

# Focusing As Commitment

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## Abstract

The paper analyzes the decisions of a  $\beta - \delta$  consumer who has the ability, through effort invested in focusing on the future, to set the exponential discount factor  $\delta$  that will apply to her self in the next period. She has access to no other commitment technology. Because the model interprets dynamic inconsistency in a way that gives rise to the demand for costly self-control, it disambiguates the welfare benefit of formal commitment devices that limit future options. The model explains why cognitive loading is associated with impulsivity and why U.S. savings rates have exhibited increased income stratification since the 1980s. The model additionally offers a unifying theory of visionary leadership, managerial training, motivational speakers, and role models.

**Keywords** self-control; preference for commitment; time inconsistency; personal savings rate; cognitive bandwidth; visionary leadership; episodic future thinking.

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“Sire, remember the Athenians.”

- words whispered nightly by a servant in the ear of King Darius of Persia to maintain the king’s resolve to avenge the destruction of the city of Sardis

“Even as I wander, I’m keeping you in sight. You’re a candle in the window on a cold, dark winter’s night.”

- REO Speedwagon

## 1 Introduction

Evidence from psychological research indicates that focusing on the future reduces the discounting of future returns, particularly when combined with aids to visualization or imagination, such as episodic future thinking (Peters & Büchel 2010; Cheng et al. 2012; Daniel et al. 2013a, 2013b, 2015; Kaplan et al. 2016; Stein et al. 2016). It has also been shown that focusing increases success at tasks associated with a future orientation, including saving, dieting, reducing or quitting smoking, maintaining romantic relationships, and avoiding delinquent activities (Agnew et al. 1998; Benoit et al. 2011; Cheema & Bagchi 2011; Hershfield et al. 2011; Soman & Cheema 2011; Daniel et al. 2013b, 2015; Song et al. 2013; van Gelder et al. 2013; Kaplan et al. 2016; Stein et al. 2016; Green & Lynn 2017).

On the face of it, this evidence would appear to be well explained by a simple exponential discounting model in which discount factors are endogenous – and, in particular, a function of focusing or imagination effort (e.g., Becker & Mulligan 1997). The trouble is that nearly all the consumer problems for which focusing is demonstrably helpful are ones for which the challenge is not failure to sufficiently weight the future, but dynamic inconsistency. Would-be savers fail, despite an overwhelming desire to save, because of temptations to spend *now* that get in the way of longer-term intentions. Those wishing to lose weight start each day planning to stick to a diet program, but then deviate when a tempting dessert comes along or a hard day lessens their resolve. Smokers and other addicts intend to stay clean, but are triggered by environmental cues that compel them to use (Bernheim & Rangel 2004). Lovers (parents) treat their significant others (children) in ways that they regret, again despite best intentions; those wanting to start an exercise regimen never do so because it is always more attractive, when the moment to exercise arrives, to postpone until tomorrow; and on and on. In all these cases, individuals behave

in a way that their “long-run selves” do not appreciate (O’Donoghue & Rabin 1999).

This paper proposes a model of focusing as commitment. Agents in the model exhibit present bias as characterized by a quasi-hyperbolic  $\beta - \delta$  discount structure (Phelps & Pollak 1968, Laibson 1997), whereby they may plan to execute a strategy to prepare for the future – such as, say, saving – but then fail to follow through. Agents therefore exhibit a demand for commitment.<sup>1</sup> The distinguishing feature of my framework is that the dynamic inconsistency of preferences is conceived as arising from a sort of “laziness” with respect to long-term intertemporal values. Priorities that are not kept “front and center” in one’s mind cease to be salient, causing the individual to fall prey to present-centered impulses. Focusing effort, directed at prioritizing the future, may therefore be used by the individual to bring her values back into focus so that they *feel* important and actionable at the relevant decision moment. Because the failure to keep the future top-of-mind is treatable, individuals are not properly myopic, but *amblyopic*.<sup>2</sup>

I develop a parsimonious representation of amblyopia via a simple extension of Laibson’s (1997) framework for intertemporal decision-making with hyperbolic discounting. The consumer in my model focuses in the present to influence her next-period self’s exponential discount factor  $\delta$  applied to future periods – in doing so, she in effect sets that discount factor. Each new period the “laziness” returns, and the consumer must again focus to set the discount factor for her *next*-period’s self. My model shows that – for an amblyopic consumer – focusing serves as a form of commitment, such that it can effectively take the place of an illiquid asset (i.e., golden eggs) instrument.

An essential and novel recognition in this effort is that the problem of commitment is, broadly and at heart, a salience problem. If temptations in the present derail the individual from accomplishing what she had previously set out to achieve, it is invariably because those temptations impose themselves on her consciousness in that moment. The commitment problem so construed may be solved in one of two ways. It may be solved by limiting the response to the salient temptation – either physically, or through psychological incentives. This is the means described in much of the existing literature (e.g., Laibson 1997, Bénabou & Tirole 2004). But it may also be solved by making salient for the future self at the moment of action the desirability of the object – whether a specific

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<sup>1</sup>There is substantial evidence that discount functions are approximately hyperbolic (Ainslie 1992, 2005).

<sup>2</sup>Gabaix & Laibson (2017) conceive of a myopic consumer who discounts the future because he does not see it clearly. In their model, hyperbolic discounting emerges, but – unlike my model – the consumer has no taste for commitment.

future object or broad emphasis on future outcomes - that is salient to the present self. One can, so to speak, either bind Odysseus to the mast, or else induce him to be so completely focused on reaching his destination that he doesn't heed the sirens. Notably, in "focusing," my theory conceives of a cognitive activity that effectively influences the individual's valuation of a future action while providing neither new information nor being – in any conventional sense – persuasive about the value of the action.

The focusing model offers several important contributions. It provides for a "hot-state" (or, rather, lazy-state) interpretation of hyperbolic discounting that naturally gives rise to a demand for costly self-control; thus it offers a clear basis for evaluating the welfare effect of hard commitments that limit options *ex ante*. It offers an explanation of why cognitive loading is associated with impulsivity. Relatedly, it explains the increasingly stratified pattern of savings rates observed in the U.S. since the 1980s: as access to instant credit eliminated implicit commitment opportunities, people with low cognitive loading maintained commitment through focusing effort while others failed to do so. It thereby enables the extension of Laibson's (1997) welfare framing of the excess liquidity problem to formalize the notion that excess liquidity disproportionately harms the poor. Finally, in recognizing focusing as commitment, the framework makes evident that a range of phenomena – motivational speakers, managerial training, evangelical pastors, visionary leaders, role models, and others – represent extrinsic aids to commitment.

After discussing the related literature in the rest of this section, I outline in Section 2 the critical elements that characterize the use of focusing effort for the purposes of commitment, with reference to the experimental literature from psychology. The experimental evidence is consistent with my conception of an amblyopic consumer; importantly, it strongly suggests that focusing can only be effectively understood in the context of a hyperbolic discounting framework. Section 3 presents a model based on the experimentally-derived primitives. Section 4 analyzes its equilibrium. Section 5 discusses implications of the model. Section 6 explores extrinsic aids to commitment. Section 7 concludes. All proofs are contained in the Appendix.

## 1.1 Related Literature

Two approaches to commitment are distinguished in existing work<sup>3</sup>: hard commitments, involving real economic incentives to comply or externally binding constraints; and soft

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<sup>3</sup>See Bryan et al. (2010) for a recent survey.

commitments, which are built mainly on psychological incentives for compliance.

The economic literature on soft commitment, into which the current paper fits, identifies several behaviors that serve a commitment purpose, including: self-signaling resolve by adherence to personal rules (Bénabou & Tirole 2004), maintaining motivation through self-confidence (Bénabou & Tirole 2002), and thwarting future undesired behavior through strategic ignorance (Carrillo & Mariotti 2000). Relatedly, Bernheim & Rangel (2004) develop a cue-based theory of addiction according to which the presence of certain environmental cues cause individuals to enter a “hot” state in which they are more prone to give in to the temptation to use. Cue avoidance flows naturally from this framework as a soft commitment strategy, and indeed addicts recognize their susceptibility and practice cue avoidance with some degree of sophistication (Bernheim & Rangel 2004, p1559).

None of the papers in this literature explicitly address the possibility of focusing on a desired object as a commitment device. Ainslie (1992) examines how directing one’s attention *away* from sources of temptation (i.e., repression or suppression) may aid commitment; he does not address efforts to focus toward desired objectives. His analysis is therefore more properly viewed in connection with Carrillo & Mariotti (2000) and Bernheim & Rangel (2004).

The most closely-related discussion is offered by Boyer (2008) on what he terms “mental time travel” (MTT) – the ability to re-experience situations previously encountered, or to vividly conceive of future situations.<sup>4</sup> Boyer posits that MTT functions as a defensive internal mechanism for addressing impulsiveness in situations in which no external commitment devices are available. Particularly notable in light of the current work is his idea that MTT functions as a “calibration device” by generating emotional rewards in the present that are “immediate and, therefore, bypass the usual discounting of future consequences of actions (p221).” In support of this proposed mechanism, Boyer points to evidence that amnesiac patients, who would not have the capacity for MTT, are more susceptible to tempting but self-defeating strategies (Gutbrod et al. 2006).

In contrast with my conception, Boyer conceives of MTT as consisting of *involuntary*, primarily negative recollections or visions that act as an automatic restraint on impulsive choices. This notion is more in line with Frank’s (1987) analysis of “conscience” – the spontaneous experience of crushing guilt that protects the individual’s long-term interests by tripping up self-serving impulses deleterious to pro-relationship goals – than it is with

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<sup>4</sup>For the originating discussion of MTT, see Suddendorf & Corballis (2007).

the *discretionary* notion of focusing I deal with here.

Recent work by Laibson (2015) has suggested that, despite theoretical indications that dynamically inconsistent preferences engender a demand for commitment, very little hard commitment is actually observed in the economy – in part because such commitments are costly. For this reason among others, focusing effort and other soft commitments may have substantial real-world relevance.

## 2 Critical Elements of Future-Oriented Focusing

While there are many ways in which people focus their attention - for different purposes and under a range of different conditions - studies that measure the positive influence that focusing has on future-oriented decision-making characterize a very specific kind of focusing, applied in a specific context. I outline the characteristics and the context of this sort of focusing here with reference to key examples, primarily from the experimental literature.

### 2.1 Focusing Effort Associated with Reduced Discounting

Two main types of focusing treatments appear in the experimental literature. Episodic future thinking treatments involve engaging participants in thinking about vivid, positive future events that correspond to the period in the future associated with a decision that they are asked to contemplate (Peters & Büchel 2010, Benoit et al. 2011, Daniel et al. 2013a, Daniel et al. 2013b, Daniel et al. 2015, Stein et al. 2016). For example, while contemplating a choice between \$95 now and \$100 in 6 months, participants would typically be asked to think about a vivid event occurring in 6 months, such as a birthday party (Daniel et al. 2013a). Visualization treatments present participants with a visual representation of themselves as they might appear in the future (Hershfield et al. 2011, Song et al. 2013, van Gelder et al. 2013, Kaplan et al. 2016); or some other object, such as a picture of the participant’s children, specifically intended to visually focus participants on a valued future objective, such as saving money (Soman & Cheema 2011).

Episodic future thinking treatments that focus participants on events in a specific future period have been associated with reduced discounting of returns identified with that period, relative to a control group (Peters & Büchel 2010; Benoit et al. 2011; Daniel et al. 2013a, 2013b, 2015; Stein et al. 2016). For example, if a participant focused on vivid

thoughts of a birthday party anticipated in 6 months, she would discount an amount of money to be received in 6 months less when weighing decisions involving immediate cash versus a 6-month-delayed payment.

## 2.2 Self-Preparation in Advance of, and Reinforcement in, the Decision Moment

Focusing treatment experiments invariably incorporate a decision or decisions that participants must make; these form the basis for measuring the impact of the treatments. The treatments at the front end typically involve participants making some sort of focusing-oriented self-preparation in advance of the decision moment, paired with a process that serves to reinforce focus at the moment of the decision. (In some instances in which the decision immediately follows the self-preparation, no reinforcement process is engaged in the decision moment.) Decision outcomes are also measured for control groups who are not exposed to these treatments as a basis for comparison to the treatment groups. Table 1 summarizes these components for a number of experimental studies of focusing.

The near-universal use of self-preparation and reinforcement in these designs drives home two critical aspects of future-oriented focusing and its impact. First, the effects of such focusing efforts are transitory, based on the salience of what is focused upon in a key moment. For example, a picture of the participant's children affixed to an envelope meant to hold money for savings functions by bringing the children to the participant's consciousness at the moment she might contemplate removing cash to spend impulsively (Soman & Cheema 2011). Second, particularly in view of the self-administration of advance preparations, the focusing does not so much precipitate an actual change in preferences as a *reminder* of one's existing preferences. This is an essential point, and it draws a critical distinction between what we observe experimentally and what has been proposed by Becker & Mulligan (1997). Becker & Mulligan (1997) contend that individuals may engage in "imagination" effort to increase the "propinquity" of future outcomes such that they value those outcomes more (p734). But this interpretation of the effect of focusing relies on a contradiction - the idea that a person with a certain set of relative intertemporal preferences would choose to convince herself that she should value the future more than she currently does. While individuals could conceivably experience a change in their relative intertemporal preferences, such a change would have to be exogenously induced by new information, or else as a mistake by someone with no such

Table 1: Focusing Treatments: Summary of Experimental Studies

PAPER	PARTICIPANTS	PARTICIPANTS' ADVANCE SELF-PREPARATION (TREATMENT GROUP)	DECISION(S)	REINFORCEMENT IN DECISION MOMENT (TREATMENT GROUP)
<b>Episodic Future Thinking Treatments</b>				
Peters and Buchel (2010)	Men and women, average age = 25	List positive events occurring in the future	Large delayed reward vs. small immediate reward	View tag of self-described event (e.g., "vacation Paris") corresponding to period of delayed reward
Benoit et al (2011)	Men and women, average age = 27	Imagine spending a certain amount of money at a certain point in the future at a specific activity (e.g., museum, dining out)	Large delayed reward vs. small immediate reward	View task-and-scenario cue (e.g., "imagine dining out")
Daniel et al (2013a)	Women age 18-40	Generate detailed descriptions of positive future events	Large delayed reward vs. small immediate reward	Think about most vivid pre-generated future event corresponding to period of delayed reward
Daniel et al (2013b)	Overweight/obese women wanting to control food intake, average age = 26	List positive events occurring in specified future period, make audio recording of detailed descriptions of most vivid events	1) Ad libitum eating; 2) large delayed reward vs. small immediate reward	Listen to audio recordings of event descriptions during #1; think about future events corresponding to period of delayed reward during #2
Daniel et al (2015)	Overweight/obese 9-14 year olds	List positive events occurring in specified future period, make audio recording of detailed descriptions of most vivid events	1) Ad libitum eating; 2) large delayed reward vs. small immediate reward	Listen to audio recordings of event descriptions during #1; think about future events corresponding to period of delayed reward during #2
Stein et al (2016)	Smokers wanting to quit smoking	Make audio recording of detailed description of vivid positive future event, write abbreviated textual description	1) Ad libitum smoking; 2) large delayed reward vs. small immediate reward	Listen to audio recording of event description and read textual description during #1; read textual description during #2
<b>Visualization Treatments</b>				
Hershfield et al (2011)	Men and women, average age = 20	Answer personal questions while in virtual reality (VR) simulation seeing self as computer-gen future self	Contribution to retirement savings out of hypothetical windfall payment	None, but decision made immediately following self-prep
van Gelder et al (2013)	Men and women, average age = 22	VR simulation seeing self as computer-gen future self	Whether to cheat on quiz for money	None, but decision made immediately following self-prep
Song et al (2013)	Infrequent smokers, average age = 22	Play 2nd stage of game with computer-gen future self aged based on smoking decisions at 1st stage	Attitudes toward smoking, intention to quit	None, but decision made immediately following self-prep
Kaplan et al (2016)	Undergraduate women	Write detailed answers to 4 questions about future life, while looking at computer-gen image of future self	Quit a "hobby that is bad for your health" in 30 years	Look at image of future self
Soman and Cheema (2011)	Laborers in rural India	None	Remove money for immediate spending from envelope earmarked for saving, or not	Photographs of participant's children printed on the savings envelope

intention. What the experiments demonstrate, rather, is participants engaging (with themselves) in the equivalent of King Darius of Persia asking a servant to remind him every night not to forget to avenge the sacking of Sardis on the Athenians. While the focus provided by the preparation and reinforcement is helpful, it effects nothing that the participant did not already want to do.

### 2.3 Context of Dynamic Inconsistency

As discussed in the introduction, the beneficial effects of focusing observed in laboratory experiments have largely been identified with problems involving dynamic inconsistency. The perceived central role of dynamic inconsistency in the functionality of focusing is reinforced by participant selection in experimental studies of episodic future thinking. These have often been limited to individuals who reference a desire to achieve a particular goal but who either state, or demonstrate that, they have been unable to do so in the past. For example, Daniel et al. (2013b) selected for overweight or obese women who



indicated a desire to control their food intake. Stein et al. (2016) sought participants who met the DSM-IV criteria for nicotine dependence and reported a desire to quit smoking. The behaviors of individuals in these groups offer prima facie evidence of a conflict between the individual’s long-run preferences and actions in the moment. Their selection for these studies suggests dynamic inconsistency provides critical context for measuring the benefits of focusing efforts.

Additional indications come from Bernheim & Rangel (2004) that dynamic inconsistency is at the heart, specifically, of addictive behaviors - an area with respect to which focusing has been shown to have ameliorative properties. The authors provide extensive evidence that substance use by addicts is frequently a mistake rather than an intentional act. The substance addict faces heightened susceptibility to unplanned use based on environmental cues that are to some degree predictable. A smoker knows that being around friends who smoke will trigger her. A heroin addict knows that a return to a location where previous use took place will cue repeat consumption. Addicts are often sophisticated about their triggers and employ a range of commitment devices to manage their susceptibilities. These include hard commitments, such as “lock-up” rehabilitation facilities and medications that produce unpleasant side effects if the substance is later consumed.

### 3 Model

There are numerous tasks for which success may depend upon a future orientation. In this model, I focus on the archetypal economic example of saving one’s money on a continual basis over time. I assume a consumer who must make consumption and savings decisions over a finite horizon in discrete time  $t \in \{1, 2, \dots, T\}$ . Consumers exhibit quasi-hyperbolic  $\beta - \delta$  discounting, and thus face an ongoing problem of present bias. The consumer has only one savings instrument available to her, a liquid asset  $x$ . There are no illiquid assets.

However, the consumer has the ability to engage in focusing effort. How to model the effects of such effort requires special consideration. As discussed in the previous section, the experimental literature provides evidence that individuals induced to focus on a specific future period experience reduced discounting with respect to that period. It is reasonable to expect that a consumer with a time-specific goal of future consumption, such as having the money to pay for college five years hence, would choose to focus on

the relevant future period such that discounting with respect to that period - and only that period - would be reduced. But the problem of managing ongoing consumption and saving is different: it is one of continuation, rather than of getting to a certain specific place at a specific time.

Relevant evidence suggests that this problem is best conceived as an effort to keep the generalized future clearly in sight. Several studies involving visualization treatments present the participant with a non-specifically aged avatar of herself as an inducement to make broadly future-oriented choices (Hershfield et al. 2011, Song et al. 2013, van Gelder et al. 2013). To induce generalized saving and deter immediate consumption, Soman & Cheema (2011) present their participants with a reminder of the importance of the future - again, non-specifically - in the form of pictures of their children. Based on these and other indications,<sup>5</sup> I model the effect of focusing effort for the proposed decision problem as a reduction in the consumer's  $\delta$ . That is, focusing is conceived as incrementally collapsing the future into the present such that the priority placed on all future periods is increased proportional to the exponential discount factor in the  $\beta - \delta$  model.

Every time period is divided into four subperiods. In the first subperiod, the consumer's savings  $x_{t-1}$  yield a return of  $R_t = 1 + r_t$ . In the second subperiod, the consumer earns labor income  $y_t$  and gets access to her savings,  $R_t \cdot x_{t-1}$ . In the third subperiod the consumer chooses her current consumption,  $c_t \leq y_t + R_t x_{t-1}$ . What she does not consume, she saves, thus

$$y_t + R_t x_{t-1} - c_t = x_t$$

where  $c_t \leq y_t + R_t x_{t-1}$  ensures  $x_t \geq 0$ . This constraint rules out forced savings contracts (Laibson 1997). In the fourth subperiod, the consumer chooses how much to focus on the future; this activity serves to set the discount factor,  $\delta_t$ , that will influence her at  $t + 1$  when she makes her consumption and savings decisions in that period. The consumer begins life with exogenous endowments  $x_0 \geq 0, \delta_0 \in [0, 1]$ .

The essential assumption of amblyopia is a dichotomy in the discount factor,  $\delta$ . I conceive of  $\delta_0$  - the endowed discount factor - as embodying the consumer's underlying intertemporal preference, which is fixed. The setting of  $\delta_t \geq \delta_0$ , by contrast, represents a transitory increase in the salience of future consumption. It does not alter the  $t + 1$ -

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<sup>5</sup>The servant's nightly reminder to King Darius - "Sire, remember the Athenians" - is essentially a reminder to keep the future (i.e., future revenge) in sight, the sort of intervention that might reasonably be interpreted as increasing the unique  $\delta$  parameter in a  $\beta - \delta$  model.

consumer's preference for future consumption per se, so much as it "reminds" her of that preference at the critical moment of decision between current and future consumption. It thus enables her to act more effectively pursuant to her underlying intertemporal preference, which - being naturally "lazy" about the future - she forgets when faced with the tempting prospect of current consumption. While we will think of  $\delta_t$  as applying to the consumption and saving decision for the  $t + 1$ -consumer, it will not apply to that consumer's subsequent choice of  $\delta_{t+1}$ , which - taken in a subperiod in which her mind is no longer mobbed by a decision involving current consumption - she makes with reference to her fixed intertemporal preference  $\delta_0$ .

The consumer faces a time-additive utility function  $U_t$  of the form proposed by Laibson (1997):

$$U_t = u(c_t) + \beta \sum_{\tau=1}^{T-t} \delta^\tau u(c_{t+\tau}) \quad (1)$$

In view of the dichotomy between the consumer's functional discount factor - based on salience of the future - and her permanent preference for future consumption, the parameter  $\delta$  in (1) takes different values depending upon the decision the consumer is making. When she chooses consumption and saving, she maximizes the following utility function:

$$U_t = u(c_t) + \beta \sum_{\tau=1}^{T-t} \delta_{t-1}^\tau u(c_{t+\tau})$$

Thus she makes her consumption and savings decisions following the relative weighting of different periods imposed on her by the focusing effort she engaged in the previous period. In contrast, when she sets the discount factor, she does so subject to the "permanent" utility,

$$U_t = u(c_t) + \beta \sum_{\tau=1}^{T-t} \delta_0^\tau u(c_{t+\tau}) \quad (2)$$

based on her endowed discount factor  $\delta_0$ .

The utility function in (1) represents dynamically inconsistent preferences. Consistent with Pollak (1968), Peleg & Yaari (1973), Goldman (1980), and Laibson (1997), I model the consumer as a sequence of temporal selves making choices in a dynamic game with their future selves. Hence, a  $T$ -period consumption problem is represented by a  $T$ -period game, with  $T$  players ("selves") indexed by their respective periods of control over the consumption, saving, and focusing decisions. I seek subgame perfect equilibrium (SPE) strategies of this game.

I adopt Laibson's restriction on labor income, given by

$$u'(y_t) \geq \beta \delta_0^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(y_{t+\tau}) \quad (3)$$

which allows marginal conditions to be used to characterize the equilibrium strategies. Additionally, I adopt similar notation to Laibson (1997), though adapted to the differing choices variables in my game. In particular, let  $s_t$  represent a strategy at time  $t$ :  $\{c_t, x_t, \delta_t\}$ ; and let  $h_t$  represent a feasible history at time  $t$ , such that in my game  $h_t$  represents all the moves that have been made from time 0 to  $t-1$ :  $\{x_0, \delta_0, (c_\tau, x_\tau, \delta_\tau)_{\tau=1}^{t-1}\}$ . Let  $S_t$  represent the set of feasible strategies for self  $t$ . Finally, let  $S = \prod_{t=1}^T S_t$  represent the joint strategy space of all selves.

We will say that a sequence of feasible consumption/savings/focusing actions,  $\{c_{\hat{t}}, x_{\hat{t}}, \delta_{\hat{t}}, \dots, c_T, x_T, \delta_T\}$  satisfies C1-C5 if  $\forall t \geq \hat{t}$ ,

$$\mathbf{C1} \quad u'(c_t) \geq \max_{\tau \in \{1, \dots, T-t\}} \beta \delta_{t-1}^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(c_{t+\tau})$$

$$\mathbf{C2} \quad u'(c_t) > \max_{\tau \in \{1, \dots, T-t\}} \beta \delta_{t-1}^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(c_{t+\tau}) \Rightarrow c_t = y_t + R_t x_{t-1}$$

$$\mathbf{C3} \quad u'(c_{t+1}) \geq \max_{\tau \in \{1, \dots, T-t-1\}} \delta_0^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(c_{t+1+\tau})$$

$$\mathbf{C4} \quad u'(c_{t+1}) > \max_{\tau \in \{1, \dots, T-t-1\}} \delta_0^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(c_{t+1+\tau}) \Rightarrow c_{t+1} = y_{t+1} + R_{t+1} x_t$$

$$\mathbf{C5} \quad \delta_0 \leq \delta_t \leq \frac{\delta_0}{\beta}$$

It is now possible to state the main theorem of this paper:

**Theorem 1.** *Fix any  $T$ -period consumption game with exogenous variables satisfying (3). There exists a unique resource-exhausting joint strategy,  $s^* \in S$ , that satisfies C1-C5, and this strategy is the unique subgame perfect equilibrium strategy of this game.*

## 4 Analysis of Equilibrium

The theorem shows that focusing effort arises as a commitment device in equilibrium in any state (i.e., for all feasible values of exogenous variables) in which the consumer would

have invested in the illiquid asset had it been available. Conversely, if a positive quantity of the illiquid asset is not chosen in equilibrium in the game in which the illiquid asset is available (i.e., the game in Laibson 1997), then neither will the agent in my game choose to reduce her discount factor  $\delta_t$ .

The theorem shows more precisely that focusing effort will be employed up to the point at which the present bias of the consumer's future self is rendered inconsequential - that is, up to the point at which the illiquid asset, if it were available, would be chosen in zero quantity (i.e.,  $z_t = 0$ ). Moreover, it is apparent from the model that focusing may be a more effective form of commitment than an illiquid asset under certain parameter values. Given the constraint of  $x \geq 0$  - which binds under the condition identified in Laibson's P3 - the  $t + 1$  self cannot always be forced to comply with the consumer at  $t$ 's preferred consumption agenda when the illiquid asset is available but focusing is not. In particular, the consumer at  $t$  who has only an illiquid asset instrument has no power to constrain the  $t + 1$ -consumer's use of her labor income. Meanwhile, focusing achieves compliance consistently via the optimal choice of  $\delta_t$ , even to the point of optimally guiding the tradeoff of consumption versus saving out of labor income.

The range of values observed by  $\delta_t$  in equilibrium under the theorem are notable in several respects. Property C5 specifies that  $\delta_t$ , as set in period  $t$ , will fall within a prescribed range: it will be no less than the endowed discount factor  $\delta_0$  representing the consumer's fixed, underlying intertemporal preference, and no more than the value that would completely neutralize the consumer's present bias for the relevant period  $t + 1$ . It is important to recognize that focusing in equilibrium does not per se eliminate present bias. Rather, it makes the future sufficiently salient to render the present bias inconsequential, but no more. In general, if the consumer at  $t$  were to set  $\delta_t = \frac{\delta_0}{\beta}$ , she would be setting the relative weight between  $t + 1$  and  $t + 2$  correctly, viewed in isolation. But she would be overweighting periods beyond  $t + 2$  and so cause over-saving and under-consumption in  $t$ . Her choice of  $\delta_t$  balances weight on the future against weight on the present in such a way that C3 and C4 are met.

Note also in view of C5 that  $\delta_t > 1$  is theoretically possible. That is, the consumer at  $t$  might induce the consumer at  $t + 1$  to place relatively greater weight on successive periods beyond the next period. This result is consistent with the possibilities that obtain in Becker & Mulligan (1997).

## 5 Implications of the Model

I now consider a number of implications of the focusing model. All of these flow from the model with the additional recognition that cognitive effort – such as is required to focus on the future – is a scarce resource, hence costly. The implications generally depend upon the more specific assumption that the costliness of focusing is a monotonic function of the reduction in the exponential discount factor,  $\delta$ .

### 5.1 Costly Self-Control and the Welfare Effect of Hard Commitments

The focusing model remedies a weakness in the hyperbolic discounting commitment framework identified by Gul & Pesendorfer (2001) (henceforth “GP”) that the welfare effect of a policy that enforces a hard commitment – that is, that removes available options – is generally ambiguous under such a framework.

The focusing model conceives of hyperbolic discounting as arising out of amblyopia – a chronic failure to experience future events as salient. As such, my framework recognizes focusing as an advance preparation that individuals can take to remedy their amblyopia when other forms of commitment fail to constrain their options. In view of its being imposed in advance, focusing would be distinguished by GP as commitment rather than self-control; yet in a cost sense it behaves much the same as GP’s temptation cost, in that the costs associated with focusing rise with the seriousness of the threat that it is intended to address.

Intuitively, focusing functions like a levee: the individual must invest in protection sufficient to withstand the temptation that is anticipated to loom large in the present moment. Assuming the cost of that protection is nontrivial, it is the case, as in GP, that the individual would prefer not to have a tempting item on the menu even if it is not chosen in equilibrium. Having it on the menu – so long as it is sufficiently tempting – necessitates the construction of the levee. With it off the menu, the levee is unnecessary and the cost of construction is avoided. This implies clear welfare consequences for focusing – and an unambiguous welfare benefit to hard commitments that alleviate the need to focus – in a fashion that parallels the GP model.

Note that a distinction between the focusing model and the GP model is that in the focusing model items on the menu impose a self-control cost only if they reach a threshold for requiring cognitive action to avoid the temptation – that is, if the present bias

achieves consequentiality. In the GP model, the most tempting item on the menu always imposes a cost. Introspection suggests the threshold characteristic is more realistic: not every stimulus in the environment is sufficiently salient to call attention to itself. This suggests that the welfare benefits of hard commitment indicated by the GP model may be overstated.

A further advantage of the focusing model, relative to GP, is that it gives a concrete psychological conception to self-control costs that is based on evidence from the literature. That evidence indicates that the efforts that shift decisions away from temptations almost invariably involve so-called mental time travel. This realization reinforces, *inter alia*, the appropriateness of a hyperbolic discounting model of self-control.

## 5.2 Cognitive Load and Impulsivity

The focusing model may be the key to understanding why cognitive load results in greater impulsivity. In a famous experiment, Shiv & Fedorikhin (1999) show that, all else equal, cognitively-loaded individuals are more likely to choose chocolate cake as a snack – an impulsive choice – in preference to a healthier option of fresh fruit.<sup>6</sup> The authors characterize this finding as indicating that limitations in processing resources cause individuals to default to an automatic, affect-driven choice process, whereas they would otherwise rely on a more controlled process that results in cognitions about the consequences of different choices.

The focusing model sharpens the description of this process around its rational-choice components. The “automatic” affect-driven process treats the present moment as primary, in effect placing greater weight on the present and discounting the future. In contrast, considering consequences brings the future into greater focus, reducing the discount factor applied to that future. This explanation is aligned with the psychological evidence, cited in the introduction, that focusing effort both reduces discounting and ensures success at future-oriented behaviors. Put in the parlance of the model, cognitive load interferes with the amblyopic individual’s ability to engage in focusing effort, such she fails to align her discount factor with her true values concerning future consumption. Her regard for the future remains “lazy,” and so she acts on her impulses.

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<sup>6</sup>von Hippel & Gonsalkorale (2005) make similar findings, showing that participants under cognitive load are more likely to blurt out an inappropriate and negative response in situations that evoke such affect. Individuals not so loaded exhibit greater inhibitory function.

### 5.3 The Stratification of Declining Savings Since the 1980s

In demonstrating that focusing effort substitutes for an illiquid asset as a commitment device, the focusing model may help to explain why cognitive loading is associated with debt, and relatedly why the period beginning with the 1980s saw not just a reduction in savings rates but an increased stratification in savings rates by income level. Laibson (1997) argues that the availability of instantaneous credit led to a decline in savings rates in the U.S. during the 1980s. In particular, he points to data showing a precipitous drop in U.S. personal savings as a percent of disposable income between the 30-year period leading up to 1984, and the 10-year period that followed. Laibson reasons that instantaneous credit represented an opportunity to borrow against illiquid assets; it thereby reduced their effectiveness as a commitment device.

But what happened during the relevant period went beyond a simple decline in savings across all consumers. Savings data for the period 1978 to 2007 from the Distributional National Accounts and Congressional Budget Office show that the top 1% of the income distribution actually increased their savings modestly, while for the next 9% savings essentially held steady. It is only the lowest 90% who experienced substantial dissaving during the period (Mian et al. 2021).<sup>7</sup>

One possible explanation proceeds as follows. With illiquid assets becoming increasingly ineffective, consumers during the 1980s were forced to fall back on focusing as commitment. Those consumers with cognitive resources to spare – mainly the rich – mustered the wherewithal to maintain commitment through focus and continued to save. Meanwhile, the poor, who have always been cognitively taxed, did not have the “bandwidth” resources to devote to focusing effort, and so fell prey to access to instant credit disproportionately. Thus we observe not only a declining general rate of saving, but an increased stratification of this decline after credit cards became widely available.

## 6 Extrinsic Aids to Commitment

“If you want to build a ship, don’t drum up people to collect wood and don’t assign them tasks and work, but rather teach them to long for the endless immensity of the sea.”

- Antoine de Saint-Exupery

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<sup>7</sup>The same sectoral trends are observed when one looks at the period only up through the publication date of Laibson’s paper in 1997.



So far, I have treated focusing as an isolated decision by an individual to make use of what is in effect an endowed personal commitment resource. This is not a wholly adequate characterization for two reasons.

First, as discussed above, focusing is likely costly in that it utilizes a scarce resource. The efficiency with which individuals may engage in it likely varies from person to person and, for a given person, from moment to moment. It follows that there conceivably exist more efficient ways to obtain focus than simply doing it based on one's native resources at a particular moment. If that is true, then individuals will typically demand access to external "technologies" of focusing. These technologies may take the form of services offered by people, for whom focusing efficiently or the ability to motivate is an element of their human capital. They may also include media that provide focusing "know-how" or motivation.

Second, much as Benabou and Tirole (2002, p873) have noted that various people may have a vested interest in an individual's self-confidence, so too is it true that individuals and organizations will more broadly have a vested interest in an individual's commitment. These principals will, in relevant situations, have an incentive to build up the individual's ability at focusing. Their manipulations may take various forms, many of which are readily recognizable in common institutions and other familiar phenomena.

Below, I offer several examples of extrinsic aids to commitment – such as may be sought by a decision maker as useful technology, or imposed on a decision-making agent by a principal with a vested interest. All involve, in effect, applied focusing effort.

## 6.1 Self-Help Books and Managerial Training

In his book, *The 7 Habits of Highly Effective People*, Stephen R. Covey (1989) introduces as his second habit a strategy for what he calls "personal leadership": "Begin with the end in mind." The core idea is that one should develop a cohesive vision as to what one is going to do in life, aligned with one's values. Then one should live while maintaining focus on that vision. As Covey explains: "Personal leadership is not a singular experience. It doesn't begin and end with the writing of a personal mission statement. It is, rather, the ongoing process of *keeping your vision and values before you* and aligning your life to be congruent with those most important things (p132, emphasis added)."

Covey illustrates the application of this process with an example. A parent loves his children, but has trouble overreacting to them on a daily basis. To solve this problem,

the parent writes an affirmation that lays out in personal, visual and emotional terms the principles according to which he would prefer to respond to his children in the context of the specific triggering situation. He then engages in vividly visualizing an application of the principles in his affirmation:

I can spend a few minutes each day and totally relax my mind and body. I can think about situations in which my children might misbehave. I can visualize them in rich detail. I can feel the texture of the chair I might be sitting on, the floor under my feet, the sweater I'm wearing. I can see the dress my daughter has on, the expression on her face.... Then I can see her do something very specific which normally makes my heart pound and my temper start to flare. But instead of seeing my normal response, I can see myself handle the situation with all the love, the power, the self-control I have captured in my affirmation.... And if I do this, day after day my behavior will change.

Covey's process comprises the three critical elements that characterize focusing effort for commitment, as outlined in section 2. The problem addressed is one of dynamic inconsistency: one wishes to live one's life in line with a certain set of values - say, by being a good parent - but one finds that one's "future self" naturally deviates. The solution - an affirmation - involves focusing effort (i.e., episodic future thinking), whereby the individual acts as if time were collapsed and the future were more immediate. Finally, the affirmation is prepared and rehearsed in advance, so that when a critical moment arises the individual's long-run values are salient, as by design.

The elements at the center of Covey's advice on personal leadership appear similarly in self-help books and training curricula aimed at developing organizational leadership skills. As one example: a leadership training program at a Fortune 500 pharmaceutical company advises trainees to maintain focus on their priorities when faced with personal "triggers." In other words, the individual should strive to recognize what work situations may trigger her to respond in a way that is inconsistent with her preferred behavior. She should develop a clear and visual sense of her priorities - as a person and as a manager - and learn to focus on these. Then, when the triggering moment arises, she evokes and sustains the learned focus in order to resist her "triggers" and maintain behavior in alignment with her long-run values.

## 6.2 Visionary Leadership

The fact that successful commitment leads individuals to follow through on relevant actions over the long term means that organizations will frequently find themselves in the position of wanting to inspire their employees with increased powers of focus. An important manifestation of this is leadership in organizations. In particular, one often hears the term “visionary leadership,” or hears about special leaders – particularly company founders – who had extraordinary vision. But what is visionary leadership? And what, for that matter, is meant by “vision,” when referenced in the context of leadership?

The focusing model suggests that it is not in the ideas. Individuals may have remarkable ideas, but that does not make them leaders. Rather, vision as relates to leadership consists in the ability to impel commitment to a course of action. The skills of the visionary are precisely in the ability to reduce the applied discount factor of one’s followers. Thinking of an overarching theme with respect to a course of action is not critical to the success of the action; committing people to the action dynamically is.

The model thus provides a rational-agent account of why leaders are valued for their “vision.” Rather than relating to a far-fetched expectation that some people have superior or even supernatural powers to predict the future, the model suggests successful leaders merely possess above-average powers of commitment, paired with the ability to inspire similar commitment in others.

The model suggests that those least adept at focusing are the most dependent on the visionary services of leadership. Adept focusers, whether they are skilled at inspiring focus in others or not, are more likely to succeed at commitment-oriented tasks without being led. Thus organizations will tend to allocate visionary leaders to workgroups based on where their focus is most needed. And they will tend to allocate employees to bosses and workgroups based, in part, on who stands to gain the most (i.e., in productivity) from the scarce commitment services of skilled visionary leaders.

## 6.3 Motivational Speakers

The model provides an explanation of why we observe demand for financial gurus, evangelical pastors, and other motivational speakers (such as TED presenters) – even when such people provide no new *information* on the value, respectively, of saving money, attaining salvation, and pursuing other aspirational goals. Rather than being the most knowledgeable about some area, the most effective members of these groups are the most

“visionary” – which is to say, the most able to motivate sustained focus and thereby inspire commitment in others.

The fact that people are often willing to pay for the services provided by these people provides some sense of the economic value of the commitment that focusing provides.

## 6.4 Role Models

In their motivational theory of role models, Morgenroth et al. (2015) describe role models as “representations of the possible.” As such, the individuals in question do not show *how* to do something, but rather *that* something is possible (p3).

This particular function of role models mirrors in its effects on an individual’s prospective actions the role of episodic future thinking about those same actions: the role model with whom one identifies and to whose achievements one aspires becomes a vivid and dynamic representation of one’s own desired future. In doing this, the role model reduces the individual’s discount factor with respect to future goals that align with the role model’s achievements. Viewed through the lens of the focusing model, then, the role model offers an extrinsic aid to commitment.<sup>8</sup>

Role modeling can play a similar role in group activities. A runner motivates herself by running with others. The motivation arises in part because the other runners - assuming the runner chooses her running buddies wisely - provide visual role models who persevere and run hard, reminding of her of her core values in the running and challenging her to do as they do.

## 7 Conclusion

This paper has demonstrated that focusing effort serves as a commitment device. I have outlined several contributions of the focusing framework and have offered some examples of the focusing mechanism in action in the guise of real-world phenomena.

Focusing may largely be the commitment device of the well-to-do. If one is fortunate enough to have the cognitive bandwidth to devote to focusing on the future – or if one is able to hire a servant to whisper in one’s ear, as did King Darius of Persia – one may fare better at resisting temptations, saving one’s money, and so on. The financial reforms that began in the 1980s and have continued to this day have, in weakening essential sources

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<sup>8</sup>For an economic study demonstrating the effects of role models, see Porter & Serra (2020).

of hard commitment – as noted by Laibson (1997) – have made consumers increasingly dependent on extrinsic aids to commitment, such as those discussed in Section 6. Indeed, the proliferation of audiobooks and podcasts by financial gurus who claim the unique ability to help people get on a secure financial path may be a direct outcome of the financial reforms – not because those reforms have made more financial options available, but precisely because they have rendered certain previously existing financial options impotent.

To be sure, there is a certain romance in the “commitment the hard way” that focusing effort represents. Pining for one’s beloved is a centuries-old ritual for maintaining commitment in long-distance relationships.<sup>9</sup> Similarly, the obsessive spirit of King Darius – or, for that matter, Inigo Montoya in *The Princess Bride* – earns a certain reverence. That said, as discussed earlier in this paper, a key use of observations both of focusing effort and of the employment of aids to that effort is the measurement of the opportunity cost – in terms of money, time, and effort – of the counterfactual availability of formal commitment devices.

## A Appendix

The proof of my Theorem 1 takes as its starting point Laibson’s (1997) Theorem 1. The proof involves demonstrating that a translation of Laibson’s result applies to the  $T$ -period game I describe in my theorem.

Three preliminary lemmas are required to complete the proof.

**Lemma 1.** *Consider a modification of the game described in Laibson’s (1997) Theorem 1 as follows. Fix any  $t$ , and let  $\delta_t$  apply specifically to the consumer’s decision problem at  $t + 1$ . The subgame perfect equilibrium decisions  $x_t$  and  $z_t$  of the consumer at  $t$ , and  $c_{t+1}$  and  $x_{t+1}$  of the consumer at  $t + 1$ , are monotone in  $\delta_t$ ; specifically,  $\frac{\partial x_t}{\partial \delta_t} \geq 0$ ,  $\frac{\partial z_t}{\partial \delta_t} \leq 0$ ,  $\frac{\partial c_{t+1}}{\partial \delta_t} \leq 0$ , and  $\frac{\partial x_{t+1}}{\partial \delta_t} \geq 0$ . Moreover,  $c_{t+1} < y_{t+1} + R_{t+1}x_t$  and  $z_t > 0$  imply  $\frac{\partial x_t}{\partial \delta_t} > 0$  and  $\frac{\partial z_t}{\partial \delta_t} < 0$ , and  $c_{t+1} < y_{t+1} + R_{t+1}x_t$  implies  $\frac{\partial c_{t+1}}{\partial \delta_t} < 0$ .*

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<sup>9</sup>It has even been given physical manifestation in architecture: a turret atop seaside houses called the “widow’s walk” allowed the wife of the sailor to pace while keeping her eyes fixed on the sea in anticipation of her husband’s return.

*Proof.* The Kuhn-Tucker conditions for consumer  $t + 1$ 's optimization yield

$$u'(c_{t+1}) \geq \max_{\tau \in \{1, \dots, T-t-1\}} \beta \delta_t^\tau u'(c_{t+\tau+1}) \left( \prod_{i=1}^{\tau} R_{t+i+1} \right) \quad (\text{A.1})$$

If  $c_{t+1} < y_{t+1} + R_{t+1}x_t$ , then Laibson's P1 and P2 imply equality holds in (A.1). Fix any  $\tau$  such that  $t = \tau$  satisfies  $\arg \max \left\{ \beta \delta_t^\tau u'(c_{t+\tau+1}) \left( \prod_{i=1}^{\tau} R_{t+i+1} \right) \right\}$ , and assume  $t = 1$  also satisfies. It follows that

$$u'(c_{t+1}) = \beta \delta_t u'(c_{t+2}) R_{t+2} = \beta \delta_t^\tau u'(c_{t+\tau+1}) \left( \prod_{i=1}^{\tau} R_{t+i+1} \right)$$

Total differentiation yields,

$$\begin{aligned} \beta \delta_t u''(c_{t+2}) R_{t+2}^2 dx_{t+1} &= -\beta u'(c_{t+2}) R_{t+2} d\delta_t \\ u''(c_{t+1}) dc_{t+1} &= \tau \beta \delta_t^{\tau-1} u'(c_{t+\tau+1}) \left( \prod_{i=1}^{\tau} R_{t+i+1} \right) d\delta_t \end{aligned}$$

Using Cramer's rule,

$$\begin{aligned} \frac{\partial c_{t+1}}{\partial \delta_t} &= \frac{\hat{\tau} \beta \delta_t^{\hat{\tau}-1} u'(c_{t+\hat{\tau}+1}) \left( \prod_{i=1}^{\hat{\tau}} R_{t+i+1} \right)}{u''(c_{t+1})} < 0 \\ \frac{\partial x_{t+1}}{\partial \delta_t} &= -\frac{u'(c_{t+2})}{\delta_t u''(c_{t+2}) R_{t+2}} > 0 \end{aligned} \quad (\text{A.2})$$

Assume WLOG instead that  $c_{t+1} = y_{t+1} + R_{t+1}x_t$ . Then  $c_{t+1}$  is no longer a function of  $\delta_t$ , implying  $\frac{\partial c_{t+1}}{\partial \delta_t} = 0$ . Similarly, if we assume WLOG that  $t = 1$  does not satisfy  $\arg \max \left\{ \beta \delta_t^\tau u'(c_{t+\tau+1}) \left( \prod_{i=1}^{\tau} R_{t+i+1} \right) \right\}$ ,  $\frac{\partial x_{t+1}}{\partial \delta_t} = 0$ .

We turn to the Kuhn-Tucker conditions for consumer  $t$ 's optimization, which yield

$$u'(c_t) \geq \max_{\tau \in \{1, \dots, T-t\}} \beta \delta_{t-1}^\tau u'(c_{t+\tau}) \left( \prod_{i=1}^{\tau} R_{t+i} \right) \quad (\text{A.3})$$

Consumer  $t$ 's decisions with respect to  $x_t$  and  $z_t$  are influenced by  $\delta_t$  through the parameter's effect on consumer  $t + 1$ 's consumption decision. If  $c_{t+1} < y_{t+1} + R_{t+1}x_t$  and  $z_t > 0$ ,

then  $t = 1$  and  $t = 2$  both satisfy  $\arg \max \left\{ \beta \delta_{t-1}^\tau u'(c_{t+\tau}) \left( \prod_{i=1}^{\tau} R_{t+i} \right) \right\}$ . It follows that

$$\beta \delta_{t-1}^2 u'(c_{t+2}) R_{t+1} R_{t+2} = \beta \delta_{t-1} u'(c_{t+1}) R_{t+1} \quad (\text{A.4})$$

Totally differentiation yields

$$\begin{aligned} \beta \delta_{t-1}^2 u''(c_{t+2}) R_{t+1}^2 R_{t+2}^2 dz_t &= \beta \delta_{t-1} u''(c_{t+1}) \frac{\partial c_{t+1}}{\partial \delta_t} R_{t+1} d\delta_t \\ -\beta \delta_{t-1} u''(c_{t+1}) R_{t+1}^2 dx_t &= \beta \delta_{t-1} u''(c_{t+1}) \frac{\partial c_{t+1}}{\partial \delta_t} R_{t+1} d\delta_t \\ -R_{t+1} dx_t &= \frac{\partial c_{t+1}}{\partial \delta_t} d\delta_t \end{aligned}$$

Recalling that  $c_{t+1} < y_{t+1} + R_{t+1}x_t$  implies  $\frac{\partial c_{t+1}}{\partial \delta_t} < 0$ , it follows that

$$\begin{aligned} \frac{\partial z_t}{\partial \delta_t} &= \frac{u''(c_{t+1})}{\delta_{t-1} u''(c_{t+2}) R_{t+1} R_{t+2}^2} \frac{\partial c_{t+1}}{\partial \delta_t} < 0 \\ \frac{\partial x_t}{\partial \delta_t} &= -\frac{1}{R_{t+1}} \frac{\partial c_{t+1}}{\partial \delta_t} > 0 \end{aligned}$$

It is straightforward to show that relaxation of either  $c_{t+1} < y_{t+1} + R_{t+1}x_t$  or  $z_t > 0$  implies  $\frac{\partial z_t}{\partial \delta_t} = 0$ , and relaxation of  $c_{t+1} < y_{t+1} + R_{t+1}x_t$  implies  $\frac{\partial x_t}{\partial \delta_t} = 0$ .  $\square$

**Lemma 2.** *Consider a modification of the game described in Laibson's (1997) Theorem 1 such that there exist  $\delta_0, \delta_1, \dots, \delta_{T-1}$  whereby, for each  $t = 1, \dots, T$ ,  $\delta_{t-1}$  applies to the consumer's decision problem at  $t$ . There exists a unique resource-exhausting joint strategy,  $s^* \in S$ , that satisfies Laibson's P1-P4 with  $\delta_{t-1}$  in lieu of  $\delta$ , and this strategy is the unique SPE strategy of this modified game.*

*Proof.* Follows trivially from Lemma 1. In particular, resource exhaustion follows, as the decision facing the consumer at  $T$  is unaffected by the tweak.  $\square$

**Lemma 3.** *Consider the modified game described in Lemma 2. Fix any particular value of  $t$ ,  $\delta_t = \bar{\delta}_t$ , feasible history  $h_t$ , and any set of permissible values of all other exogenous variables. Let  $\{c_t^*, x_t^*, z_t^*\}$  represent the actions in period  $t$  corresponding to the unique SPE strategy of the game. For any  $z_t^{**}$  such that  $z_t^* \geq z_t^{**} > 0$ , there exists a function  $\hat{\delta}_t(z_t^*, z_t^{**})$  continuous on the domain of its arguments such that  $\{c_t^{**}, x_t^{**}, z_t^{**}\}$  for some  $c_t^{**}, x_t^{**} \geq 0$  represents the unique SPE strategy of the game when  $\hat{\delta}_t$  replaces  $\bar{\delta}_t$ .*

*Proof.* Assume first that  $c_{t+1}^* < y_{t+1} + R_{t+1}x_t^*$  holds for the unique SPE. Then by Lemma 1,  $\frac{\partial x_t^*}{\partial \delta_t} > 0$ ,  $\frac{\partial z_t^*}{\partial \delta_t} < 0$ , and  $\frac{\partial c_{t+1}^*}{\partial \delta_t} < 0$ . The monotonicity of these statics in the neighborhood of the SPE implies further that  $c_{t+1} < y_{t+1} + R_{t+1}x_t$  holds for  $z_t \in (0, z_t^*]$ , thus  $\frac{\partial z_t}{\partial \delta_t} < 0$  similarly holds with strict inequality for  $z_t \in (0, z_t^*]$ . The existence of  $\hat{\delta}_t(z_t^*, z_t^{**})$  as described follows by the Inverse Function Theorem.

Now WLOG assume  $c_{t+1}^* = y_{t+1} + R_{t+1}x_t^*$  for the unique SPE. It is clear that increasing  $\delta_t$  from  $\bar{\delta}_t$  eventually results in equality in the Kuhn-Tucker expression in (A.1), whereby  $c_{t+1} < y_{t+1} + R_{t+1}x_t$  so that  $\frac{\partial x_t}{\partial \delta_t} > 0$ ,  $\frac{\partial z_t}{\partial \delta_t} < 0$ , and  $\frac{\partial c_{t+1}}{\partial \delta_t} < 0$  follow by Lemma 1. The monotonicity of these statics in the neighborhood of the new SPE implies further that  $c_{t+1} < y_{t+1} + R_{t+1}x_t$  holds for  $z_t \in (0, z_t^*]$ , thus  $\frac{\partial z_t}{\partial \delta_t} < 0$  similarly holds with strict inequality for  $z_t \in (0, z_t^*]$ . The existence of  $\hat{\delta}_t(z_t^*, z_t^{**})$  as described follows, here again, by the Inverse Function Theorem.

To prove continuity, first assume not. Then there exists  $\tilde{z}_t \in (0, z_t^*)$  such that either  $\lim_{z_t^+ \rightarrow \tilde{z}_t} \hat{\delta}_t(z_t^*, z_t) < \hat{\delta}_t(z_t^*, \tilde{z}_t)$  or  $\lim_{z_t^- \rightarrow \tilde{z}_t} \hat{\delta}_t(z_t^*, z_t) > \hat{\delta}_t(z_t^*, \tilde{z}_t)$ . Assume WLOG that  $\lim_{z_t^+ \rightarrow \tilde{z}_t} \hat{\delta}_t(z_t^*, z_t) < \hat{\delta}_t(z_t^*, \tilde{z}_t)$  and define  $\hat{\delta} \equiv \lim_{z_t^+ \rightarrow \tilde{z}_t} \hat{\delta}_t(z_t^*, z_t)$ . We have established earlier in the proof that within the relevant neighborhood  $\frac{\partial z_t}{\partial \delta_t} < 0$  with strict inequality; but then there exists  $\hat{z}_t > \tilde{z}_t$  such that  $\hat{\delta}_t(z_t^*, \hat{z}_t) \in (\hat{\delta}_t(z_t^*, \tilde{z}_t), \hat{\delta})$ , which contradicts  $\hat{\delta} = \lim_{z_t^+ \rightarrow \tilde{z}_t} \hat{\delta}_t(z_t^*, z_t)$ . The continuity of  $\hat{\delta}_t(\cdot, \cdot)$  follows.  $\square$

**Proof of Theorem 1.** Fix any period  $t$  and feasible history  $h_t$ . Taking the existence and continuity of  $\hat{\delta}_t(z_t^*, z_t^{**})$  as provided by Lemma 3, let us define

$$\delta_t^{**} \equiv \lim_{z_t^{**} \rightarrow 0} \hat{\delta}_t(z_t^*, z_t^{**}) \quad (\text{A.5})$$

Because we began with arbitrary  $t$  and history  $h_t$ , it follows that  $\{c_{t+\tau}^{**}, x_{t+\tau}^{**}, \delta_{t+\tau}^{**}\}_{\tau=0}^{T-t}$  is the resource-exhausting joint strategy,  $s^* \in S$ , that is the unique subgame perfect equilibrium strategy of the game as defined.

It remains to show that  $s^*$  satisfies C1-C5. C1 and C2 follow immediately as the Euler conditions from consumer  $t$ 's optimization, which is unchanged from the Laibson setup with respect to the consumer's tradeoff of current period consumption versus future consumption, except that  $\delta_{t-1}$  replaces  $\delta$ . To show that C5 is met, consider that  $\frac{\partial z_t}{\partial \delta_t} < 0$  (Lemma 1) and definition of  $\delta_t^{**}$  in (A.5) imply  $\delta_t^{**} \geq \delta_0$ . To show  $\delta_t^{**} \leq \frac{\delta_0}{\beta}$ , let us first assume not. For any  $t > 1$ ,  $\delta_t^{**} > \frac{\delta_0}{\beta}$  induces a contradiction between C1 and C2 on the



one hand, and C3 and C4 on the other. Therefore,  $\frac{\delta_0}{\beta} \geq \delta_t^{**} \geq \delta_0$ .

With regard to satisfaction of C3 and C4, consider three cases from the Laibson setup. First, suppose,  $u'(c_{t+1}) = \max_{\tau \in \{1, \dots, T-t-1\}} \delta^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(c_{t+\tau+1})$ . In this case neither  $x_t = 0$  nor  $z_t = 0$  bind. It follows from  $\frac{\partial z_t}{\partial \delta_t} < 0$  (Lemma 1) and definition of  $\delta_t^{**}$  in (A.5) that a constraint of  $z_t = 0$ , consistent with my setup, implies  $\delta_t^{**} > \delta_0$  as an element of the unique SPE such that  $u'(c_{t+1}) = \max_{\tau \in \{1, \dots, T-t-1\}} \delta_0^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(c_{t+\tau+1})$ . This satisfies C3, whereby it follows that C3 and C4 are satisfied for this case.

Alternatively, suppose  $u'(c_{t+1}) > \max_{\tau \in \{1, \dots, T-t-1\}} \delta^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(c_{t+\tau+1})$ . By P4, this implies  $z_t = 0$  under the Laibson setup. By the definition of  $\delta_t^{**}$  in (A.5), the unique SPE under my setup therefore implies  $\delta_t^{**} = \delta_0$ . Thus  $u'(c_{t+1}) > \max_{\tau \in \{1, \dots, T-t-1\}} \delta_0^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(c_{t+\tau+1}) > \max_{\tau \in \{1, \dots, T-t-1\}} \beta \delta_0^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(c_{t+\tau+1})$ , whereby the Euler condition for consumer  $t+1$ 's optimization implies  $c_{t+1}^{**} = y_{t+1} + R_{t+1}x_t^{**}$ . This satisfies C4, hence it follows that C3 and C4 are satisfied for this case.

Finally, let us suppose  $u'(c_{t+1}) < \max_{\tau \in \{1, \dots, T-t-1\}} \delta^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(c_{t+\tau+1})$ . By P3, this implies  $x_t = 0$  under the Laibson setup, which means therefore also  $z_t > 0$ . As in the first case, this implies  $\delta_t^{**} > \delta_0$  as an element of the unique SPE under my setup such that  $u'(c_{t+1}) = \max_{\tau \in \{1, \dots, T-t-1\}} \delta_0^\tau \left( \prod_{i=1}^{\tau} R_{t+i} \right) u'(c_{t+\tau+1})$ . This satisfies C3, whereby it follows that C3 and C4 are satisfied for this case.

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