal duration of play in Period t by not playing, which she would be willing to carry out if she is not present-biased ($\beta = 1$). She therefore would not use I. If playing is possible in Period $t+2$, however, the player would play in Period t and use I in the same period. This is because she believes that with probability $\hat{p}$ she would not be able to use I in Period $t+1$, and $u_{t+1}(1) \geq c(n_{t-1} + 1)$ implies $u_t(1) \geq c(n_{t-1} + 1)$ by Assumption 2 and Assumption 1. □

B.4 An Example: without commitment

Let $\eta_1 = \eta_2 = \eta = 2.2$, $\eta_3 = -0.6$, $\epsilon \in \{-1.25, 0, 1.25\}$ with equal chances and $C(n) = n^2$. Since there is no discounting for the exponentially-discounted expected utility, a time-consistent player's utility simply depends on the number of periods played. The welfare-maximizing strategy is given by

$$\max_n U_0 = \max_n \{(\eta + \epsilon) \cdot n - C(n)\} = \max_n \left\{(2.2 + \epsilon) \cdot n - n^2\right\}$$

It is straightforward to verify that the optimal strategy is not to play if $\epsilon = -1.25$, play in one period if $\epsilon = 0$ and in two periods if $\epsilon = 1.25$.

Departing from time-consistency, I start with the case of a naïve present-biased player who is cue insensitive, with $\beta = 0.7$, $\hat{\beta} = 1$ and $\hat{p} = p = 0$. Such a player believes erroneously her future action would be time-consistent. To see how the player would overplay, consider the case where $\epsilon = 0$, in which the time-consistent strategy is to play in one period. With $\beta < 1$, the future cost of playing is being discounted relative to its current benefit, and therefore the naïve player will at least play the time-consistent amount. Furthermore, because of the discounting introduced by β, she would want to play as soon as possible. She would thus initialize the game in Period 0 and play in Period 1. In Period 2, the player faces the choice of whether to play a second period,

$$\begin{aligned} V_2(1, \varnothing) &= \eta \cdot 1 - \beta C(2) = -0.6 \\ V_2(0, \varnothing) &= \eta \cdot 0 - \beta C(1) = -0.7 \end{aligned}$$

She would therefore play for a second period.[21] A similar calculation would show that the player overplays for one period when $\epsilon = -1.25$.

Would sophistication have helped in this case? The sophisticated player can forsee that

[21] The player knows that playing for second period would only result in a total cost of $C(2)$ because playing in Period 3 is suboptimal (Lemma 1). The player will not play in Period 3 unless she is cue-sensitive.

she would overplay in Period 2, and as such she might choose not to play in Period 1. However, given the expectation that she would be playing in Period 2, her utility in Period 1 is

$$
\begin{aligned}
V_1(1,\varnothing) &= \eta + \beta[\eta - C(2)] = 0.94 \\
V_1(0,\varnothing) &= 0 + \beta[\eta - C(1)] = 0.84
\end{aligned}
$$

Notice that the marginal utility from playing is identical to the case of the naïve player, and thus the sophisticated player will behave exactly identical to the naïve player, despite knowing that she would be overplaying. In general, once playing is initialized a sophisticated player will often behave very similarly to a naïve player, the intuition being that she is already under the influence of present-biasedness. But initialization is the key here—the sophisticated player does not have to initialize the game at the earliest possible period. Initializing late mitigates overplaying: if the sophisticated player initializes at Period 1 instead, she can bindingly limit herself to at most one period of playing.[22] The tradeoff of doing so is that she would not be able to play two periods if ϵ turns out to be high. In this example,

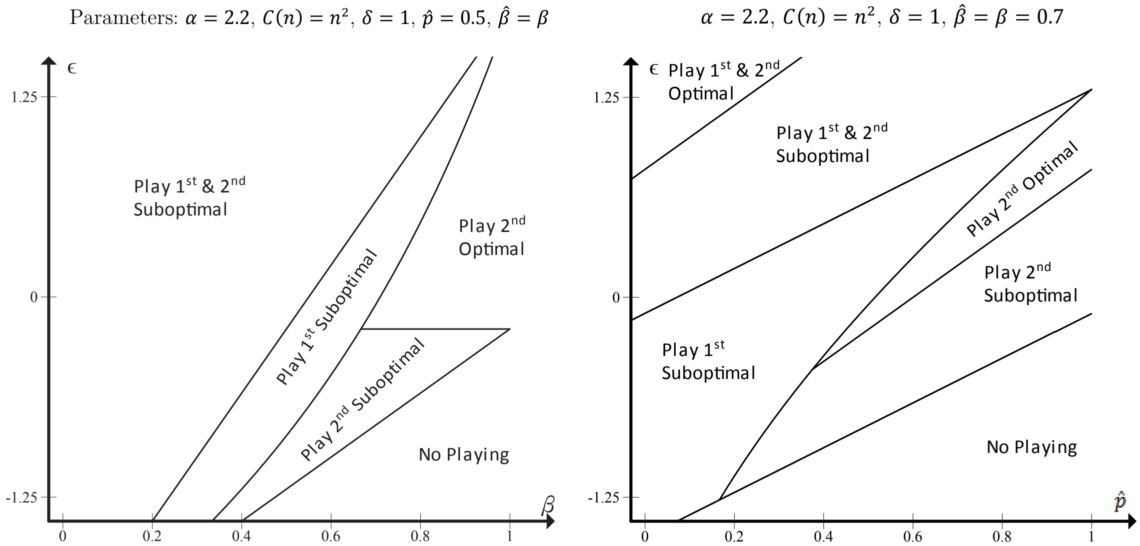
$$
\begin{aligned}
V_0(0,1) &= \beta\left\{\frac{1}{3}\left[(\eta-1.25)-C(1)\right]+\frac{1}{3}\left[2\eta-C(2)\right]+\frac{1}{3}\left[2(\eta+1.25)-C(2)\right]\right\}=0.76 \\
V_0(0,0) &= \beta\left[\frac{1}{3}(\eta-1.25)+\frac{1}{3}\eta+\frac{1}{3}(\eta+1.25)-C(1)\right]=0.84
\end{aligned}
$$

so the sophisticated player would indeed initialize the game late.

Turning to cue-sensitivity. If the player is naïve about her cue-sensitivity, her strategy is essentially identical to the case without cue-sensitivity—play if the marginal benefit of playing is higher than the β-discounted marginal cost. She will be weakly playing more due to cue-triggering, but such playing is not under her control. In contrast, a sophisticated player has in every period an extra incentive not to play, because of the possibility that she

[22] Technically the player can play for two periods, but playing in Period 3 is suboptimal by assumption.

Figure B.1: Threshold Plots



might overplay in future periods. Suppose $\hat{p} = 0.5$ and using again $\epsilon = 0$ as an example, it can be shown that if the game is initialized in Period 0, the player would only play in Period 2 if she had not played in Period 1. She takes this into consideration in Period 1,

$$V_1(1, \varnothing) = \eta + \beta \{\hat{p}[\eta_4 - C(2)] + (1 - \hat{p})[-C(1)]\} = 0.24$$

$$V_1(0, \varnothing) = 0 + \beta \{\eta + \hat{p}[\eta_4 - C(2)] + (1 - \hat{p})[-C(1)]\} = -0.42$$

and plays in Period 1 but not in Period 2. Such restraint does not, however, always happen. For example if $\beta = 0.5$, $E_2[U_2|a_1 = 1, a_2 = 1] = -1.19 > -2.53 = E_2[U_2|a_1 = 1, a_2 = 0]$, so the player would not refrain from playing. Intuitively there is a tug-of-war between present-biasedness and awareness of cue-sensitivity—the former makes the player more likely to choose to play early, while the later makes her less likely to do so.

Figure B.1 plots the ϵ-thresholds for the parameters in this example, varying β and $\hat{p}$, *assuming that she never enters the hot mode in any period.* The player becomes less likely to play as either β or $\hat{p}$ goes up. As expected, present-biasedness (lower β) makes the player more likely to play in earlier periods, while awareness of cue-sensitivity (higher $\hat{p}$) makes the player less likely to play in earlier periods.

B.5 Example Continued: with Commitment

Consider again the player who is present-biased but cue insensitive. If she is naïve, she never forsees herself overplaying, so she never uses any commitment device. But if she is sophisticated, her awareness of her present-biasedness might lead her to using a commitment.

If the player only has access to X, would she use it? In this example she would. Consider the choice of setting a limit of one period of gameplay,

$$\begin{aligned}
V_0(0,1,0,0) &= \beta\left\{\frac{1}{3}\left[(\eta-1.25)-C(1)\right]+\frac{1}{3}\left[2\eta-C(2)\right]+\frac{1}{3}\left[2(\eta+1.25)-C(2)\right]\right\} \\
&= 0.74 \\
V_0(0,1,0,1) &= \beta\left[\frac{1}{3}(\eta-1.25)+\frac{1}{3}\eta+\frac{1}{3}(\eta+1.25)-C(1)\right]=0.85
\end{aligned}$$

Notice that setting $X = 1$ gives the same utility as initializing in Period 1 as calculated before. This should not be surprising, as both limit the maximum number of periods the player can play. The player does not always use X though, but rather she would use it only if the expected cost of overplaying outweights the expected benefit of optimal playing. For example, suppose $\epsilon \in \{-2.5, 0, 0.83\}$ with probability $(\frac{1}{6}, \frac{1}{3}, \frac{1}{2})$ respectively. This ϵ distribution raises the probability of high realization while maintaining the expected values. The same calculations now yield $E_1[U_1|X=0] = 0.81 < 0.75 = E_1[U_1|X=1]$, so she would not use X.

Returning to the original ϵ distribution, suppose the player only has access to I instead. If she uses I at Period 1 when $\epsilon = 0$,

$$\begin{aligned}
V_1(1,\varnothing,1,0) &= \eta-\beta C(1)=1.5 \\
V_1(1,\varnothing,0,0) &= \eta+\beta\left[\eta-C(2)\right]=0.94 \\
V_1(0,\varnothing,0,0) &= \beta\left[\eta-C(1)\right]=0.84
\end{aligned}$$

So using I is indeed better. Furthermore, since I completely eliminates her self-control problem when $\epsilon = 0$ while allowing an additional period of playing when $\epsilon = 1.25$, it is strictly better than X. The player therefore would only use I regardless of whether X is available.

Turn to cue sensitivity. Notice that since playing in Period 3 is never optimal, a sophisticated player would always use X whenever available, if only to prevent herself from playing in Period 3. In addition, she might set a shorter limit if the probability of being cue-triggered is high enough. Consider $\hat{p} = 0.5$ and $\hat{\beta} = \beta = 1$, so the player is not present-biased.

$$
\begin{aligned}
V_0(0,1,0,0) &= \frac{1}{3}\left\{\hat{p}^2\left[2(\eta - 1.25) - C(2)\right] + 2(1-\hat{p})\hat{p}\left[(\eta - 1.25) - C(1)\right] + (1-\hat{p})^2 \cdot 0\right\} \\
&\quad + \frac{1}{3}\left\{\hat{p}\left[2\eta - C(2)\right] + (1-\hat{p})\left[\eta - C(1)\right]\right\} + \frac{1}{3}\left[(\eta + 1.25)\cdot 2 - C(2)\right] \\
&= 1.05 \\
V_0(0,1,0,1) &= \frac{1}{3}(\eta - 1.25) + \frac{1}{3}\eta + \frac{1}{3}(\eta + 1.25) - C(1) = 1.2
\end{aligned}
$$

Thus setting a limit of one period is the better option. Furthermore, for the cue-sensitive player using X is strictly better than initializing late—on one hand, initializing in Period 2 is never worthwhile by assumption, on the other hand initializing in Period 1 leaves room for the possibility of cue-triggered overplaying in Period 3.

Now consider the scenario when only I is available. Whenever the player is in cold mode at the beginning of a period, she evaluates whether she should use the device. Suppose $\epsilon = 0$. Since playing in only one period is optimal, we would therefore expect the player to use I at the earliest possible occasion. This is indeed the case. Taking into consideration that in Period 2 she would use I if she is in cold mode, the player's expected utility in Period 1 is

$$
\begin{aligned}
V_1(0,\varnothing,0,0) &= \hat{p}^2\left[\eta + \eta_4 - C(2)\right] + (1-\hat{p})(1+\hat{p})\left[\eta - C(1)\right] = 0.3 \\
V_1(1,\varnothing,0,0) &= \eta + \hat{p}^2\left[\eta + \eta_4 - C(3)\right] + \hat{p}(1-\hat{p})\left[\eta - C(2)\right] + (1-\hat{p})\left[-C(1)\right] = -0.6 \\
V_1(1,\varnothing,1,0) &= \eta - C(1) = 1.2
\end{aligned}
$$

and so she would use I in Period 1.

Finally, consider the case when both devices are available. As above it is optimal to set $X = 2$. If the player is also present-biased, she would also use I in Period 1,

$$\begin{aligned} V_1(0, \varnothing, 0, 2) &= \beta\left[\eta - C(1)\right] = 0.84 \\ V_1(1, \varnothing, 0, 2) &= \eta + \beta\left\{\hat{p}\left[\eta - C(2)\right] + (1 - \hat{p})\left[-C(1)\right]\right\} = 1.22 \\ V_1(1, \varnothing, 1, 2) &= \eta - \beta C(1) = 1.5 \end{aligned}$$

Note that present-biasedness is needed here only because there is no exponential discounting. Were the latter to be present, the cue-aware player would have used both devices even in the absence of present-biasedness.

C Original Instructions

(Not for publication)

C.1 Website Instructions

C.1.1 Sign-up

To sign up for this experiment you must be able to truthfully answer "yes" to questions 1-4 below.

If you answer untruthfully you will not get paid for the experiment.

1. I am 18 years of age or older. Yes No
2. I am currently an UC undergrad. Yes No
3. I am a regular player of a non-browser-based MMORPG. Yes No
4. Every computer I use for playing MMORPG's runs Windows Yes No

5. Please list all the computer games that you play regularly.

C.1.2 Willingness-to-Pay Solicitation

One final question before you sign up. Please read the following carefully. You will be asked to download and install one small software package. There are two possible packages, "Package 1" and "Package 2".

- **Package 1** is very simple. It just records when, and how long, you play MMORPG's.
- **Package 2** does the same thing, plus the following:

Here is the final question: (Please read the whole page above before answering this question.)

Would you be willing to give up $1 out of your first $15 participation payment in order to receive Package 2 instead of Package 1? [**Note: We are recruiting both subjects who say "Yes" and subjects who say "No".**]

Yes No

C.1.3 Pre-Treatment Questionnaire

1. Which University of California campus are you enrolled in? UCB UCD UCSB UCSC UCSD Other
2. When did you begin playing the MMORPG you currently play? Month: Year:
3. When did you begin playing MMORGP's generally? Month: Year:
4. When did you begin playing computer games of any kind? Month: Year:
5. How many days per week do play the MMORPG you currently play?
6. How many hours per week do spend playing the MMORPG you currently play?
7. Do you typically play your MMORPG alone or with other people? Alone With others

8. How often does playing online role-playing games make it easier for you to complete your school work? Rarely Occasionally Often Always

9. How often does playing online role-playing games make it harder for you to complete your school work? Rarely Occasionally Often Always

10. Looking back on the past week, how would you rate each of the following: (1 - Very poor 4 - Moderate 7 - Very good)

11. Your overall health 1 2 3 4 5 6 7

12. Your sleep quality 1 2 3 4 5 6 7

13. Your academic performance 1 2 3 4 5 6 7

14. Your social life (outside of the MMORPG you play) 1 2 3 4 5 6 7

15. Your social life (inside of the MMORPG you play) 1 2 3 4 5 6 7

16. Your overall happiness 1 2 3 4 5 6 7

Next please complete the following exercise. (Five questions.) This is an imaginary exercise. Imagine that you have just won a gift certificate from your favorite store.

This is an unusual kind of gift certificate in two ways:

You have to spend it immediately, as soon as you receive it. (Assume you can get to the store quickly and easily.)

The store will make the gift certificate bigger if you are willing to postpone receiving it, by a month, six months, or more.

If you decide to receive (and spend) the gift certificate today it will be worth $100. If you are willing to wait, the store will make it bigger.

Each of the questions below asks you how big the store would have to make the gift certificate in order for you to be willing to wait a certain length of time.

Note: These are not real offers. These are imaginary gift certificates. I am simply asking you how big the store would have to make the gift certificate in order for you to be willing to wait, if such a gift certificate actually existed.

[Remember, if you take the gift certificate today it is worth $100.]

1. To make me willing to wait one month the gift certificate would need to be for

2. To make me willing to wait six months the gift certificate would need to be for

3. To make me willing to wait one year the gift certificate would need to be for

4. To make me willing to wait two years the gift certificate would need to be for

5. To make me willing to wait ten years the gift certificate would need to be for

C.1.4 Prediction

Please try your best recalling the amount of time you spent playing MMORPG on the week of March 14 - 20.

__________ hours ___________ minutes

C.1.5 Post-Treatment Willingness-to-Pay

Would you like to continue using BlokSet?

At this point you have an opportunity to give up a portion of your upcoming $25 participation payment in order to continue using BlokSet.

By doing so you will obtain the following benefits,

- No data collection.
- BlokSet can be installed and used on any number of computers.
- No expiration date. Use BlokSet for as long as you wish.
- Continued technical support for a minimum of one year.

In a moment you will be asked to state the maximum amount of your participation payment that you would be willing to give up to continue using BlokSet. On July 1st 2010, we will randomly select a target number x between \$0 and \$25.[23] If the amount you state is higher than x, you will be able to continue using BlokSet, and receive a second payment of \$(25 - x). If the amount you state is lower than x, you will not be able to use BlokSet after July 1st, and will receive a second payment of \$25.

It is in your interest to state your true maximum willingness to pay, because if you overstate you might wind up paying more than the device is worth to you, and if you understate you might miss the opportunity to get the device at a price that is worth it to you. Unless x happens to equal to your stated amount, you will always pay less than your stated amount.

Please state the amount of participation payment you are willing to give up in the text box below.

___________ dollars _____________ cents

C.2 User Guide of BlokSet

C.2.1 BlokSet User Guide Overview

BlokSet consists of three different devices, each of which allows you to limit when, or for how long, you can play MMORPG's. You do this by setting "blocks". A block is just a time period during which BlokSet "blocks" you from playing MMORPG's.
Blocks work in two ways.

1. If you try to launch your RPG software during a block that you have set, BlokSet will prevent the software from launching.

2. If you are playing your MMORPG when a block is scheduled to begin, BlokSet will simply close your RPG software at the beginning of the block. BlokSet will give you a

[23] The formula we shall use is 25 * ((d mod 10)/10)^9 rounded to the closest cent, where d is the closing value of Dow Jones Industrial Average on June 5th.

verbal reminder and show you a countdown timer so that you can wrap up your game session before the block begins.

[Note: BlokSet is not a plug-in. It will not modify any of the files of your RPG software in any way.]

Each of the three devices allows you to set blocks in different ways.

1. The Calendar Blocker allows you to schedule blocks on a calendar, for all or part of any day.

2. The Pre-Game Blocker gives you the option, at the begining of a game- session, to set a block for that session. In effect, you are choosing how long to play, and when that time is up the game-session ends and the block begins. In addition, the Pre-Game device allows you to display a timer so you can see how long you have been playing. You can choose the timer with or without setting a block.

3. The In-Game Blocker allows you, in the middle of a game session, to set a block for that session. In effect, you are choosing how much longer you want to play, and when that time is up the game-session ends and the block begins.

In addition to these three devices, there is a "settings" page where you can select default options for how the three devices work.

C.2.2 Using the Calendar Blocker

To use the Calendar Block device, click on the BlokSet icon in your icon tray at any time. When the BlokSet main window opens, select the Calendar tab.

Click on the day you want to set a block. The "Schedule New Block" dialog will open.

Set the duration of the block

Click "All Day" to block yourself from playing your RPG for the entire day, midnight to midnight.

To set a block for part of the day, enter the beginning and ending times for the period you want to be blocked.

Set a repeating block

To set a repeating block, select daily, weekly, or monthly repeat and then select the date after which you want the repeat to end.

Cancel a scheduled block

Right-click on a scheduled block and click "delete" on the pop-up menu.
Note: The deadline for canceling any calendar block is exactly one week before the block begins. You cannot cancel a calendar block during the week leading up to the block.

Checking for scheduled blocks

To see a quick reminder of blocks you have set, roll your cursor over the BlokSet icon in your icon tray.

C.2.3 Using the Pre-Game Blocker

The Pre-Game Block device opens automatically every time you launch your RPG software. You will see the Pre-Game Block dialog before the RPG software opens.
To set a block or display a timer during the session you are about to play, check the appropriate box and click "Set". You can check one or the other or both. Both boxes are checked by default when you install BlokSet. To change these default settings, use the Settings Page. If you choose to set a block, select the number of minutes you want to play before the block begins, and the number of minutes you want the block to last. BlokSet will give you a voice reminder 15 minutes before your block begins. After that you will see a timer that counts down to the beginning of the block.

You can change the default settings for minutes played and minutes blocked on the Settings Page.

If you choose to display the timer, you will see a count-up timer in a corner of the screen during your play session.

Once you have checked the boxes and entered the settings you want, click "set" to start your RPG with those settings.

If you do not want to set a block or display a timer, click "skip" to start your RPG straight away. You do not need to uncheck any boxes before clicking "skip".

C.2.4 Using the In-Game Blocker

To set an In-Game Block while you are playing your RPG, press the "pause" button on your keyboard at any time.

You will be asked to enter the number of minutes that you want to play before the block begins.

If the default number of minutes is okay, just press "enter".

To change the number of minutes, use your backspace key to clear the default and type in a new number. Then press "enter"

Press "enter" again to confirm. The block will be set.

The number of minutes that the block will last is set by default to 60 minutes.

To change the default number of minutes before the block begins, or the default number of minutes that the block lasts, go to the Settings page.

Using the Settings page

To change default settings for the Pre-Game Blocker or the In-Game Blocker, click on the BlokSet icon in your icon tray and select the "Settings" tab in the BlokSet main window.

In-Game Blocker settings

You can set the default for the number of minutes you want to play, and the number of minutes you want to be blocked afterwards.

You can set different defaults for each day of the week.

Pre-Game Blocker settings

You can set the default for the number of minutes you want to play, and the number of minutes you want to be blocked afterwards.

You can set different defaults for each day of the week.

In addition you can change whether the "block" and "timer" check boxes are checked or unchecked by default.