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Temporal Profiles of Instant Utility during Anticipation and Recall

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We propose the Anticipation and Recall model, an integrative theoretical framework that predicts the temporal profiles of instant utility experienced before, during, and after a given event. Total utility is calculated as the sum integral of instant utility. At a process level, the model captures several psychological principles such as conceptual consumption, adaptation, and time distance. The model offers numerous predictions and implications. The profile of instant utility is U-shaped during anticipation. Shortening anticipation makes a positive event more surprising and leads to an increase in utility from recall. Under certain conditions, surprises are optimal, in the sense that zero anticipation maximizes total utility. We investigate the case of anticipating negative events, and provide prescription on how individuals may better cope with negative situations. The model also provides insight into optimal hedonic editing and deceptive postponement. Empirical evidence in favor of the main implications of the model is discussed.
Keywords: instant utility, anticipation, time distance, magnitude effect.

Introduction

> *"If for example you come at four o'clock in the afternoon, I shall start feeling happy at three o'clock. As the time passes, I shall feel happier and happier. At four o'clock, I shall become agitated and start worrying; I shall discover the price of happiness. But if you come at just any time, I shall never know when I should prepare my heart to greet you... One must observe certain rites."*
>
> – *The Little Prince*, Antoine de Saint-Exupery, 1943.

The Little Prince exhorts the fox to let him know the exact arrival time of her visit because he does not want to miss the anticipatory feelings of happiness and excitement prior to the upcoming meeting. Indeed, there are many events whose duration is very short relative to the duration of anticipation and recall. Examples include admiring a beautiful building or natural wonder, a visit by a distant friend or relative, a brief romantic encounter, a short but painful medical procedure, or meeting a celebrity. Lazarus (1966) demonstrated that certain forms of physical pain, such as pinpricks, do not produce measurable psychological-stress reactions beyond those produced by the mere anticipation of them. Two studies that examined travelers' experiences found that, regardless of the type of trip, vacationers were happier in the period leading up to their vacation than during the vacation (Nawijn et al., 2010; Mitchell et al., 1997). In such cases, the sum integral of the utility experienced during the occurrence of the event may be small compared to the total utility derived from the event, that is, considering the utility derived before (anticipation), during (occurrence), and after (recall) the event.

Bentham (1789) was among the first to recognize that anticipation is an important source of pleasure and pain. Jevons (1913) later distinguished between anticipation of future events, sensation of present events, and memory of past events. Kahneman et al. (1997, p. 376) argue that "Total utility is a normative concept constructed from temporal profiles of instant utility."

Existing research, however, has not proposed a comprehensive model of instant utility during anticipation, occurrence, and recall. In this paper, we propose the Anticipation Recall model (AR model), formally linking the three components of total utility on a continuous time interval that includes the occurrence of the event, as well as the time during which it is anticipated and recalled. The AR model is based on well-established psychological principles, such as conceptual consumption, adaptation, and time distance. Given a small set of general inputs (i.e., the magnitude and duration of the event, and the duration of anticipation and recall), the AR model produces a temporal profile of instant utility associated with an event. The sum integral of instant utility over time produces the total utility associated with the event. According to Kahneman et al. (1997), a rational individual will seek to maximize total utility.

Conceptual Consumption, Adaptation, and Time Distance

The process model we propose entails three key psychological elements. The first element is *conceptual consumption* (Ariely & Norton, 2009), defined as psychological consumption that can occur independent of physical consumption. Anticipatory emotions arise in reaction to mental discrete images of the outcome of a decision (Damasio, 1994). For example, when anticipating a future, upcoming event, individuals are conceptually consuming images of the event prior to its physical occurrence. The ability to generate such mental simulations is a fundamental ability of the human mind (Gilbert & Wilson, 2007). Conceptual consumption produces "savoring" and "dread" during anticipation (G. Loewenstein, 1987; Golub et al., 2009). Similarly for recall, contemplation of the past through memory produces pleasure or pain in the present (Elster & Loewenstein, 1992). People recall salient instants of pleasure or pain and tend to neglect the duration of the event (Kahneman et al., 1993; Fredrickson & Kahneman, 1993; Fredrickson, 2000). Consistent with this research, we posit that mental images of future events (Elster & Loewenstein, 1992), or "snapshots" of the event experienced in the past (Fredrickson & Kahneman, 1993), determine the intensity of conceptual consumption before and after the physical occurrence of the event.

The second psychological element is *adaptation* before and during the event. Adaptation, which is understood as a decreased response to a repeated stimuli, has been part of the toolset of psychologists for a long time (Helson, 1964). In formal utility models, adaptation is often described by means of a reference point that approaches the consumption rate (Wathieu, 1997; Baucells & Sarin, 2010). We posit that not only consumption during the event, but also conceptual consumption before the event, produces adaptation. Anticipating an event increases the level of expectations against which future outcomes will be valued (Kahneman & Miller, 1986; Olson et al., 1996). Formally, anticipation modifies the reference point (Kőszegi & Rabin, 2006; Kőszegi & Rabin, 2009). Thus, overly optimistic expectations hold the potential for lowering the utility from the event by setting high counterfactuals (Shepperd & McNulty, 2002). Indeed extensive research demonstrates that unmet anticipatory expectations produce disappointment in a variety of settings, such as romantic dates (Norton et al., 2007), athletic competitions (Medvec et al., 1995), promotions in the work place (Harvey & Martinko, 2009), academic tests (Shepperd & McNulty, 2002), and hotel services (Boulding et al., 1993). People typically use a recollection of similar events, which occurred in the past and are stored in their memory, to form their expectations of upcoming events (Weber et al., 2007; Stewart et al., 2006) and to set the reference point against which future outcomes will be measured (Anderson & Milson, 1989).

Thus stored past experiences shape the upper and lower limits of the range of comparisons, which in turn influence the pleasure one gets from any given event (Elster & Loewenstein, 1992, p.217).

The third psychological element of the AR model is *time distance* to the event. Time distance modulates instant utility during anticipation and recall by means of a discount factor. The discount factor is not a function of the calendar time. Instead, it depends on the time distance to and from the event. Discounting captures the notions of decreasing impatience for anticipation (G. F. Loewenstein & Prelec, 1993; Frederick et al., 2002) and of transience for recall (Ebbinghaus, 1913; Wixted, 2004; Brown et al., 2007). We also incorporate magnitude effects in discounting: the smaller the magnitude of the event, the smaller the discount factor (R. Thaler, 1981; Frederick et al., 2002). This feature captures the "peak" element of the peak-end rule (Kahneman et al., 1993; Fredrickson, 2000). Time distance, together with conceptual consumption, is consistent with construal level theory, which proposes that individuals form abstract mental construals of distal objects and realities (Trope & Liberman, 2010), and derive pleasure or pain from these thoughts.

We set our model under conditions of certainty and focus on the described psychological elements of conceptual consumption, hedonic adaptation, and time distance. Thus, we effectively contribute to the literature by modeling the combined effect of these three elements in a unique and comprehensive formulation. As detailed in the description of the model, we capture these elements using a parametric specification (see Table D1 below).

Review of Anticipatory Utility Models

Many formal models of anticipation have been proposed. Existing models of anticipation are typically set in discrete time and propose general functional forms by which future outcomes and events affect current utility. In the seminal paper by G. Loewenstein (1987), individuals derive utility from anticipation, and such utility is proportional to the total future utility that will be obtained during the event. In Brunnermeier & Parker (2005) and Gollier & Muermann (2010), agents derive utility from being optimistic, and choose expectations (probabilities) in order to optimally trade-off optimism with poor decision-making (associated with having wrong probabilities) and regret (Bell, 1982). As models of anticipation, these papers assume the same formulation as G. Loewenstein (1987).

Kőszegi & Rabin (2009) propose a model of anticipation by which individuals derive consumption utility during the event plus gain/loss utility before the event. Gain/loss utility is driven by changes in expectations, and it is updated immediately when these changes occur. When applied to the context of the AR model, individuals would obtain a boost of utility at the moment they plan for an upcoming event (gain/loss utility), a second boost of utility at the moment of consuming, and no utility in between. Our focus is on gradual adaptation, i.e., on how this initial surprise is savored over time.

Caplin & Leahy (2001) propose a modification of expected utility whereby utility is obtained from psychological states, rather than physical outcomes. These psychological states depend on the current and future physical outcomes, and hence produce anticipatory feelings such as anxiety. Caplin & Leahy (2001) and similar economic models abstract from specific details. For example, discrete-time models of anticipation may introduce a parameter or a state called the anticipation level. However, little detail is given on what determines the anticipation level or the mechanism through which the anticipation level affects the utility of the event. There is a need for a model focused more on psychology, which explicitly maps physical outcomes to psychological states, and provides sufficient detail to derive the temporal profile of experienced utility.

This paper aims to fill this gap. To keep things simple, we focus on conditions of certainty, and on single event cases (e.g., an upcoming dinner at a nice restaurant that is expected to occur with certainty). Departing from existing models, our setup uses continuous time. This is an important modeling choice because it forces us to confront questions on how anticipation might work. For instance, how does utility of anticipation exactly evolve over time? How does the precise duration of anticipation affect the utility of the event?

By virtue of its richer formulation capturing diverse elements (e.g., adaptation during anticipation, magnitude effects in discounting), the AR model produces a wide set of insights and testable implications. For example, consistent with Breznitz (1984), the resulting profile of instant utility during anticipation is U-shaped. In examining total utility, we find that increasing anticipation makes the event less surprising and leads to an decreases in the utility experienced during and after the event. Thus, there is such a thing as the optimal duration of anticipation. In fact, we identify conditions under which a surprise event (i.e., zero anticipation) is optimal. We also investigate how to optimally anticipate negative events. Finally, the model provides insight into optimal hedonic editing and deceptive postponement. We test some of the predictions of the AR model with participants in the lab and provide supporting empirical evidence. Full details of each study are reported in the paper appendix.

The Anticipation-Recall Model

The General Model

Let t denote continuous calendar time. Four moments are relevant: the moment the event starts to be anticipated, t_0, the moment the event begins, t_b, the moment the event ends, t_e, and the moment the recall of the event ends, T. We assume $t_0 \leq t_b \leq t_e \leq T$. Thus, the event is anticipated during $[t_0, t_b)$, it takes place during $[t_b, t_e)$, and it is recalled during $[t_e, T)$. Let $\Delta_a = t_b - t_0$ be the duration of anticipation and $\Delta_e = t_e - t_b$ the duration of the event. Unless stated otherwise, we conveniently set $T = +\infty$.

Events, such as a concert or a minor surgery, can influence utility first through savoring or dread, then through the unfolding of the experience, and finally through memory (Elster & Loewenstein, 1992). In our model, the full consumption profile associated with the event consists of a rate that extends over time c_t, $t_0 \leq t < T$. This is a rate of *physical* consumption while the event is taking place and a rate of *conceptual* consumption during anticipation and recall (Ariely & Norton, 2009). For pleasurable events (e.g., a dinner out), physical consumption is positive; for painful events (e.g., a surgical procedure), physical consumption is negative. For $t_b \leq t < t_e$, the value of c_t may be a function of the objective attributes of the event (quantity, quality, etc.). For example, consider an individual making a reservation at a high-quality restaurant for the following week. Because the restaurant is high-scale (better wine, better ambience, more elaborate menu), the consumption rate during the event will be higher (e.g., around 80 out of an imaginary 100 points scale) than if the reservation had been for a fast-food restaurant (e.g., around 30 out of 100).

Given a rate of consumption during the event, c_t,

$t_b \leq t < t_e$, conceptual consumption before and after the event is composed of samples of snapshots of c_t during the event. In other words, the model disallows setting conceptual consumption to levels that are impossible to attain in reality (one is required to buy the lottery ticket in order to gain the right to imagine that one might be millionaire). Formally, the level of conceptual consumption at any point in time during anticipation and recall is a decision variable constrained to take values in $C = \{c_t : t_b \leq t < t_e\}$, the range of event consumption. For simplicity, we will assume that consumption is constant throughout the event. In the example, this means that $c_t = 80$ during the dinner. Because $C = \{80\}$, the rate of conceptual consumption during anticipation and recall will be 80 as well.

There is a reference point, $r_t, t \geq t_0$. Given c_t, $t \geq t_0$, the reference point adapts to c_t (i.e., approaches c_t) during the anticipation phase and during the event. Because the reference point is determined by the level of conceptual consumption, which is a deterministic choice variable, the reference point at every point in time is a deterministic value.[1] The carrier of utility is given by the difference between the consumption rate, c_t, and the reference point, r_t, by means of a value function $v(c_t - r_t)$ (Kahneman & Miller, 1986; Wathieu, 1997). A *value function*, $v : \mathbb{R} \to \mathbb{R}$ is any strictly increasing function with $v(0) = 0$ (Kahneman & Tversky, 1979). It is a ratio-scale function, that is, unique up to multiplication by a positive scalar. We label the difference $c_t - r_t$ the *effective consumption* (Figure C1). Continuing with our restaurant example, in the week prior to the dinner, the individual will savor the upcoming dinner by having thoughts of a savory entree in a nice setting. Engaging in such conceptual consumption will progressively elevate the reference point for the upcoming dinner toward the specific level of conceptual consumption (e.g., towards 80 in the case of the high-scale dinner). Thus, when the dinner finally occurs, the effective consumption rate will be determined by the level of conceptual consumption minus the reference point developed during anticipation.

[Figure 1 about here.]

Finally, there is time distance and discounting. Following Baucells & Heukamp (2012), time distance is defined as calendar distance multiplied by a discount rate. Let $\rho_a, \rho_r > 0$ be the *discount rates* for anticipation and recall, respectively. Given discount rates, the *time distance*, τ_t, to and from the event is given by

$$\tau_t = \begin{cases} \rho_a(t_b - t), & t \in [t_0, t_b), \\ 0, & t \in [t_b, t_e), \\ \rho_r(t - t_e), & t \in [t_e, \infty). \end{cases}$$

Discounting is a decreasing function of time distance, and given by $f(\tau_t) = e^{-\pi(\tau_t)}$, where $\pi : [0, \infty] \to [0, \infty]$ is a *psychological distance function*, any strictly increasing function with $\pi(0) = 0$ and $\pi(\infty) = \infty$. Of course, this implies $f(0) = 1$ and $f(\infty) = 0$. The case of $\pi(\tau) = \tau$, for example, corresponds to exponential discounting.[2]

With these three elements in mind, we are ready to define the AR model.

Definition 1 *Given the level of actual and conceptual consumption, the reference point, and time distance,* ***instant utility*** *in the anticipation-recall model (AR) is given*

[1] In contrast, both Kőszegi & Rabin (2006) and Kőszegi & Rabin (2009) assume that the reference point is stochastic, i.e., gain/loss utility is derived by comparing each potential outcome with all its counterfactuals, weighted by the product of probabilities.

[2] Note that discounting is a function of the distance to and from the event, and not of the passage of calendar time. To keep things simple we do not incorporate discounting as a function of the calendar time. This implies that the decision maker is indifferent to changes in t_0, provided Δ_a and Δ_e are maintained.

by

$$u(t) \quad = \quad v(c_t - r_t)f(\tau_t), \; t \in [t_0, T];$$

and ***total utility*** *(of anticipation, of the event, and of recall, respectively), is given by*

$$\begin{aligned} U &= U^A + U^E + U^R \\ &= \int_{t_0}^{t_b} u(t)dt + \int_{t_b}^{t_e} u(t)dt + \int_{t_e}^{T} u(t)dt. \end{aligned}$$

We interpret $u(t) = 0$ as a neutral state, and $u(t) > 0$ ($u(t) < 0$) as instants in which the individual is in a positive (negative) state. Considering the absolute value of instant utility, we call $|u(t)|$ the instant (dis)utility at time t, and $|U|$ the total (dis)utility.

Assumptions

In order to produce a relatively tractable model and derive insights, we make five specific assumptions, which we later discuss.

A1. ***Constant consumption rate.*** Let $c \in \mathbb{R}$ be the *consumption level*. We set $c_t = c$, $t_b \leq t < t_e$. We call the absolute value of c, $|c|$, the *magnitude of the event*.

A2. ***Reference point.*** Let $\alpha \geq 0$ be the *speed of adaptation*. Given c_t, $t_0 \leq t < T$, we set $r_0 = 0$, $r'_t = \alpha(c_t - r_t)$, $t_0 \leq t < t_e$; and $r_t = r_{t_e}$ for $t \geq t_e$.

A3. ***Value function.*** Let $\lambda \geq 1$ be the *parameter of loss aversion*. We set $v(c) = c$, $c \geq 0$; and $v(c) = \lambda c$, $c < 0$.

A4. ***Discount rates.*** Let $\rho_0 > 0$ be the *base discount*, and $\mu \geq 0$ the parameter of *magnitude effect*. We set the discount rates as follows. If $\mu = 0$, then $\rho_a = \rho_r = \rho_0$; otherwise

$$\rho_a = \frac{\rho_0}{|v(c)|^\mu}, \quad \text{and} \tag{1}$$

$$\rho_r = \frac{\rho_0}{\max_{t\in[t_b,t_e)} |v(c_t - r_t)|^\mu}. \tag{2}$$

A5. ***Discount factor.*** To capture diminishing sensitivity to time distance, we assume that $\pi(\tau)$ is a concave function. We consider two specific forms. Both involve $\delta \in (0, 1]$, the *sensitivity to time distance*.

A5.1. ***Power.*** $\pi(\tau) = \tau^\delta$, $\tau \geq 0$.

A5.2. ***Constant sensitivity.*** $\pi(\tau) = (1 - \delta) + \delta\tau$, $\tau > 0$, $\pi(0) = 0$.

The associated discount factors are $f(\tau) = e^{-(\tau^\delta)}$ and $f(\tau) = e^{\delta-1}e^{-\delta\tau}$, respectively.

[Table 1 about here.]

A1-A5 result in a parametric model with three external decision variables, (c, Δ_a, Δ_e), and five internal parameters. Each parameter captures a distinct psychological element (see Table D1). The different elements can be activated at will. For example, setting $\alpha = 0$ turns off adaptation; setting $\lambda = 1$ eliminates loss aversion; setting $\delta = 1$ produces exponential discounting; and setting $\mu = 0$ eliminates the magnitude effect in discounting. Such choices would result in a continuous-time version of G. Loewenstein (1987).

Discussion of the Assumptions

A1. The rate of consumption during the event is assumed to be constant, as in G. Loewenstein (1987). This automatically implies that $C = \{c\}$, and therefore the level of conceptual consumption before and after the event are equal to c as well. In this simple setup, the anticipation of the event matches the reality of the event, and so does the recall of it. Hence, the complex problem of choosing appropriate levels of conceptual consumption is made trivial. We do so in purpose to focus our analysis on other aspects of the model.

A2. A reference point that gradually adapts to consumption is standard in modeling habit formation and consumer preferences (Constantinides, 1990; Wathieu, 1997; Mazumdar et al., 2005; Rozen, 2010). Our model is the first to consider a gradual process of adaptation before the event. A1-A2 yield the convenient expression $c_t - r_t = ce^{-\alpha(t-t_0)}$, $t_0 \leq t < t_e$; and $c_t - r_t = ce^{-\alpha(t_e-t_0)}$, $t \geq t_e$.[3] Thus, as soon as upcoming positive event starts to be anticipated, the effective consumption takes value $c > 0$, and decays exponentially with the passage of time. This is because the reference point increases, and the gap between c and r_t decreases. This adaptation mitigates not only the enjoyment of the event, but also the enjoyment during the remaining anticipatory time.

Suppose an event is unexpectedly cancelled at some time after t_0 but before t_b. Because the reference point has increased, the AR model predicts that the decision maker would experience disappointment; and the intensity of these negative feelings would be stronger the closer to the event the cancellation occurs. Conversely, a cancelled negative event would produce relief and the intensity of the relief is higher the more time one has been dreading the negative event. There is plenty of evidence supporting these predictions. Learning that a future positive (negative) event is suddenly cancelled induces disappointment (relief) (Hoch & Loewenstein, 1991). Chen & Rao (2002) confirm that people experience disappointment following the cancellation of a positive event (*dashed hope*) and relief upon cancellation of a negative event (*false alarm*). For auctions, Heyman et al. (2004) provide evidence of *quasi-endowment*: bidders develop a partial ownership for objects during an auction, even though they are not the owners yet. Once the idea of possessing an item is set in the minds of bidders, not having the item is perceived as a loss. Thus, adaptation during anticipation is a realistic assumption.

A3. We use the simplest value function that captures loss aversion. All of our results generalize to the case of a S-shaped value function with a power form (Kahneman & Tversky, 1979). Because no additional insights are obtained, we keep a simple piecewise linear form.

A4. Empirical measurements of discount rates consistently show that larger amounts are discounted less than smaller amounts (R. Thaler, 1981; Frederick et al., 2002). The AR model captures magnitude effects by having the discount rates be a decreasing function of $|c|$. Moreover, the denominator of ρ_r depends on the "peak" value of the event, $\max_{t\in[t_b,t_e]} |v(c_t - r_t)|$. This is consistent with the "peak" part of the peak-end rule (Kahneman et al., 1993; Fredrickson, 2000), by which recall of experiences is greatly influenced by the peak moments, either good or bad, that stood out regardless of how long the experience lasted. This is a novel and distinctive feature of the model. Specifically, under A1-A4 and $\mu > 0$,

$$(3) \qquad \rho_a = \frac{\rho_0}{|v(c)|^\mu} \quad \text{and} \quad \rho_r = \frac{\rho_0}{|v(c)|^\mu e^{-\alpha\mu\Delta_a}}.$$

Due to adaptation, discount rates for recall will be higher than for anticipation (indeed, $\rho_r = \rho_a e^{\alpha\mu\Delta_a}$). This aligns with research suggesting that people

[3] The fact that r_t during recall remains constant at r_{t_e} provides tractability and captures the "end" part of the peak-end rule (Kahneman et al., 1993).

experience a "wrinkle in time," such that future events are valued more than equivalent events in the equidistant past (Caruso et al., 2008). Note also that, due to loss aversion, negative events will be discounted less than positive events. This is consistent with the prevalent finding that gains are discounted at a higher rate than losses (Frederick et al., 2002).

A5. Because $\pi(\tau)$ is concave, the discount factor decays rapidly near $\tau = 0$, and the decay rate slows down when τ is large. This agrees with observed patterns of decreasing impatience before the event (G. F. Loewenstein & Prelec, 1993; Frederick et al., 2002) and transience in recall, i.e., most forgetting occurs during early delays, and slows at later delays (Ebbinghaus, 1913; Wixted, 2004; Brown et al., 2007).

The specific power form A5.1 was proposed by Ebert & Prelec (2007). A5.2 exhibits constant sensitivity and produces a magnitude-dependent quasi-hyperbolic discounting function (Laibson, 1997). If $\delta < 1$, then A5.2 is discontinuous at $\tau = 0$ because $f(0^+) = e^{\delta-1} < 1$. Forms similar to A5.1 and A5.2 have been proposed to capture memory decay (Anderson, 1990; Wixted & Ebbesen, 1997). Both A5.1 and A5.2 have exponential discounting as special case when $\delta = 1$.

The Shape of Temporal Profiles of Instant utility

Under A1-A5, the profile of instant utility is given by

$$\begin{aligned} u(t) &= v(c) \cdot 1_{[t_0,t_b)} \cdot e^{-\alpha(t-t_0)} f\left(\rho_a(t_b - t)\right) \\ &+ v(c) \cdot 1_{[t_b,t_e)} \cdot e^{-\alpha(t-t_0)} \\ &+ v(c) \cdot 1_{[t_e,T)} \cdot e^{-\alpha(t_e-t_0)} f\left(\rho_r(t - t_e)\right). \end{aligned}$$

Note that the magnitude of the event has a direct influence through the term $v(c)$, and an indirect effect through ρ_a and ρ_r, as given in (3). Because both effects run in the same direction (an event of larger magnitude increases effective consumption and decreases the discount rate), instant (dis)utility is increasing in $|c|$ for all t. By A1, the sign of instant utility at all times has the same valence as the sign of c, i.e., positive events induce a positive profile, and negative events induce a negative profile. The entire profile of instant utility decreases if we increase the speed of adaptation, α, or increase the base discount rate, ρ_0 (Figure C2).

[Figure 2 about here.]

Because of adaptation, (dis)utility is decreasing over time during the occurrence of the event and the recall phase (Figure C2). During anticipation, however, two opposite forces determine the shape of the temporal profile of instant utility. On the one hand, the discount factor increases with the passage of time. On the other hand, adaptation decreases effective consumption with the passage of time. The net result is that the profile of instant (dis)utility during anticipation is unimodal (Figure C2).

Proposition 1 *Assume A1-A5. Instant (dis)utility is unimodal during anticipation, i.e., there is a* $t_m \in [t_0, t_b]$*, such that* $|u(t)|$ *is decreasing on* $[t_0, t_m]$ *and increasing on* $[t_m, t_b]$.

If the psychological distance function, π, is strictly concave, then $t_0 < t_m < t_b$ under general conditions and instant utility during anticipation is U-shaped.[4] Assum-

[4] To find t_m we solve for $u'(t) = 0$, $t_0 \le t < t_b$, where $u(t) = v(c)e^{-\alpha(t-t_0)}e^{-\pi(\rho_a(t_b-t))}$. This produces $\rho_a\pi'(\rho_a(t_b - t)) = \alpha$. If π' is decreasing and $\pi'(0^+) > \alpha/\rho_a$, then there is a unique solution $t_m < t_b$ (otherwise, $t_m = t_b$). If π' is constant, as in A5.2, then $|u(t)|$ during anticipation is strictly increasing if $\delta\rho_a > \alpha$, constant if $\delta\rho_a = \alpha$, and strictly decreasing if $\delta\rho_a < \alpha$.

ing A5.1, for example, we find that instant (dis)utility during anticipation takes its minimum at

$$t_m = \max\left\{t_0, t_b - \frac{1}{\rho_a}\left(\frac{\delta\rho_a}{\alpha}\right)^{\frac{1}{1-\delta}}\right\}.$$

Previous theoretical models of anticipation predict only the increasing portion of the U-shape (G. Loewenstein, 1987). The AR model allows for individuals to get very excited when they first learn about an upcoming event, such as a concert or a holiday. The excitement then decays, but is rekindled when the event draws near.

Breznitz (1984) suggests that once an individual is fully aware of an upcoming threat, the time path of anxiety tends to be U-shaped. There is intense fear when an individual is first informed of an upcoming threat. This fear then diminishes before rising sharply in anticipation of the impact closer to the event. Proposition 1 is consistent with this pattern, as the U-shape profile is predicted for both positive and negative events.

We experimentally test the proposition that the temporal profile of instant utility during anticipation may be U-shaped. In our Study 1 (see Appendix for details), participants were asked to imagine an upcoming birthday party and to rate how excited they expected to be in the anticipation of the event. Specifically, respondents predicted their excitement at three points in time: on the day when they were first told about the event, a month before the event, and the day before the event. The answers, on a 7-point scale, were 5.2, 4.0, and 5.7, respectively. The U-shaped pattern is statistically significant ($5.2 > 4.0$, $p < 0.001$; $4.0 < 5.7$, $p < 0.001$). As predicted by Proposition 1, the participants' enthusiasm is a U-shaped function of time.

Total Utility

To obtain total utility, we integrate instant utility over time. We obtain a tractable expression by integrating with respect to time distance. Let $\Sigma = \int_0^T f(\tau)d\tau$ be the *coefficient of recall.*[5]

Proposition 2 *Under A1-A5, total utility is given by*

(4)
$$U = v(c)e^{-\alpha\Delta_a}\left[\frac{1}{\rho_a}\int_0^{\rho_a\Delta_a} e^{\frac{\alpha}{\rho_a}\tau} f(\tau)d\tau + \frac{\left(1 - e^{-\alpha\Delta_e}\right)}{\alpha} + \frac{e^{-\alpha\Delta_e}}{\rho_r}\Sigma\right].$$

In this section, our focus will be on the effect of c on U. The next two sections will consider the effect of Δ_e and Δ_a, respectively.

If the discount rates, ρ_a and ρ_r, are independent of c (i.e., $\mu = 0$), then the term in brackets does not depend on c. This implies that total utility of consumption is proportional to $v(c)$. In other words, the rest of complexities—adaptation, discounting, duration of the anticipation and of the event— just modify the value function by means of a constant of proportionality (Baucells & Sarin, 2007). This produces the convenient results that the ratio scale function $v(c)$ is a valid proxy for the total utility from the event.

Recall that c may be a function of the attributes of the events (e.g., quantity). Assume, as usual, that such a function is concave. If $\mu = 0$, then the total utility will also be a concave function of the attribute of the events. As is standard in micro-economic analysis, this will lead individuals to seek variety and *diversify* their resources of time and money throughout multiple experiences of moderate cost (Mas-Colell et al., 1995).

Anticipation, Event, and Recall

If the discount rates depend on c (i.e., $\mu > 0$), then the details of the event must be considered when calculating the functional relationship between U and c. Note that increasing $|c|$ has a double effect: it increases $|v(c)|$ and it lowers the discount rates. The utility during the

[5] A5.1 produces $\Sigma = \Gamma(1/\delta + 1)$ (recall that $\Gamma(n + 1) = n!$), and A5.2 yields $\Sigma = e^{\delta-1}/\delta$.

even, which is not affected by discounting, remains proportional to $|c|$ (elasticity equal to one). If $\mu > 0$, then the utility of anticipation and recall is convex in $|c|$ (elasticity greater than one).

Proposition 3 *Assume A1-A5. The elasticity of* $|U|^A$*,* $|U|^E$*, and* $|U|^R$ *with respect to* $|c|$ *is given by* $(1 + \mu\psi)$*,* 1*, and* $(1 + \mu)$*, respectively, where* $g_\tau = e^{\frac{\alpha}{\rho_a}\tau - \pi(\tau)}$ *and*

$$\psi = \frac{\int_0^{\rho_a \Delta_a} \tau \pi'_\tau g_\tau d\tau}{\int_0^{\rho_a \Delta_a} g_\tau d\tau}.$$

Assume $\mu > 0$ and $\Delta_a > 0$. For $|c|$ small, the discount rates for anticipation and recall are very high, leading to $|U| \approx |U|^E$, which is linear in $|c|$. As $|c|$ increases, the discount rate for anticipation, ρ_a, decreases and utility of anticipation takes a more prominent role. The analysis of total utility of anticipation reveals that $|U|^A$ will be close to linear for small values of $|c|$, convex for intermediate values of $|c|$, and approach linearity for large values of $|c|$.[6] As $|c|$ further increasing, the discount rates for recall, ρ_r, decrease as well and recall becomes more prominent. In fact, because $1 + \mu > 1$, total utility of recall is convex with $|c|$ (large events might be more than twice as memorable as events half the size). Because for large $|c|$ both $|U|^A$ and $|U|^E$ have a linear effect, whereas $|U|^R$ is convex, we conclude that $|U|^R$ will necessarily be the largest component of $|U|$ as $|c|$ takes large values.

[Figure 3 about here.]

In Figure C3, we illustrate the effect of the level of consumption on total utility. For small experiences (e.g., eating ice cream), most utility will be event utility. For intermediate experiences (e.g., a weekend outing), anticipation will play a key role. For large experiences (e.g., a honeymoon), the model predicts most of utility will be derived from recall.

The implications for micro-economic analysis are that individuals may optimally choose to *diversify* resources of time and money on multiple events of small magnitude, while at the same time *concentrate* their resources on a few, memorable experiences. In other words, spending relatively large sums of money on a few special events, such as a wedding trip or a memorable birthday party, may be optimal.

Hedonic Editing

The shape of U as a function of $|c|$ also has implications for hedonic editing, understood as the strategic aggregation or desegregation of gains and losses. Hedonic editing, as conceptualized by R. H. Thaler (1985), predicts a preference for segregating gains and aggregating losses. This strategy is based on the S-shaped curvature of the value function. If the magnitude effect in discounting is turned off, $\mu = 0$, then the AR model recommend this same hedonic editing strategy.

If $\mu > 0$, then the AR model suggests that aggregating gains might produce a lasting memorable experience. By the same token, aggregating losses would induce a large negative experience that will be remembered for a long time. Moreover, because loss aversion lowers the discount rate for recall, such tendency to desegregate is predicted to be stronger for losses than for gains.[7] Indeed, it has been repeatedly shown that individuals are averse to aggregating losses (Linville & Fisher, 1991; R. Thaler & Johnson, 1990). The AR model is the first theoretical account for the observed preference to disaggregate

[6] To see this, observe that $|U|^A$ is bounded from below by $|c|^{(1+\mu)} e^{-\alpha \Delta_a} \Sigma / \rho_0$, and bounded from above by $|c| f(0^+) \Delta_a$. For $|c|$ small, $\partial |U|^A / \partial |c| \to e^{-\alpha \Delta_a} \Sigma / \rho_0$, and for $|c|$ large, $\partial |U|^A / \partial |c| \to f(0^+) \Delta_a$. More formally, if $\tau \pi'(\tau)$ is increasing, then ψ will be bell shaped, taking value 0 at $|c| = 0$, increasing with $|c|$ up to a point, and then decreasing back to zero as $|c|$ tends to infinity.

[7] Recall that individuals discount less for losses, as $\rho_a^- = \rho_a^+ / \lambda^\mu$ and $\rho_r^- = \rho_r^+ / \lambda^\mu$.

losses.

Unique vs. Repeated Experiences

In this section, we focus on the effect of Δ_e on total utility. In their experiments on recall utility, Kahneman et al. (1993) demonstrate that the intensity of recall is insensitive to the duration of the event, for which they coin the term "duration neglect." The AR model captures the notion of "duration neglect" in a very strong sense. The model predicts that, due to adaptation, extending the duration of the event actually lowers the intensity of recall.

Proposition 4 *Increasing the duration of the event, Δ_e, has no effect on the (dis)utility of anticipation, increases the (dis)utility of the event, and strictly decreases the (dis)utility of recall. Total (dis)utility decreases with Δ_e if and only if $\alpha\Sigma \geq \rho_r$.*

Do people agree with the notion that extending an experience, through repetition, might lower the utility of recall? In Study 2 (see appendix for details), we asked participants whether they would consider it more memorable to kiss their favorite movie star only once (i.e., one time) or once daily for one week (i.e., seven times). Sixty-eight percent of respondents selected the single time over the seven times ($\chi^2 = 18.2, p < 0.001$), giving it a higher score on a 7-point scale (6.4 vs. 5.5, $p < 0.001$).

According to Proposition 4, the optimal value of Δ_e, assuming we preserve the integrity of the experience, is either zero or infinite. In practice, Δ_e can be increased by repeating the experience multiple times, as, for example, by dining out regularly. Conversely, Δ_e can be shortened by avoiding repetition (e.g., one-time experiences such as a special trip, or a very romantic encounter). The inequality $\alpha\Sigma \geq \rho_r$ produces a clear dichotomy between events that are best experienced just once and those that are best to experience repeatedly.

Contributors to having one-time experiences are the factors that increase the utility of recall: high speed of adaptation, high coefficient of recall, and low discounting for recall. If $\mu > 0$, then ρ_r decreases with c and increases with Δ_a. One-time experiences will most likely be events of large magnitude. Also, it may be optimal for one-time experiences to be surprises or to have shorter anticipation phases.

Zauberman et al. (2008) find that, when people truly enjoy an experience, they forgo ever repeating it.[8] The authors suggest such aversion is driven by a desire to protect the memory of the event from future experiences that might not be as pleasurable. The AR model rationalizes this highly psychological process.

Duration of Anticipation

In this section, we focus on the effect of Δ_a on total utility. Decision-making research has documented that total utility may increase given more time to savor anticipation (G. Loewenstein, 1987; Nowlis et al., 2004). There might be, however, an optimal duration of anticipation. In an experiment entailing real consumption of chocolate, Chan & Mukhopadhyay (2010) found that participants who had to wait one week before consumption evaluated the chocolate more highly than those who were given the chocolate immediately as well as those who were given it after delays of two and four weeks.

[8] In one study, participants in one condition were asked to recall a special evening out; in the other condition, they were asked to recall a typical evening out. Not surprisingly, special evenings were rated more highly than typical ones. But when the researchers then asked participants which experience they would want to repeat, participants were more likely to want to repeat the typical evening than the special evening, even though they had just rated this experience as providing less utility.

In some cases, decision makers have some discretion over the duration of anticipation. If t_0 is known and fixed, then we vary t_b (e.g., by choosing the date of the event). If t_b is fixed, then we vary t_0 (e.g., by choosing the date at which to start planning for a holiday trip or deciding how long in advance to release news about an upcoming event). In what follows, we set the duration of anticipation as a decision variable and seek to find its ideal length.

The effect of Δ_a on instant utility and total utility is three-fold. First, a positive *duration effect*: Δ_a increases the interval over which anticipation is experienced. Second, a negative *adaptation effect*: Δ_a reduces utility by a factor $e^{-\alpha\Delta_a}$. Third, a negative *magnitude effect*: Δ_a increases the discount rate for recall, ρ_r, and reduces the utility of recall. Under A1-A5,

$$\frac{\partial U}{\partial \Delta_a} = \underbrace{v(c)f(\rho_a\Delta_a)}_{Duration} - \underbrace{\alpha U}_{Adaptation} - \underbrace{\alpha\mu U^R}_{Magnitude}$$
$$= \underbrace{v(c)f(\rho_a\Delta_a) - \alpha U^A}_{\partial U^A/\partial\Delta_a} - \underbrace{\alpha U^E}_{\partial U^E/\partial\Delta_a} - \underbrace{\alpha(1+\mu)U^R}_{\partial U^R/\partial\Delta_a}.$$

Clearly, both $|U|^E$ and $|U|^R$ are decreasing with Δ_a. The effect of Δ_a on $|U|^A$ is mixed: as Figure C4 (right) shows, when Δ_a increases, instant utility lasts longer, but adaptation reduces the average instant utility.

[Figure 4 about here.]

Figure C4 (left) illustrates the effect of Δ_a on total utility. In the figure, both U and U^A are unimodal (only U^A is guaranteed to be so in general). We now show that the duration of anticipation that maximizes U is shorter than the duration of anticipation that maximizes U^A.

Proposition 5 *Assume A1-A5, $\alpha > 0$ and $c > 0$. Let*

$$G(\Delta) = f(0^+) - \int_0^{\rho_a\Delta} e^{\frac{\alpha}{\rho_a}\tau} f(\tau)\pi'_\tau d\tau.$$

Utility of anticipation, U^A, is a unimodal function of Δ_a, reaching the peak at some $0 < \Delta_A < \infty$ that solves $G(\Delta) = 0$. Moreover, if $-\tau\pi''_\tau/\pi'_\tau < 1$, then Δ_A strictly decreases with α and ρ_0 and increases with c.

Total Utility, U, is maximized at some value, $\Delta_* < \Delta_A$. Specifically, if $\partial U/\partial\Delta_a|_{\Delta_a=0} \leq 0$, then $\Delta_* = 0$; otherwise, $\Delta_* > 0$ solves

$$G(\Delta) = 1 - e^{-\alpha\Delta_e} + e^{-\alpha\Delta_e}\frac{\alpha(1+\mu)\Sigma}{\rho_a}e^{-\alpha\mu\Delta}.$$

Moreover, there is a $\hat{\mu} > 0$ such that if $0 \leq \mu < \hat{\mu}$ then Δ_* is unique.

We conclude this section by providing an analytic solution for the constant-sensitivity case.

Proposition 6 *Assume A1-A4, A5.2, $\alpha > 0$ and $c > 0$. If $\delta\rho_a = \alpha$, then $\Delta_A = 1/\alpha$; otherwise, $\Delta_A = (\ln\delta\rho_a - \ln\alpha)/(\delta\rho_a - \alpha)$. If $e^{1-\delta}(1-e^{-\alpha\Delta_e}) + \frac{\alpha(1+\mu)}{\delta\rho_a}e^{-\alpha\Delta_e} \geq 1$, then $\Delta^* = 0$; otherwise, $\delta\rho_a - \alpha > 0$ and $\Delta^* > 0$ is the unique solution of the recursion*

$$\Delta_* = \frac{-\ln\left\{1 - \frac{\delta\rho_a-\alpha}{\delta\rho_a}\left[1 - e^{1-\delta}(1-e^{-\alpha\Delta_e}) - \frac{\alpha(1+\mu)}{\delta\rho_a}e^{-\alpha\Delta_e}e^{-\alpha\mu\Delta_*}\right]\right\}}{\delta\rho_a - \alpha}.$$

Experimental Evidence

Do people have an intuition about an ideal duration of anticipation? If so, does the ideal duration change with the magnitude of the event? To empirically address these two questions, we provided participants with a randomized list of 11 different positive events (see Study 3 in Appendix for details). We told participants to assume that all outcomes were certain to occur at the designated time. We also instructed them to ignore organizational issues (e.g. no booking or reservation issues). We then asked respondents to indicate how long in advance they would like to be told about each event.

Participants have an intuition about the ideal date to begin anticipating an upcoming event depending on the event itself. For example, most participants said they wanted to start anticipating the "wedding of their best friend" six months before; the "concert of their favorite band" one month before; or a "dinner in a fancy restaurant" one week prior. Moreover, this ideal anticipation time changes with the magnitude of the event. Comparing pairs of similar events but with different magnitudes shows that the ideal duration of anticipation increases with event magnitude. For example, participants wished to anticipate significantly longer the wedding of their best friend (180 days) than that of a distant relative (54 days) and to anticipate a two-week vacation longer than that of a weekend vacation (60 vs. 18 days). Both differences are significant ($p < 0.001$).

The findings of Study 3 are consistent with the AR model, and provide an indirect indication of magnitude effects in discounting.[9]

Positive Surprises

Proposition 5 shows that, for positive events, it may be optimal to set the duration of anticipation to zero. Specifically, $\Delta^* = 0$ if and only if $\partial|U|/\partial\Delta_a|_{\Delta_a=0} \leq 0$.[10] For simplicity, assume the psychological distance function is continuous (i.e., $f(0^+) = 1$). Then the combination of parameters that establishes the optimality of positive surprises is[11]

$$\alpha(1+\mu)\Sigma \geq \rho_a. \tag{5}$$

Recall that for positive events, $\rho_a = \rho_0/c^\mu$. Intuitively, surprise experiences are always optimal if recall is more valuable than anticipation. Contributors to a positive surprise are high speed of adaptation (α), high coefficient of recall (small sensitivity to time distance, δ), low base discount rate (ρ_0), and high magnitude of the event (c).

How shall one administer surprises to oneself? One possibility is by means of instant and unplanned purchases. While impulse buying behaviors are often considered a sign of low self-control (Baumeister, 2002), their high prevalence suggests that they may be optimal in some occasions. Alternatively, individuals could even find it optimal to set negative levels of anticipation for positive events and thus leave room for pleasant outcomes (Shepperd & McNulty, 2002). The well-documented strategy of defensive pessimism involves setting unrealistically low expectations for success (Norem & Cantor, 1986; Martin et al., 2001). The idea, again, is that total utility is maximized by creating a large positive surprise.

Yet, another possibility is to rely on others. Surprise gifts are common in many cultures. The AR model shows that surprise gifts can be optimal even if some value is lost because the giver does not know the exact preferences of the recipient. Asking the recipient her desires in advance might trigger anticipation and reduce the effect of surprise. In relationships, for example, it is quite common to "strategically" set a delivery time of good news in order to produce greater surprise. Receiving an engagement ring is often a surprise experience, and the instant utility increases when the recipient is not (yet) expecting it.

Proposition 5 suggests that shortening the anticipation time may be welfare-increasing in some circumstances. Many successful business models are based on shortening the time between planning and execution of con-

[9] If $\mu = 0$, then both Δ_A and Δ_* are independent of c.

[10] That when $\Delta_a = 0$ is a local maximum then it is necessarily a global maximum is not trivial. For some parameter values, U initially decreases with Δ_a, then it reaches a local minimum, then it increases to a local maximum, and finally it decreases to zero. In the proof of Proposition 5 we show that this second local maximum produces less utility than U at $\Delta_a = 0$.

[11] In view of (8), $\partial|U|/\partial\Delta_a|_{\Delta_a=0} \leq 0$ iff $1 - e^{-\alpha\Delta_e} + \alpha(1+\mu)\rho_a^{-1}e^{-\alpha\Delta_e}\Sigma \geq f(0^+)$. If $f(0^+) = 1$, then (5) is necessary and sufficient. Otherwise, $\partial|U|/\partial\Delta_a|_{\Delta_a=0} \leq 0$ iff either (5) holds or (5) fails and $\Delta_e \geq \frac{1}{\alpha} \ln \frac{1-\alpha(1+\mu)\rho_a^{-1}\Sigma}{1-f(0^+)}$.

sumption experiences. For example fast delivery was the competitive advantage of Toyota in the 90's, and today NikeID (a customization service of clothing offered by the brand Nike) is one of the leaders in mass customization processes thanks to the shortened delivery time of individually customized items.

Surprise ending is a common element in many folktales, story jokes and advertising. J. Loewenstein et al. (2001) show that the repetition-break plot structure (plot structures using repetition among obviously similar items to establish a pattern, and then a final contrasting item that breaks with the pattern to generate surprise) is extremely engaging. Similarly in our framework, repetition creates adaptation/expectation, and the contrasting item provokes the surprise.

Coping with Negative Events

An upcoming negative event induces anxiety. Anticipating the negative experience, however, can help one endure the event and reduce total pain. The literature on coping identifies several ways in which people respond to upcoming stress (Carver et al., 1989) and it examines coping strategies for health-related events (Scheier & Carver, 1985; Carver et al., 1993). Our current setup allows us to examine the effect that adaptation has on modifying the reference point, and reduce total disutility.

Suppose we lear we need to undergo surgery. We have certain flexibility regarding the calendar date of the surgery, e.g., any time within the next three months. In the context of the AR model, when shall we schedule the surgery? A second situation is the following. Suppose we need to tell some close one that he/she has to undergo some critical surgery. The critical surgery has already been scheduled in a month from now. When shall we tell this relative the news? Now, in one week, in two weeks, or a few days before the surgery? In both these examples the goal is to decide the optimal amount of anticipation before a negative event.

When the duration of anticipation can be increased without bounds, the AR model recommends anticipating the negative event for as long as possible.

Proposition 7 *Assume A1-A5 and that $\tau f(\tau)$ goes to zero as τ goes to infinity. If $\alpha > 0$, then total disutility tends to zero (not necessarily in a monotonic way) as Δ_a goes to infinity. Hence, $\Delta_a = \infty$ minimizes disutility.*

In many instances, however, the duration of anticipation cannot be increased beyond some limit (e.g., a surgery cannot be postponed indefinitely). Because disutility may not be monotonic in Δ_a, it is possible that the optimal duration of anticipation be shorter than the total time available to anticipate. Let Δ be the longest possible duration of anticipation (three and one month in the case of our two examples). The goal is then to choose the value of Δ_a in the range $[0, \Delta]$ that minimizes $|U|$. We denote such optimal anticipatory time with Δ_*^-.

The formulation of G. Loewenstein (1987) produces two optimal strategies that can be labelled "get over it as soon as possible" ($\Delta_*^- = 0$), or "adapt for as long as possible" ($\Delta_*^- = \Delta$). Mathematically, these are extreme solutions. The AR model admits a third possibility, namely, "some right amount of time to adapt" and prepare for the negative event ($0 < \Delta_*^- < \Delta$). This mathematically interior solution is only possible if the parameter of magnitude effect, μ, is sufficiently large. If μ is large, some anticipation has the positive effect of lowering the discount rates for recall. Figure C5 plots disutility as a function of Δ_a in three representative parameter specifications.

The following results assume A5.2 to ensure uniqueness of the solution, although the three-fold typology of the solutions holds for any psychological distance function.

Proposition 8 *Assume A1-A4, A5.2, $\alpha > 0$, and $c < 0$. Let $\Delta > 0$ be the maximum time available to adapt to the bad news. The optimal adaptation time, Δ_*^-, is given by:*

*1. **[Get over it as soon as possible]** If $\partial|U|/\partial\Delta_a|_{\Delta_a=0} > 0$, then there is a unique $\Delta_n > 0$ solving $U_0 = U_{\Delta_n}$. If $\Delta < \Delta_n$, then $\Delta_*^- = 0$.*

*2. **[Some right amount of time to adapt]** If $\partial|U|/\partial\Delta_a|_{\Delta_a=0} < 0$ and μ is sufficiently large (at least $\sqrt{\frac{1}{4} + e^{\alpha\Delta_e}\left(\frac{\delta\rho_a}{\alpha}\right)^2} - \frac{1}{2}$), then $|U|$ has a unique local minimum at $\Delta_m > 0$ and a unique $\Delta_n > \Delta_m$ solving $U_{\Delta_m} = U_{\Delta_n}$. If $\Delta_m \leq \Delta < \Delta_n$, then $\Delta_*^- = \Delta_m$.*

*3. **[Adapt for as long as possible]** If none of the above holds, then $\Delta_*^- = \Delta$.*

[Figure 5 about here.]

Facilitators of the "get over it" strategy are the same that produce an optimal positive duration of anticipation: low adaptation, small magnitude of the event, low coefficient of recall, and high base discount. The AR model predicts that people will prefer to quickly experience negative events of small magnitude, such as G. Loewenstein (1987)'s mild electroshock, but prefer more time to anticipate and adapt to larger negative events such as surgery.

Deceptive Postponement

Models of utility of anticipation face the problem of reverse time consistency or *deceptive postponement* (G. Loewenstein, 1987): upon reaching t_b, the individual may gain utility by postponing t_b to a later date.[12] From a rational viewpoint, the strategy is dubious, as it requires the self-deception of not knowing in advance that t_b will be moved. In many practical circumstances, events such as a concert take place on given calendar date and it is not up to the decision maker to decide. Other events, such as a vacation, can be postponed. It is conceivable, therefore, that individuals may use commitment mechanisms to avoid deceptive postponement. Ways to ensure that the event happens at $t = t_b$ include buying tickets in advance or rejecting cancelation options or insurances.

Still, in the absence of frictions, the AR model exhibits a tendency to postpone events at t_b. When the date of the event is postponed, the discount factor immediately adjusts downward due to the updated time distance to the event. But the instant utility obtained between t_0 and the original date, t_b, is not affected by this readjustment of the discount factor. The sudden postponement of t_b thus produces additional utility.

In the AR model, the marginal benefits of such postponement is given by

$$\left.\frac{\partial U}{\partial \Delta_a}\right|_{\Delta_a=t_b-t_0} = e^{-\alpha\Delta_a} \left.\frac{\partial U}{\partial \Delta_a}\right|_{\Delta_a=0}.$$

Hence, the condition that ensures that anticipation is optimal, $\left.\frac{\partial U}{\partial \Delta_a}\right|_{\Delta_a=0} > 0$, also implies that engaging in deceptive postponement is optimal. Note, however, that the net marginal benefit is proportional to $e^{-\alpha\Delta_a}$, which decreases with the total time of anticipation. If $\alpha\Delta_a$ is large and there is some cost to postponement, then postponement is not advantageous. The problem of deceptive postponement is more acute in G. Loewenstein (1987)'s model, where the gain to deceptive postponement does not decay.

[12] Issues of dynamic consistency with respect to one's actions are commonplace in models of anticipation (Caplin & Leahy, 2001; Kőszegi & Rabin, 2006). Basically, if the value of certain state variable today (e.g., the current reference point) depends on what individual i thought yesterday that he/she would do today, as it does in the AR model, then rational expectations require that i be consistent and carry out the anticipated plan. The requirement creates a circularity in the model that needs to be resolved by means of a Nash equilibrium between the "multiple selfs" involved in the model. In single-individual contexts, such equilibrium is called a Personal Equilibrium. Personal Equilibrium often takes the form of a pre-commitment.

The AR model supports the notion that delaying a gratification may not be costly. This is consistent with Baumeister & Tierney (2011), who argue that one of the few psychological strategies that help exercising self-control without depleting the finite resource of willpower is *delaying*, rather than *denying*, immediate gratification.

Conclusions

In this paper, we propose the Anticipation Recall (AR) model that formally links the three components of total utility (i.e., utility from anticipation, event utility, and recall utility) in a comprehensive formulation. By virtue of its continuous time setting, the AR model produces the temporal profile of instant utility throughout the whole event time line. The AR model entails several unique modeling features directly inspired by psychological principles such conceptual consumption (Ariely & Norton, 2009) affecting utility before and after the event, adaptation (Helson, 1964; Wathieu, 1997) during anticipation, and magnitude effects in discounting (Frederick et al., 2002).

The implications of the model have prescriptive value for rational individuals seeking to maximize total utility. One of our main findings is the trade-off between anticipation and (dis)utility. For positive events, individuals could mitigate the effect of adaptation by ensuring that the experience differs from what is expected. For example, being vague about an upcoming event (e.g., avoiding detailed information by not reviewing web images or reading book guides) can lead to a positive surprise. Adding elements of ambiguity or surprise can also increase the satisfaction derived from consumption and improve interpersonal experiences (Norton et al., 2007) or even consumption events. For example, one leading guide praises a restaurant precisely for being a place where "The only thing customers know to expect is the unexpected" (S.Pellegrino World's 50 Best Restaurants). The AR model suggests the benefits of such strategies may reside in creating surprise even after prolonged anticipation. For negative events, the opposite seems advisable. The more accurate the knowledge and images about the upcoming reality, the more individuals might find that the actual event was not as bad as anticipated.

Future research could fruitfully extend the AR model to include event variability and uncertainty. If the event can take multiple potential levels and/or there is uncertainty about how good or bad the upcoming event will be, then conceptual consumption can take values in some nontrivial range C, which creates many interesting possibilities. For one, the optimal level of conceptual consumption may not be a constant level, but rather a function of time. When conceptual consumption during the time of anticipation is set as a decision variable taking values on $[0, \bar{c}]$, our numerical results suggest that it might be optimal setting high conceptual consumption at first (e.g., we may imagine that a vacation will be extraordinary three months prior to the departure date) and then lowering the level of conceptual consumption as the event draws nearer so that the event can still generate a final pleasant surprise (e.g., we imagine that the upcoming vacation will be just good enough the week before leaving). Optimally managing created expectations allows deriving some positive utility from anticipating the upcoming event, while at the same time leaving potential for positive surprise when the event occurs.

In the presence of uncertainty, people react more to the possibility of good/bad outcomes rather than the probability of those good/bad outcomes (Kahneman & Tversky, 1979). Our specification of conceptual consumption, driven by images of upcoming events, naturally captures this idea. Under event uncertainty, individuals may choose to imagine the peak moment of a vacation, derive anticipation utility from these thoughts, while at the same time holding realistic probabilities about the realization of the upcoming event.

The model has still room for more psychological realism. For example, research suggests that recall of past experiences might be driven by prior beliefs and distorted positive images of reality (Mitchell et al., 1997; Stangor & McMillan, 1992; Xu & Schwarz, 2009; Ross, 1989). For example, Ross (1989) suggests that people use their implicit theories of self to construct their personal histories and recall their memories. The process of anticipation and forecasting is also subject to a variety of biases such as people's reliance on highly available but unrepresentative memories of the past (Morewedge et al., 2005; Hertwig et al., 2004; Ungemach et al., 2009). Indeed future research could expand the AR model to capture such psychological processes and lead to predictions of instant utility that match robust empirical findings.

In conclusion, we hope that our work is a step toward providing a more articulated model capturing the total utility associated with an event. Built on psychological principles and set in continuous time frame, the AR model predicts the temporal profiles of instant utility experienced before, during, and after a given event.

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Appendix A
Experimental Design

Study 1. The U-shape of instant utility before the event

Objective. Is the instant utility before the event U-shaped, as predicted by Proposition 1?

Method. Participants were 147 individuals in the Boston area who engaged in a series of unrelated lab studies. All respondents were asked to imagine that their best friend, or a member of the family, just told them that he/she was willing to organize a nice birthday party for them. Next, participants' excitement about the upcoming event was measured at three points in time. Specifically, participants were asked three questions: "How excited are you (today) about your birthday celebrations," "How excited do you think you will be "a month before" the birthday celebrations," and "How excited do you think you will be "the day prior" to the birthday celebrations." Responses were measured on a 7-point scale ranging from (1) "not excited at all," to (7) "extremely excited."

Results. Excitement ratings about the party were analyzed using one-way repeated-measures ANOVA. The results show that excitement ratings about the party were significantly affected by time frame of the evaluation ($F(1.7, 240.8) = 131.1$, $p < .000$). Post hoc Bonferroni tests revealed that respondents predicted more excitement about the party when first told about the event than one month before the event (5.2 vs. 4.0, $p < 0.001$). Moreover, participants were significantly more excited about the party the day prior to the event than a month before the event (4.0 vs. 5.7, $p < 0.001$). To further examine the U-shape of the results, trend analyses were conducted. Both the linear trend ($F(1, 146) = 43.4$, $p < .000$) and the quadratic trend ($F(1.7, 146) = 163.7$, $p < .000$) for excitement ratings were significant, with the quadratic trend accounting for a greater proportion of the variance ($\eta^2_{linear} = 0.23$ vs. $\eta^2_{quadratic} = 0.53$). In summary, using a within-subjects design we demonstrated that participants positive anticipation about an upcoming event follows a U-shape.

Excitement ratings about the party were analyzed using paired-samples t-tests. Respondents were significantly more excited about the party when the first told about the event than a month before it (5.2 vs. 4.0, $t = 9.4, p < 0.001$). Moreover, participants were significantly more excited about the party the day prior to the event than a month before (4.0 vs. 5.7, $t = 14.0, p < 0.001$). In summary, using a within-subjects design we demonstrated that participants positive anticipation about an upcoming event follows a U-shape.

Study 2. Preference for Unique, Non-Repeated Experiences

Objective. Is the memorability of experiences, such as kissing one's favorite movie star, higher when the event occurs only once, as compared to multiple times?

Method. Participants were 148 individuals in the Boston area who participated in a series of unrelated lab studies. Respondents were asked to pick the most memorable of two events. Specifically, participants were asked: "Would it be more memorable if you kissed your favorite movie star only once (i.e., one time) *or* once a day per one week (i.e., seven times)?" Subsequently, memorability of both events was measured within-subjects. Participants were asked to rate on a scale from 1 to 7 the memorability of each of the two kisses experiences. The scale ranged from (1) "not memorable at all," to (7) "extremely memorable."

Results. Sixty-eight percent of respondents selected the kiss one time as the most memorable experience between the two (Chi-square = 18.2, $p < 0.001$). Moreover participants rated kissing the movie star only once as significantly more memorable than kissing the movie star once a day per one week (6.4 vs. 5.5, $t = 6.6$, $p < 0.001$). In conclusion, results from this study confirm that, ceteris paribus, the memorability of a unique experience is higher when the event happens only once, rather than multiple times.

Study 3. The optimal duration of anticipation

Objective. First we sought to demonstrate that there is an ideal date to begin anticipating an upcoming event, depending on the specific event. Second, we wanted to document that such ideal date depends on the magnitude of the event.

Method. Participants were 155 individuals in the Boston area who participated in a series of unrelated lab studies. All respondents were told that they would be provided with a list of positive events and asked to read the following paragraph: "Imagine you can decide when to be told about each event. In other words, you can decide for how long you will be anticipating the event." Given the nature of some events, participants were also told to ignore potential complications that might arise in the future: "There are no other issues or constraints and the event will happen in the anticipated day (e.g. events will not be sold out, there are no booking or reservation issues, some other obligation will not get on its way)". The list included the 11 events listed in Table D2.

[Table 2 about here.]

The order of events was randomized. Participants were asked "How long in advance would you ideally like to be told about each of the following events?" Responses were measured on the following 1-8 time scale: (1) 1 year; (2) 9 months; (3) 6 months; (4) 3 months; (5) 1 month; (6) 2 weeks; (7) 1 week; (8) the day prior.

Results. We calculated average ratings and, using linear interpolation, the equivalent time in days. Ratings of ideal anticipation time were analyzed using one-way repeated-measures ANOVA. The overall model was significant ($F(5.9, 868.8) = 444.4$, $p < .000$) and paired-samples t-tests between all the events revealed that the ideal anticipation time indicated by participants for each event was significantly different from all the other events ($p < 0.001$), with the only exception of the pair "Two-week vacation" and "Wedding of a relative distant" (4.3 vs. 4.4, n.s.). As seen in Table D2, participants indicated "Wedding of your best friend" as the event that they wanted to start anticipating at the earliest date (3.1, equivalent to 6 months prior), followed respectively by "Two-week vacation" (4.4, 3 months). The events that participants wanted to anticipate for the shorter time were "Movie at home on DVD" (7.7, day prior), and "Eating ice cream" (7.9, day prior). Furthermore, the comparisons between events of similar nature, but different magnitude, revealed that participants clearly preferred anticipating earlier in time events of bigger magnitude. Specifically, participants expressed a preference for anticipating earlier the "Wedding of their best friend" rather than the "Wedding of a distant relative" (3.1 vs. 4.4, $t = 9.3, p < 0.001$), a "Two-week vacation" rather than "A weekend vacation" (4.4 vs. 5.8, $t = 16.5, p < 0.001$), "Relaxing for one day at a Spa" rather than "Receiving a massage" (6.7 vs. 7.2, $t = 7.5, p < 0.001$), and finally "Dining at a restaurant" rather than "Eating an ice cream" (7.0 vs. 7.9, $t = 14.7, p < 0.001$).

One may still suspect that the longer time needed to make arrangements for a larger event (e.g., buying a dress for a wedding, arrange lodging for a vacation) leads to desire for longer periods of anticipation. Yet our results persist even for events requiring similar preparations (e.g., weddings of relatives or best friends).

Appendix B
Proofs

Proof of Proposition 1. We take derivatives of $u(t)$ with respect to t to obtain

$$u'(t) = v(c)e^{-\alpha\Delta_a}e^{\alpha(t_b-t)}f\left[\pi'\rho_a - \alpha\right],\ t \in [t_0, t_b).$$

Instant (dis)utility increases iff $\pi' \geq \alpha/\rho_a$. By the concavity of π, π' decreases with τ. This implies that $u'(t)$ can change signs at most once. If $\pi'(0^+) < \alpha/\rho_a$, then let $t_m = t_b$. Otherwise, let $t_m = \inf\{t \in [t_0, t_b) : \pi'(\tau_t) \geq \alpha/\rho_a\}$. It follows that $u'(t) < 0$ if $t < t_m$, and $u'(t) \geq 0$ if $t \geq t_m$. ■

Proof of Proposition 2. Use the definition of U^A, the change of variable $\tau = \rho_a(t_b - t)$, and integration by parts, respectively, to obtain

$$\begin{aligned} U^A &= v(c)\int_{t_0}^{t_b} e^{-\alpha(t-t_0)}f(\tau_t)dt \\ &= v(c)e^{-\alpha\Delta_a}\frac{1}{\rho_a}\int_0^{\rho_a\Delta_a} e^{\frac{\alpha}{\rho_a}\tau}f(\tau)d\tau \\ &= \frac{v(c)}{\alpha}\left[f(\Delta_a\rho_a) - f(0^+)e^{-\alpha\Delta_a} + e^{-\alpha\Delta_a}\int_0^{\tau_a} e^{\frac{\alpha}{\rho_a}\tau}f(\tau)\pi'_\tau d\tau\right] \end{aligned} \tag{6}$$

For event,

$$U^E = v(c)\int_{t_b}^{t_e} e^{-\alpha(t-t_0)}dt = v(c)e^{-\alpha\Delta_a}\frac{1-e^{-\alpha\Delta_e}}{\alpha}.$$

For recall, apply the change of variable $\tau = \rho_r(t - t_e)$ $[dt = d\tau/\rho_r]$ to obtain

$$\begin{aligned} U^R &= v(c)e^{-\alpha(t_e-t_0)}\int_{t_e}^{T} f(\tau_t)dt \\ &= v(c)e^{-\alpha\Delta_a}\frac{e^{-\alpha\Delta_e}}{\rho_r}\int_0^{\rho_r(T-t_e)} f(\tau)d\tau. \end{aligned}$$

Adding U^A, U^E, and U^R yields the desired expression. ■

Proof of Proposition 4. Differentiating total utility with respect to Δ_e yields

$$\begin{aligned} \frac{\partial|U|^A}{\partial\Delta_e} &= 0, \\ \frac{\partial|U|^E}{\partial\Delta_e} &= |v(c)|e^{-\alpha(\Delta_a+\Delta_e)} > 0, \text{ and} \\ \frac{\partial|U|^R}{\partial\Delta_e} &= -|v(c)|e^{-\alpha(\Delta_a+\Delta_e)}\frac{\alpha}{\rho_r}\Sigma < 0. \end{aligned}$$

Because $|U| = |U|^A + |U|^E + |U|^R$, it follows that $\partial|U|/\partial\Delta_e \leq 0$ iff $\alpha\Sigma \geq \rho_r$. Because $\rho_r \geq \rho_a$, if $\alpha\Sigma \geq \rho_r$, then $\alpha\Sigma \geq \rho_a$, (5) holds, and $\left.\frac{\partial|U|}{\partial\Delta_a}\right|_{\Delta_a=0} \leq 0$. ■

Proof of Proposition 3. Use (4) to define k_A, k_E and k_R as $|U|^A = |v(c)|k_A$, $|U|^E = |v(c)|k_E$, and $|U|^R = |v(c)|k_R$, respectively. In view of and (6), the derivative of the k_A with respect to c is given by

$$k'_A = \mu c^{-1}e^{-\alpha\Delta_a}\rho_a^{-1}\int_0^{\tau_a}\tau\pi'_\tau g_\tau d\tau = \mu c^{-1}\psi k_A > 0.$$

One can easily show that $k'_E = 0$ and $k'_R = \mu|c|^{-1}k_E$. It follows that $ck'_A/k_A = \mu\psi$ and $ck'_R/k_R = \mu$. For each utility component (A, E, or R), $|c||U|'/|U| = 1 + |c|k'/k$ and the result follows. If π is concave and $\tau\pi'(\tau)$ is increasing, then $\int_0^{\tau_a}\tau\pi'_\tau g_\tau d\tau \leq \tau_a\pi'_{\tau_a}\int_0^{\tau_a} g_\tau d\tau$, and $\psi \leq \rho_a\Delta_a\pi'(\rho_a\Delta_a) \leq \pi(\rho_a\Delta_a) - \pi(0^+)$. As $|c|$ increases, ρ_a goes to zero, ψ goes to zero, and the elasticity of $|U|^A$ goes to 1. If T is finite, then the same holds true for the elasticity of $|U|^E$. ■

Proof of Proposition 5. Let $g_\tau = e^{\frac{\alpha}{\rho_a}\tau}f(\tau)$. To optimize U^A wrt Δ_a, we use (6) to obtain

$$\begin{aligned} \frac{\partial|U|^A}{\partial\Delta_a} &= |v(c)|f(\rho_a\Delta_a) - \alpha U^A \\ &= |v(c)|e^{-\alpha\Delta_a}\left[f(0^+) - \int_0^{\rho_a\Delta_a} g_\tau\pi'_\tau d\tau\right]. \end{aligned} \tag{7}$$

To find the optimal duration of anticipation, Δ_A, we set this expression equal to zero. This is equivalent to solving for $G(\Delta_a) = 0$. We check that $G(0) = f(0^+) > 0$, $\partial G/\partial\Delta_a = -\rho_a e^{\alpha\Delta_a}f(\rho_a\Delta_a)\pi'(\rho_a\Delta_a) < 0$, and $\lim_{\Delta_a\to\infty} G(\Delta_a) = f(0^+) - \int_0^\infty g_\tau\pi'_\tau d\tau < 0.$[13] Hence, U^A is unimodal, taking it peak at $\Delta_A \in (0,\infty)$, the unique solution to $G(\Delta_A) = 0$.

Next, we show that Δ_A decreases with α and ρ_0, and increases with $|c|$. By the implicit function theorem, and knowing that $\partial G/\partial\Delta_a < 0$, suffices to show that $\partial G/\partial\alpha < 0$, $\partial G/\partial\rho_0 < 0$, and $\partial G/\partial|c| \geq 0$, respectively. Let $\tau_A = \rho_a\Delta_A$. Note that $g'_\tau = \frac{\alpha}{\rho_a}g_\tau - g_\tau\pi'_\tau$.

[13] To see the latter, note that $\int_0^\infty g_\tau\pi'_\tau d\tau > \int_0^\infty f(\tau)\pi'_\tau d\tau = -\int_0^\infty f'(\tau)d\tau = f(0^+)$.

Using $f(0^+) = \int_0^{\tau_A} g_{\tau_A}\pi'_\tau d\tau$ and $g(0^+) = f(0^+)$, we conclude that $g_{\tau_A} = \int_0^{\tau_A} g'_\tau d\tau = \frac{\alpha}{\rho_a}\int_0^{\tau_A} g_\tau d\tau$. Note also that if $-\tau\pi''/\pi' < 1$, then $(\pi'_\tau\tau)' = \tau\pi'' + \pi' > 0$ and $\pi'_\tau\tau$ is strictly increasing. Thus,

$$\left.\frac{\partial G}{\partial \alpha}\right|_{\Delta_A} = -\frac{1}{\rho_a}\int_0^{\tau_A} \tau^2 g_\tau \pi'_\tau d\tau < 0,$$

$$\left.\frac{\partial G}{\partial \rho_0}\right|_{\Delta_A} = -\frac{1}{\rho_0}\left[g_{\tau_A}\pi'_{\tau_A}\tau_A + \frac{\alpha}{\rho_a}\int_0^{\tau_A} g_\tau\pi'_\tau \tau d\tau\right]$$

$$= -\frac{\alpha}{\rho_0\rho_a}\left[\int_0^{\tau_A} g_\tau \pi'_{\tau_A}\tau_A d\tau - \int_0^{\tau_A} g_\tau\pi'_\tau\tau d\tau\right] < 0, \text{ and}$$

$$\left.\frac{\partial G}{\partial |c|}\right|_{\Delta_A} = \frac{\mu}{|c|}\left[g_{\tau_A}\pi'_{\tau_A}\tau_A - \frac{\alpha}{\rho_a}\int_0^{\tau_A} g_\tau\pi'_\tau\tau d\tau\right]$$

$$= \frac{\mu}{|c|}\frac{\alpha}{\rho_a}\left[\int_0^{\tau_A} g_\tau\pi'_{\tau_A}\tau_A d\tau - \int_0^{\tau_A} g_\tau\pi'_\tau\tau d\tau\right] \geq 0.$$

To maximize $|U|$ wrt Δ_a, we use (4) and (7) to obtain

(8)
$$\frac{\partial |U|}{\partial \Delta_a} = |v(c)|e^{-\alpha\Delta_a}\left[G(\Delta_a) - \left(1 - e^{-\alpha\Delta_e}\right) - e^{-\alpha\Delta_e}\frac{\alpha(1+\mu)\Sigma}{\rho_r}\right]$$

We argue that $\Delta_* < \Delta_A$. Indeed, if $\Delta_a \geq \Delta_A$, then $G(\Delta_a) \leq 0$ and $\partial|U|/\partial\Delta_a < 0$.

As for uniqueness, we now show that if μ is not large, then U is strictly concave in Δ_a. Taking the second derivative of $|U|$ and rearranging, we conclude that the sign of the second derivative is strictly negative iff

(9)
$$\mu < \sqrt{\frac{1}{4} + \left(\frac{\rho_a}{\alpha}\right)^2 \frac{f(\rho_a\Delta_a)\pi'(\rho_a\Delta_a)}{e^{-\alpha(1+\mu)\Delta_a}e^{-\alpha\Delta_e}\Sigma}} - \frac{1}{2}.$$

Note that

$$0 < \sqrt{\frac{1}{4} + \left(\frac{\rho_a}{\alpha}\right)^2 \frac{f(\rho_a\Delta_A)\pi'(\rho_a\Delta_A)}{e^{-\alpha\Delta_e}\Sigma}} - \frac{1}{2}$$

$$\leq \sqrt{\frac{1}{4} + \left(\frac{\rho_a}{\alpha}\right)^2 \frac{f(\rho_a\Delta_a)\pi'(\rho_a\Delta_a)}{e^{-\alpha(1+\mu)\Delta_a}e^{-\alpha\Delta_e}\Sigma}} - \frac{1}{2}.$$

Thus, at $\mu = 0$, (9) holds for all $\Delta_a \in [0, \Delta_A]$. By continuity and the fact that the right hand side of (9) is bounded away from zero for all Δ_a, the inequality will be satisfied for all μ in some interval $[0, \hat{\mu})$. This implies $|U|$ is strictly concave. Thus, if $\mu < \hat{\mu}$, then $\Delta_* \in [0, \Delta_A)$ is unique.

Clearly, if $\partial|U|/\partial\Delta_a|_{\Delta_a=0} > 0$, then $\Delta_* > 0$. Consider the case $\partial|U|/\partial\Delta_a|_{\Delta_a=0} \leq 0$. Then, $\Delta_a = 0$ is a local maximum. We claim it is a global maximum. If $\mu < \hat{\mu}$, then the second derivative is negative and the result follows. If $\mu \geq \hat{\mu}$, then (dis)utility may have a local maximum at some $\Delta_a^\ell \in (0, \Delta_A)$. We will show this local maximum is inferior to $\Delta_a = 0$, that is, $|U|_{\Delta_a^\ell} < |U|_{\Delta_a=0}$. First, replace μ by $\mu_\theta = \mu e^{-\theta\Delta_a}$ and let $|U_\theta|$ be the associated utility. If $\Delta_a = 0$, then $\mu_\theta = \mu$ and $|U_\theta|_{\Delta_a=0} = |U|_{\Delta_a=0}$. If $\theta = 0$, then $\mu_0 = \mu$ and $|U_0|_{\Delta_a^\ell} = |U|_{\Delta_a^\ell}$. We check that $\partial|U_\theta|/\partial\Delta_a|_{\Delta_a=0} \leq 0$. For any $\Delta_a > 0$, choose $\hat{\theta} > 0$ so that $\mu_{\hat{\theta}} < \hat{\mu}$. Because $\partial|U_{\hat{\theta}}|/\partial\Delta_a\big|_{\Delta_a=0} \leq 0$ and the second derivative is strictly negative, $|U_{\hat{\theta}}|$ decreases with Δ_a and $|U|_{\Delta_a=0} > |U_{\hat{\theta}}|_{\Delta_a^\ell}$. We now let θ go from $\hat{\theta}$ to zero, and show that (dis)utility can only decrease. Indeed, $\partial|U_\theta|/\partial\theta = \alpha\mu_\theta\Delta_a^2|U_\theta|^R > 0$ and $|U_{\hat{\theta}}|_{\Delta_a^\ell} > |U_0|_{\Delta_a^\ell}$. Thus, if $\partial|U|/\partial\Delta_a|_{\Delta_a=0} \leq 0$, then

$$|U|_{\Delta_a=0} > |U_{\hat{\theta}}|_{\Delta_a^\ell} > |U_0|_{\Delta_a^\ell} = |U|_{\Delta_a^\ell},$$

which implies that $\Delta_* = 0$. ■

Proof of Proposition 6. By Proposition 5, Δ_A solves $\int_0^{\rho_a\Delta_a} g_\tau\pi'_\tau d\tau = f(0^+)$. Using A5.2, $\pi(\tau) = (1-\delta) + \delta\tau$, we obtain $f(0^+) = e^{\delta-1}$, $\Sigma = e^{\delta-1}/\delta$, and $g_\tau\pi'_\tau = \delta e^{\delta-1}e^{\left(\frac{\alpha}{\rho_a}-\delta\right)\tau}$. Let $\Lambda = \delta\rho_a - \alpha$. We verify that if $\Lambda = 0$, then $\int_0^{\rho_a\Delta_a} g_\tau\pi'_\tau d\tau = e^{\delta-1}\delta\rho_a\Delta_a$; otherwise,

$$\int_0^{\rho_a\Delta_a} g_\tau\pi'_\tau d\tau = e^{\delta-1}\frac{\delta\rho_a}{\Lambda}\left(1 - e^{-\Lambda\Delta_a}\right).$$

The expression for Δ_A follows.

As for the optimal duration of anticipation, Δ_*, we first find the extremums of $|U|$ by equating (8) to zero. Note that $\partial|U|/\partial\Delta_a|_{\Delta_a=0} > 0$ iff $D < 1$, where

(10)
$$D = e^{1-\delta}(1 - e^{-\alpha\Delta_e}) + \frac{\alpha(1+\mu)}{\delta\rho_a}e^{-\alpha\Delta_e}.$$

If $\Lambda \leq 0$, then $D \geq 1$ and $\partial|U|/\partial\Delta_a|_{\Delta_a=0} \leq 0$. If $\Lambda > 0$ then D may be above or below one. Consider three cases, $\Lambda = 0$, $\Lambda > 0$ and $\Lambda < 0$.

i. $\Lambda = 0$. The extremum solves $\delta\rho_a\Delta_a = 1 - e^{1-\delta}(1 - e^{-\alpha\Delta_e}) - (1+\mu)e^{-\alpha\Delta_e}e^{-\alpha\mu\Delta_a}$, $\Delta_a \geq 0$. Because the right hand side is negative at the origin, the equation admits zero, one (tangential), or two solutions. The case of one solution corresponds to an inflection point that does not produce an extremum.

ii. $\Lambda > 0$. Let

$$A = 1 - \frac{\Lambda}{\delta\rho_a}\left[1 - e^{1-\delta}(1 - e^{-\alpha\Delta_e})\right], \text{ and}$$

$$B = \Lambda\frac{\alpha(1+\mu)}{(\delta\rho_a)^2}e^{-\alpha\Delta_e}.$$

The extremum solves $e^{-\Lambda\Delta_a} = A + Be^{-\alpha\mu\Delta_a}$, where $0 < A < 1$ and $B > 0$. If $\mu = 0$, then $\Delta_* = \frac{-\ln(A+B)}{\Lambda} > 0$ if $0 < A + B < 1$ and $\Delta_* = 0$ otherwise. If $\mu > 0$, then $C = \frac{\alpha\mu}{\Lambda} > 0$ and $x_* = e^{-\Lambda\Delta_*}$ is a fixed point of

$$H(x) = A + Bx^C, \ x \in [0, 1].$$

Note that $D = 1 - \frac{\delta\rho_a}{\Lambda}(1 - A - B)$. We have three cases.

1. If $D < 1$, then $A + B < 1$. Because $H(0) = A > 0$, $H(1) = A+B < 1$, and H is either concave ($0 < C \leq 1$) or convex ($C > 1$), we have that $H(x)$ has one unique fixed point, x_*, which can be found recursively. (Dis)utility increases up to $\Delta_* = \frac{-\ln x_*}{\Lambda}$, and then decreases.
2. If $D = 1$, then $A + B = 1$, $x_* = 1$ is the only fixed point, and $\Delta_* = 0$.
3. If $D > 1$, then $A + B > 1$. If $C \leq 1$, then $H(x)$ is concave and there is no fixed point. If $C > 1$, then H is convex and may intersect x zero, one (tangential) or two times.

iii. $\Lambda < 0$. Same equation as in $\Lambda > 0$, but with $A > 1$, $B < 0$, and

$$A+B = 1-\frac{\alpha - \delta\rho_a}{\delta\rho_a}\left[e^{1-\delta}(1 - e^{-\alpha\Delta_e}) + \frac{\alpha(1+\mu)}{\delta\rho_a}e^{-\alpha\Delta_e} - 1\right] < 1.$$

If $\mu = 0$, then $\Delta_* = 0$. If $\mu > 0$, then $C = \frac{\alpha\mu}{\alpha - \delta\rho_a} > 0$ and $x_* = e^{-\Lambda\Delta_*}$ is a fixed point of $H(x) = A+B/x^C$, $x \in [1, A]$. Because H is concave, $H(x) = x$ may have zero, one (tangential) or at most two solutions.

In the cases where $D \geq 1$, i.e., $\partial|U|/\partial\Delta_a|_{\Delta_a=0} \leq 0$, a necessary condition for having two fixed points is $H'(1) = BC > 1$, or $\mu(1+\mu) > e^{\alpha\Delta_e}\left(\frac{\delta\rho_a}{\alpha}\right)^2$, or $\mu > \sqrt{\frac{1}{4} + e^{\alpha\Delta_e}\left(\frac{\delta\rho_a}{\alpha}\right)^2} - \frac{1}{2}$. ■

Proof of Proposition 7. In view of (4), both $|U|^E$ and $|U|^R$ tend to zero as Δ_a increases. Remains to show that $|U|^A$ also goes to zero. Note that

$$\begin{aligned} |U|^A &= \frac{|v(c)|}{\rho_a}\int_0^{\rho_a\Delta_a} e^{-\alpha\left(\Delta_a - \frac{\tau}{\rho_a}\right) - \pi(\tau)}d\tau \\ &\leq \frac{|v(c)|}{\rho_a}\left[\int_0^{\frac{\rho_a\Delta_a}{2}} e^{-\alpha\frac{\Delta_a}{2}}d\tau + \int_{\frac{\rho_a\Delta_a}{2}}^{\rho_a\Delta_a} e^{-\pi(\frac{\rho_a\Delta_a}{2})}d\tau\right] \\ &\leq \frac{|v(c)|}{\rho_a}\left[e^{-\alpha\frac{\Delta_a}{2}}\frac{\rho_a\Delta_a}{2} + e^{-\pi(\frac{\rho_a\Delta_a}{2})}\frac{\rho_a\Delta_a}{2}\right]. \end{aligned}$$

If $\tau e^{-\pi(\tau)} \to 0$ as $\tau \to \infty$, then this last term goes to zero as $\Delta_a \to \infty$. ■

Proof of Proposition 8. Consider the sign of $\partial|U|/\partial\Delta_a|_{\Delta_a=0} > 0$. In view of Proposition 6, if $\partial|U|/\partial\Delta_a|_{\Delta_a=0} > 0$, then $\Lambda > 0$, and $|U|$ is unimodal. Solution 1 then follows.

If $\partial|U|/\partial\Delta_a|_{\Delta_a=0} = 0$ then $|U|$ decreases and we are in solution 3.

In view of Proposition 6, if $\partial|U|/\partial\Delta_a|_{\Delta_a=0} < 0$, then we may have zero or two extrema. Solution 2 corresponds to the case of two extrema, where (dis)utility decreases until reaching the first fixed point, increases until reaching the second fixed point, and decreases thereafter. Solution 3 corresponds to the case of zero extremum, and (dis)utility (weakly) decreases with Δ_a. ■

Appendix C
List of Figures

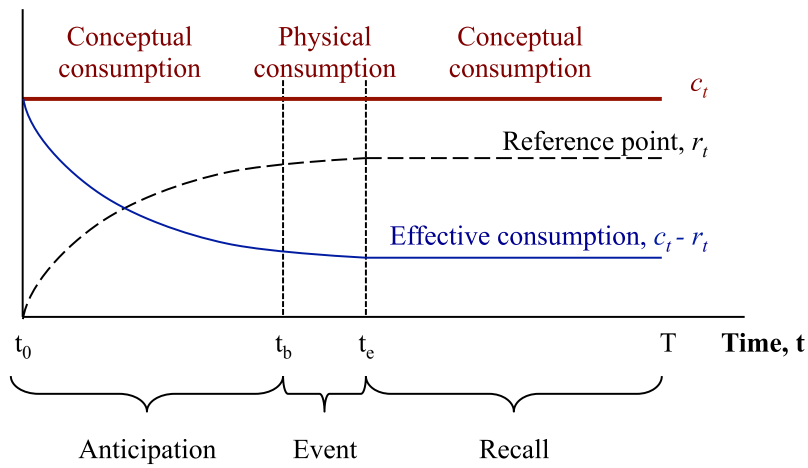


Figure C1. When conceptual consumption is constant, effective consumption is decreasing during anticipation and the event, and constant during recall.

Figure C2. The temporal profiles of instant utility, $u(t)$, for different levels of α (left) and ρ_0 (right). Base case assumptions: $c = 1$, $\Delta_a = 40$, $\Delta_e = 10$, $\alpha = 0.01$, $\pi(\tau) = \tau^{0.5}$, $\rho_0 = 0.05$ and $\mu = 2$.

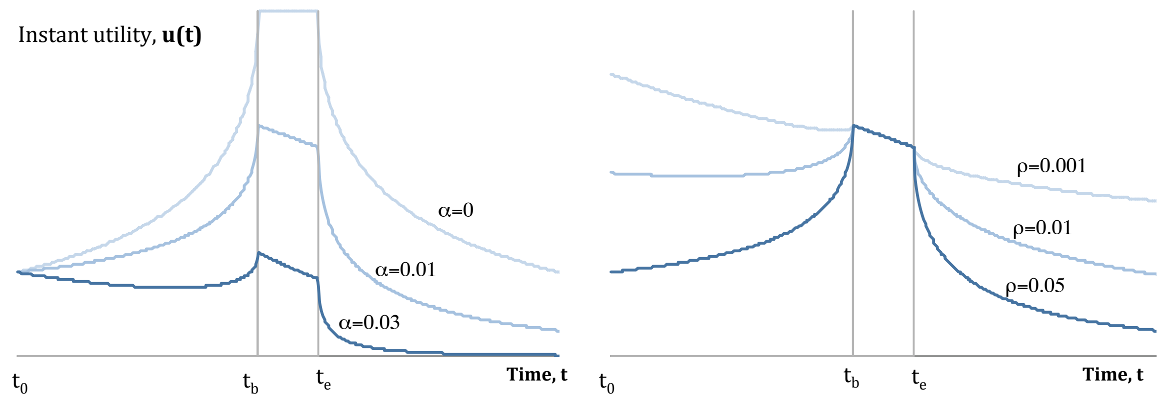


Figure C3. Utility of anticipation, of the event, and of recall as a function of c. [$\Delta_a = 10$, $\Delta_e = 5$, $\alpha = 0.04$, $\pi(\tau) = \tau$, $\rho_0 = 0.1$, and $\mu = 2$].

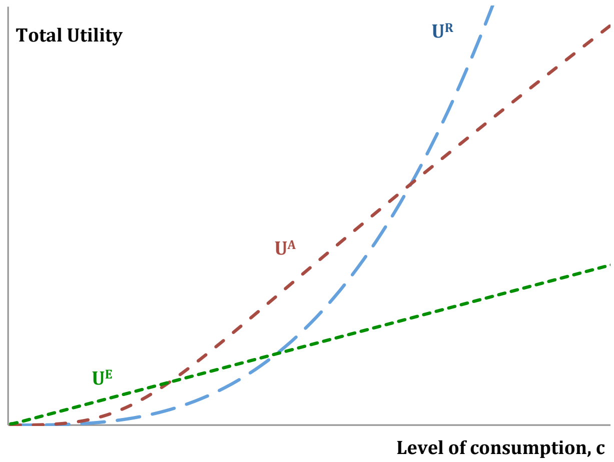


Figure C4. Left: Total utility and total utility of anticipation as a function of Δ_a. Right: The temporal profile of instant utility for two durations of anticipation, $\Delta_A = 53.2$ and $\Delta_* = 8.4$. Total utility (left) is the integral of profiles (right) for different values of Δ_a. [$c = 1$, $\Delta_e = 10$, $\alpha = 0.01$, $\pi(\tau) = \tau^{0.5}$, $\rho_0 = 0.1$, and $\mu = 0.8$.]

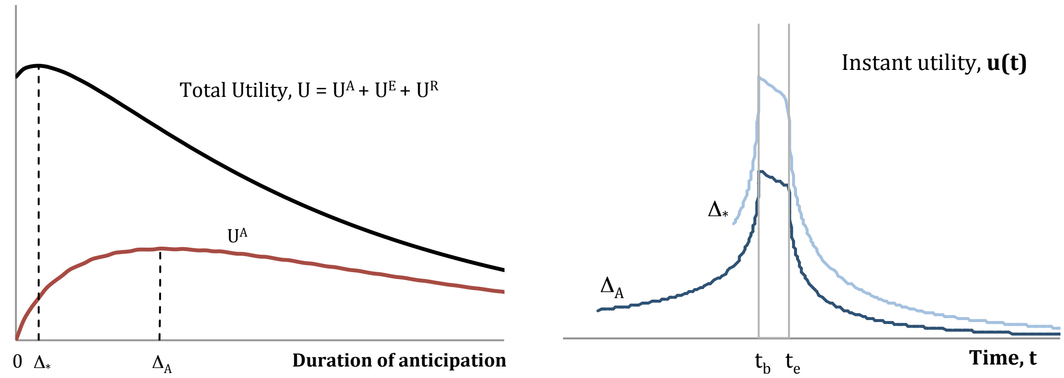
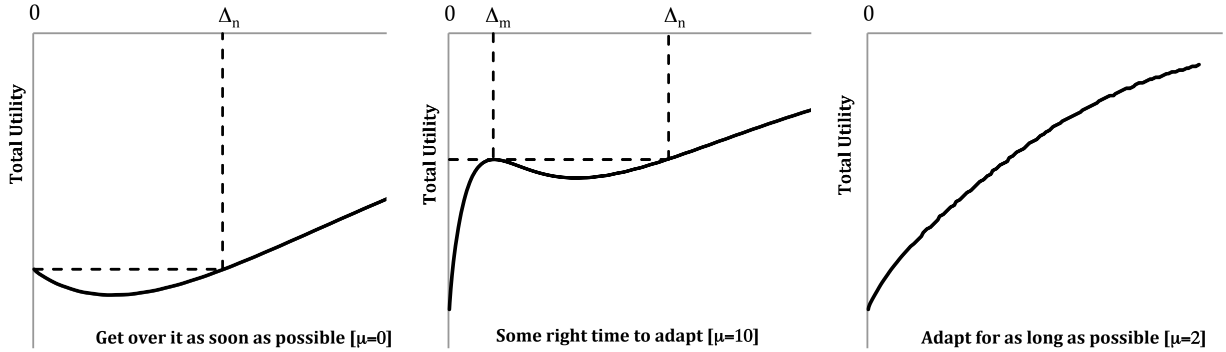


Figure C5. Utility for a negative event as a function of the duration of anticipation, and for three values of μ. [$\Delta_e = 5$, $c = -0.5$, $\lambda = 2$, $\alpha = 0.01$, $\rho_0 = 0.02$ and $\pi(\tau) = \tau$].



Appendix D
List of Tables

Table D1
Parameters of the AR model.

Function	**Psychological Principle**	**Parameters**
Value function, v	Loss aversion	$\lambda > 0$
Adaptation, $dr_t/dt = \alpha(c_t - r_t)$	Speed of adaptation	$\alpha \geq 0$
Discount rates, $\rho_a = \rho_0/\lvert v(c)\rvert^{\mu}$ and $\rho_r = \rho_a e^{\alpha\mu\Delta_a}$	Base discount Magnitude effect	$\rho_0 > 0$ $\mu \geq 0$
Discount factor, $e^{-(\tau^{\delta})}$	Diminishing sensitivity to τ	$\delta \in (0, 1]$

Table D2

Answers to: "How long in advance would you ideally like to be told about each of the following events?" Response time scale: 1= one year; 2= nine months; 3= six months; 4= three months; 5= one month; 6= two weeks; 7= one week; 8= the day prior. [N=155].

Upcoming event	**Ideal Anticipation**	
	Avg. Response (St.Dev)	Days [Interpolated]
Wedding of your best friend	3.1 (1.6)	180
Two-week vacation	4.3 (1.3)	60
Wedding of a distant relative	4.4 (1.5)	54
Concert of your favorite band	5.4 (1.3)	24
A weekend vacation	5.8 (1.1)	18
1 day at a relax spa	6.7 (1.0)	9
Dinner at a fancy restaurant	7.0 (0.8)	7
Receiving a relaxing massage	7.2 (0.9)	6
Going to the cinema	7.5 (0.7)	4
Movie at home on DVD	7.7 (0.6)	2
Eating ice cream	7.9 (0.3)	1