Topic 2D: Choice over Time
An Alternative Model: Present Bias

EC 404: Behavioral Economics
Professor: Ben Bushong

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Motivation

Exponential discounting implies constant discounting:

$$\frac{D(0)}{D(1)} = \frac{D(1)}{D(2)} = \frac{D(2)}{D(3)} = \ldots = \frac{1}{\delta}.$$

But the evidence suggests more discounting in the short run than in the long run:

$$\frac{D(0)}{D(1)} > \frac{D(1)}{D(2)} > \frac{D(2)}{D(3)} > \ldots.$$

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A Simplified Model

A simplified model: "β, δ preferences" or "present bias"

Period-t intertemporal utility is

$$U^t = u_t + \beta * \sum_{x=1}^{T-t} \delta^x u_{t+x}.$$

In other words, the discount function is:

$$D(x) = \begin{cases} 1 & \text{if } x = 0 \\ \beta * \delta^x & \text{if } x > 0. \end{cases}$$

Hence, under β, δ preferences:

$$\frac{D(0)}{D(1)} = \frac{1}{\beta\delta} > \frac{1}{\delta} = \frac{D(1)}{D(2)} = \frac{D(2)}{D(3)} = \ldots.$$

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β, δ preferences capture in the simplest way possible that a person has a time-inconsistent preference for immediate gratification.

People who assume β, δ preferences use many different names:

- present bias (present-biased preferences)
- hyperbolic discounting
- quasi-hyperbolic discounting
- preference for immediate gratification
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Example to Illustrate Time Inconsistency

Suppose there is a task that you must complete on one of the next three days. To complete this task, you incur costs as follows:

- If you complete the task in period 1, the cost is 3.
- If you complete the task in period 2, the cost is 5.
- If you complete the task in period 3, the cost is 8.

Suppose there is no reward, that you value costs linearly, and that you have $\beta = 1/2$ and $\delta = 1$.

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Your preferences from a period-1 perspective are:

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Conditional on not doing it in period 1, your preferences from a period-2 perspective are:

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To summarize, your period-1 preferences are

$$\text{(period 2)} \succ \text{(period 1)} \succ \text{(period 3)}$$

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Note the time inconsistency:

- As time passes, your preference between period 2 vs. period 3 flips.

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An important issue: Are you aware of your future self-control problems (of your future present bias)?

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If you were asked to commit yourself in period 1, you'd commit yourself to do the task in period 2.

Suppose instead that in period 1 you only choose whether or not to do the task then. Then your choice will depend on what you expect to do in period 2 (if you were to wait).

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- If so, you correctly predict that if you wait now, then in period 2 you'll prefer to wait again.
- Hence, you compare completing the task now to completing the task in period 3, and you prefer the former.

$\Longrightarrow$ Complete task in period 1.

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- If so, then since you currently prefer period 2 to period 3, you think that if you wait now, you'll just complete the task in period 2.
- Hence, you wait in period 1 planning to complete the task in period 2.
- Of course, when period 2 arrives, you'll change your mind and decide to wait.

$\Longrightarrow$ End up completing task in period 3.

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Sophistication vs. Naivete

More generally:

Two extreme assumptions about people's awareness of their own future self-control problems:

- *Sophisticates* are **fully aware** of their future self-control problems and thus correctly predict future behavior.
- *Naifs* are **fully unaware** of their future self-control problems and thus expect to behave in future exactly as they currently would like themselves to behave in future.

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Sophistication vs. Naivete

To solve for naifs:

- Each period, derive the optimal lifetime path, and follow this period's component. But when next period arrives, reassess this plan.
- **Note:** Naifs may not stick to their plans.

To solve for sophisticates:

- Treat each period-self as a separate agent, and solve for the subgame-perfect Nash equilibrium to the game played between these agents (use backward induction — start at the end, and work backward).
- Note: Sophisticates always stick to their plans.
- . . . they just never plan to do something they won't later carry out.

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Suppose there is a task that you must complete on one of the next four days. To complete this task, you incur costs as follows:

- If you complete the task in period 1, the cost is 3.
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Suppose there is no reward, that you value costs linearly, and that you have $\beta = 1/2$ and $\delta = 1$.

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Suppose there is an enjoyable activity that you get to do on one of the next four days. The reward generated by this activity is as follows:

- If you do the activity in period 1, the reward is 3.
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- Week 1: mediocre movie, 3 utils
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- Week 4: **Fast and Furious** movie, 13 utils.

Assume $\delta = 1$, $\beta = \frac{1}{2}$.

- Suppose you must *miss* one movie, and thus get 0 utils that day.

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Your (cinematic) life choices are $(u_1, u_2, u_3, u_4) =$

- $(0, 5, 8, 13)$ or $(3, 0, 8, 13)$ or $(3, 5, 0, 13)$ or $(3, 5, 8, 0)$.

You cannot commit to which movie to miss—you must decide incrementally each week whether to see that movie or skip it.

(This assumption **matters**.)

- What movie should you miss?
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Have to consider two cases: naif vs sophisticate decision-maker.

Case 1: What will a sophisticate do?

- Because $8 + \frac{1}{2}0 > 0 + \frac{1}{2}13$, the sophisticate won't skip Week 3.
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Note that even given $\beta = \frac{1}{2}$, all four selves agree that missing Vin Diesel is a bad thing to happen. Yet the naif does so.

- Despite substantial "disagreement" among "different selves", they all agree missing either the 1$^{\text{st}}$ movie or the 2$^{\text{nd}}$ movie is better than missing the 4$^{\text{th}}$.
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Aside: Let us see what we would infer from the observed behavior if we were an anachronistic economist who believed in $\beta = 1$.

An exponential discounter would have to have a *weekly* discount factor $\widetilde{\delta} \leq Min[\sqrt[3]{\frac{3}{13}}, \sqrt[2]{\frac{5}{13}}, \frac{8}{13}] \approx .61$ to be willing to miss F&F.

	Letting $\beta < 1$ $(= \widehat{\beta})$	Insisting $\beta = 1$
Week 1 weight on u_2 vs. u_1	.61	.61
Week 1 weight on u_4 vs. u_1	.61	.23

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And if we observed somebody missing the 52nd week (Fast and Furious marathon?) at the Fibonacci's Fine Arts Cinema with utilities (3,5,8,13,21,34,55...)

	Letting $\beta < 1$ $(= \widehat{\beta})$	Insisting $\beta = 1$
Week 1 u_2 vs. u_1	$\approx .61$	$\approx .61$
Week 1 u_{52} vs. u_1	$\approx .618$	$\approx .618^{52} \approx 1.36 \times 10^{-11}$

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Now suppose: Person can go to only one movie, and must skip 3 of them. Same preferences as above.

- So life utility profiles are $(u_1, u_2, u_3, u_4) =$
- $(3, 0, 0, 0)$ or $(0, 5, 0, 0)$ or $(0, 0, 8, 0)$ or $(0, 0, 0, 13)$.

What will the sophisticate do?

- Because $8 > \frac{1}{2}(13)$, if she has not seen it yet, the sophisticate will see the movie in Week 3.
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(Less Gentle) Introduction to Present-Biased Preferences

Doing It Now or Later: The Simple Example

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Example 1

Suppose there is a task that you must complete on one of the next four days. To complete this task, you incur costs as follows:

- If you complete the task in period 1, the cost is 3.
- If you complete the task in period 2, the cost is 5.
- If you complete the task in period 3, the cost is 8.
- If you complete the task in period 4, the cost is 13.

Suppose there is no reward, that you value costs linearly, and that you have $\beta = 1/2$ and $\delta = 1$.
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From a prior perspective, the best time is period 1.

Naifs complete the task in period 4.

Sophisticates complete the task in 1.

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Formal Welfare Implications

Our welfare criterion: A person's "long-run utility" — which reflects how she feels from a prior perspective — is given by

$$U^0 \; = \; \sum_{\tau=1}^{T} \delta^\tau \; u_\tau .$$

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In Example 1:

Long-run utility from best option (do it in period 1) is -3.

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Welfare loss for sophisticates is 2.

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In this simple "do-it-once" environment, for onerous tasks, naifs can suffer large harm, sophisticates cannot.

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In this simple "do-it-once" environment, for pleasurable tasks, sophisticates can suffer large harm, naifs cannot.

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In richer, real-world environments, sophistication is most likely better than naivete, because sophisticates will make use of commitment devices to overcome their self-control problems.

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Procrastination: Doing It ... Tomorrow

- Procrastination involves the "immediate gratification" of not doing something optimally onerous
- Often the main "cost" of doing some beneficial task is primarily the opportunity cost of doing something gratifying.
- Procrastination is in fact a wonderful vice: You can, and — ideally — should do it concurrently with other vices!
- Note: quitting smoking, etc. qualitatively similar to procrastination.

But what *is* it?

- Not just delaying unpleasant tasks, which is often right thing to do.
- It is delaying beyond when you yourself want to complete them.

Procrastination

Important example of unpleasant task we procrastinate on: learning.

- Learning how to do something better is pervasive example of something with long-term benefits.
- Many people recognize the enormous benefits of financial planning and literacy. And so want to do so. And plan to do so.

... tomorrow.

Procrastination Example

Suppose that, with 120 minutes of effort today, you could reduce the effort by 10 minutes needed to undertake a task every day for rest of your life.

- E.g., learn some short cuts or tricks with your word-processing package, or "fix" some annoying problem in the current user set-up.
- So, within 2 weeks, you will on net save time. In a year, 58 hours, and in a decade, 600 hours.

Suppose that value of time the same each day. No deadlines, no commitment devices.

- Do you do the task? If so, when?

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If do the task today your intertemporal well-being is:

$$U^t = -120 + \beta\delta \cdot 10 + \beta\delta^2 \cdot 10 + \beta\delta^3 \cdot 10 + \dots$$
$$= -120 + \beta\frac{\delta}{1-\delta}10,$$

relative to the utility you would get from doing nothing.

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Suppose time consistent, no taste for immediate gratification.

- E.g., $\beta = 1$, $\delta = .999$. Then:

$$U^t(\textit{fix today}) = -120 + \frac{.999}{1-.999}10 = 9,870.$$

$$U^t(\textit{fix tomorrow}) = .999(-120 + \frac{.999}{1-.999}10) = 9,861$$

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$$U^t(\textit{never}) = 0$$

So: Person will do it right away.

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The Fundamental Theorem of TC (that is, non-present-biased) Task-Assessment in Stationary Environments: Either

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- $U^t(day\ after\ tomorrow) \succ$
- $... \succ$
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or

- $U^t(never) \succ$
- $... \succ$
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- $U^t(day\ after\ tomorrow) \succ$
- $U^t(tomorrow) \succ$
- $U^t(today)$.

Procrastination

The Fundamental Theorem of TC (that is, non-present-biased) Task-Assessment in Stationary Environments: Either

- $U^t(today) \succ$
- $U^t(tomorrow) \succ$
- $U^t(day\ after\ tomorrow) \succ$
- $... \succ$
- $U^t(never)$

or

- $U^t(never) \succ$
- $... \succ$
- $U^t(day\ after\ tomorrow) \succ$
- $U^t(tomorrow) \succ$
- $U^t(today)$.

Procrastination

This is the combination we are interested in:

- $U^t(\textit{fix today}) \succ U^t(\textit{never})$, but $U^t(\textit{fix tomorrow}) \succ U^t(\textit{fix today})$.
- This would never happen for a time-consistent person, by the FT-TC-TASE.
- In a stochastic or non-stationary environment, could be that a TC person happens to not want to do it today
- But the systematic congruence of these two inequalities is the feature of interest for present bias.
- If a task is worth doing, it is worth doing right away.
- Day-to-day variation in opportunity cost, etc., then there may be particular reason to do tomorrow than today
- or today rather than tomorrow.
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Procrastination

Suppose some taste for immediate gratification (present bias).

- E.g., $\beta = .9$, $\delta = .999$.

$$U^t(\textit{fix today}) = -120 + .9\frac{.999}{1-.999}10 = 8,871$$

$$U^t(\textit{never}) = 0$$

Even with a taste for immediate gratification:

- Feels to you like you are saving about 150 hours in the future with the two hours today.
- Indeed, you would prefer doing the task today to never doing it even if it would take you 24 hours, not just 2 hours.

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So ...

- Do you do the task?
- If so, When?

If your choices were Today vs. Never, then:

- Do today.

But you could also plan to do the task tomorrow:

- $U^t(\mathit{fix\ tomorrow}) = .9 \cdot .999(-120 + \frac{.999}{1-.999}10) = 8,874$

You'd prefer to learn tomorrow rather than today.

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Intuition: Disadvantage of doing tomorrow is that you will delay the 10-minute savings by a day.

- But 2 hours tomorrow "feels like" 12 minutes less work than today.
- You'd prefer to put off the task for one day.

So: Your preferences are:

- $U^t(\textit{fix tomorrow}) \succ U^t(\textit{fix today})$
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So, repeat the question: Do you do the task?

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So, repeat the question: Do you do the task?

Procrastination

Answer: It depends.

- If you think that not doing today means you will do tomorrow, then

  ... Don't do today.

- If you think (for instance) that not doing today means you will never do, then

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- So what you do depends on your beliefs about own future behavior.
  - What will you believe?

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Recall:

- If $\beta = \frac{9}{10}$: $U^t(\textit{fix tomorrow}) \succ U^t(\textit{fix today}) \succ U^t(\textit{never})$
- If $\beta = 1$: $U^t(\textit{fix today}) \succ U^t(\textit{fix tomorrow}) \succ U^t(\textit{never})$

So if naively think that tomorrow you will have a $\beta = 1$, then you will not do today *believing* will do tomorrow.

- But when tomorrow comes:
  - You will not do, planning to do the next day.
- And when the next day comes:
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Procrastination

Sophisticates are (in this example) trickier to solve.

- Solution: would do the task either today or tomorrow.
- In both outcomes, their plan is to do it every other day (if they haven't yet done it).
  - Logic a bit complicated, but basic intuition simple.
- If aware of self-control problem, then properly nervous that you won't do it tomorrow, but delay it two or more days.
- Now you see choice not between today and two days hence.
- So (with the numbers at hand) you do it today.
- (But okay also to plan to do it tomorrow and follow through)

So: Sophistication helps overcome procrastination.

- The absurd (yet realistic) procrastination because of not just self-control problem itself, but of naivety/overoptimism about future conduct.

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- In both outcomes, their plan is to do it every other day (if they haven't yet done it).
  - Logic a bit complicated, but basic intuition simple.
- If aware of self-control problem, then properly nervous that you won't do it tomorrow, but delay it two or more days.
- Now you see choice not between today and two days hence.
- So (with the numbers at hand) you do it today.
- (But okay also to plan to do it tomorrow and follow through)

So: Sophistication helps overcome procrastination.

- The absurd (yet realistic) procrastination because of not just self-control problem itself, but of naivety/overoptimism about future conduct.

The Fundamental Theorem of Present-Biased Task-Assessment in Stationary Environments:

- Either
  - $U^t(tomorrow) \succ U^t(day\ after\ tomorrow) \succ ... \succ U^t(never)$
- or
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- If think will do the task tomorrow, you will *not* do it today.
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General principle: *Severe* procrastination for “one-shot” tasks requires some naivety.

- Intuition?

Simple style of rationality argument in economics.

- Sophisticates predict their future behavior correctly, and always have one simple action available to them ... doing the action now.
- That means their utility from their now perspective is bounded below by the utility of doing it right away.

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A mispecification/calibration exercise:

- A "deltoid" will never do task only if $-120 + \frac{\delta}{1-\delta}10 \leq 0$, so she would never do the task *only* if $\delta \leq \frac{12}{13} \Rightarrow \delta^{365} \leq .000000000002$.
- Hence, to reconcile behavior with the exponential model if we are confident in our assessment of the disutilities of effort, we would need a yearly $\widetilde{\delta} \leq (\frac{12}{13})^{365} = .000000000002$.
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Of course, effort costs probably increasing rather than linear.

- And we shouldn't assume we know utility function when inferring discount factors.
- Suppose we didn't know $\widetilde{\mu} = \frac{u(120 \text{ minutes})}{u(10 \text{ minutes})}$.

[?] What locus of $(\widetilde{\delta}, \widetilde{\mu})$ would explain avoiding 2 hours of effort immediately to save 10 minutes every day rest of your life?

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New Example:

- Consider $\beta = .9$, $\delta = .999$ naif again.
- But now:
- Suppose that the only choice available is "quick fix": 1 minute of effort today $\Longrightarrow 9\frac{1}{2}$ minutes saved each day forever.
- Would she do this? If so, when? Answer: Yes, she would. No temptation to put off the 1 minute of work until tomorrow.

$$U^t(\textit{quick fix today}) = -1 + .9\frac{.999}{1-.999}9.5 = 8540$$

$$U^t(\textit{quick tomorrow}) = .9 \cdot .999(-1 + \frac{.999}{1-.999}9.5) = 8532$$

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Now suppose **both** the 120/10 task and 1/9.5 task are available. Assume could do both sequentially, but don't save time on days when "fixing".

- The naif will compare her four choices:
  - $U^t(\textit{quick fix today}) = 8540$
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So she'll perpetually *plan* to do the full fix tomorrow—and meanwhile *never do either of them.*

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Suppose now naif has both the 120/10 and 1/9.5 options available—but that each only saves effort on 10% of days rest of her life. Then:

- $U^t(\textit{quick fix today}) = -1 + .9\frac{.999}{1-.999}\frac{9.5}{10} = 853$
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So: She'll do the quick fix immediately.

- Naif makes a (quick) fix when it is **less** important/beneficial that she do so, but not if **more** important/beneficial.
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Note:

- Somebody who is unwilling to take 120 minutes of effort to save 10 minutes *or* to take 1 minute of effort to save $9\frac{1}{2}$ minutes every day for the rest of her life seems, *interpreted through the lens of exponential discounting*, as if she is discounting at rate of

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April is the Cruelest Month

Cumulative Procrastination

- Suppose you *must* read 30 pages in 30 days—$\sum_{t=1}^{30} p_t \geq 30$. If you spend h_t hours reading on day t, then $u_t = -h_t$, and get $p_t = \sqrt{h_t}$ pages read.
- Key feature: *It is more efficient to spread out work regularly rather than doing it all in the space of a few days.*
  - Other models with this qualitative feature would yield similar results.

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Procrastination

Consider first: *June Mae*: $\delta = \beta = \widehat{\beta} = 1$.

- June Mae will read 1 hour each day, for a total of 30 hours.

Consider *April Mae*: $\delta = \widehat{\beta} = 1$, $\beta = \frac{1}{2}$.

- Day 1: April Mae will $Max_{\ h_1}\ U^1 \equiv -h_1 + \frac{1}{2}\left[-29\left(\frac{30-\sqrt{h_1}}{29}\right)^2\right]$. If she reads h_1 hours on Day 1, she'll need to read $\frac{30-\sqrt{h_1}}{29}$ pages each remaining day, spending $\left(\frac{30-\sqrt{h_1}}{29}\right)^2$ hours each day.
- Day 1: April Mae reads for $15\frac{1}{2}$ minutes (planning to read 62 minutes each of the remaining 29 days). She is planning to increase future h by 58 minutes to decrease h today by 45 minutes.

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- Day 1: April Mae reads for $15\frac{1}{2}$ minutes (planning to read 62 minutes each of the remaining 29 days). She is planning to increase future h by 58 minutes to decrease h today by 45 minutes.

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- Day 2: $Max_{\ h_2}\ U^2 \equiv -h_2 + \frac{1}{2}\left[-28\left(\frac{29.5-\sqrt{h_2}}{28}\right)^2\right]$ Day 2: April Mae reads for 16 minutes (and plans to read 64 minutes each day from now on).
- Day 3: ... 17 minutes ... (and ... 67 minutes ...).
- Day 10: ... 22 minutes (and ... 90 minutes ...).

With a week left: Has read 16 pages in 11 hours.

- Day 24: 72 minutes (and ... more than 4 hours ...).
- Day 30: April Mae reads for $23\frac{3}{4}$ hours. (an "all-nighter").

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So:

June Mae: 30 hours total.
April Mae: 51 hours total.

Consider *September "Sally" Mae*: $\delta = 1$, $\beta = \widehat{\beta} = \frac{1}{2}$.

- Solution (to a fairly tedious problem):
- Sally Mae will read 39 hours total.
- Note that the stark contrast between sophisticates and naifs, and the strong limits on harm done to sophisticates in, that we observed in one-shot situation has gone away.

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Suppose April Mae and June Mae enjoy studying together; E.g., $u_t = -.99h_t$ if study together.

- But must schedule in advance to do so.
- The enjoyment of studying together would serve as a serendipitous commitment for naifs.
- Suppose $u_t = -1.01h_t$ from studying together: But again must be planned in advance (where backing out of agreeing to study with somebody is more costly than refraining from planned studying)
- A principle: Providing "incremental incentives" may help combat "cumulative procrastination".
- Another principle: Providing deadlines may help combat "simple" procrastination.

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Details Matter

- Micro-structure of choices and incentives matter in a way that we don't ever need to worry about when $\beta = 1$.
- Return to example: Can spend 120 minutes fixing your word-processor to make a 10-minutes-a-day saving.
- Change one detail: You can't do the 120 minutes each day.
- Only can do (say) every friday. E.g., it is a weekly seminar, free to attend on your own time. You cannot do this on your own.

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- Now you think your choice is between doing it this friday vs. next friday—seven days later, not tomorrow:

$$U^t(\textit{this friday}) = -120 + .9\frac{.999}{1-.999}10 = 8871$$
$$U^t(\textit{next friday}) = .9 \cdot .999^7(-120 + \frac{.999}{1-.999}10) = 8821$$

- Now you will do it this friday.
  - Intuition: Now you realize that waiting $\Longrightarrow$ waiting a week
  - Cost you 70 minutes extra work, not just 10 minutes. Not worth it.
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Optimal design of incentives:

- Convince employees need help to improve word-processing, and schedule seminars/assistance so that they can't do it any time?
- Change cost from 120 minutes to 0 minutes by giving immediate time off from those who invest in self-improvement?
- The two big methods to combat procrastination:
  - Defaults
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