Lecture 8: Making Choices Over Time

Jonathan de Quidt

Saturday 31 December. *New Year's Resolutions. I WILL [. . .] go to the gym three times a week not merely to buy sandwich.*

Bridget Jones's Diary: A Novel

Monday 28 April. *[. . .] Gym visits 0, no. of gym visits so far this year 1, cost of gym membership per year £370; cost of single gym visit £123 (v. bad economy).*

Bridget Jones: The Edge of Reason[1]

[1] Both quoted in "Paying not to go to the gym", DellaVigna & Malmendier, 2006

Background

- With Matt you studied choices over prospects whose payoffs vary depending on the state of the world (e.g. the outcome of a coin toss).
- Today, we turn to choices over prospects whose payoffs vary over time.
- "Time preferences" are fundamental to economic analysis. Almost all important economic decisions have a dynamic component:

Example 1: deciding whether to learn a new skill

- Now
  - – Equipment costs (freezers, chainsaws, gloves)
  - – Tedium and frustration of learning
- Later
  - + Satisfaction of mastery
  - + New earnings opportunities possibilities

- How to choose?
  - Trade off benefits/costs over time

Example 2: deciding whether to eat a lot of candy

- Now
  - $+$ Candy is tasty
- Later
  - $-$ Candy is bad for you

- How to choose?
  - Trade off benefits/costs over time

Example 3: deciding whether to go to summer school

- Now
  - – Problem sets
  - – Fees
  - + Summer in London
- Later
  - + Faster graduation
  - + Higher future salary
- How to choose?
  - Trade off benefits/costs over time

More examples of important dynamic decisions

- Going to the gym
- Getting married
- Moving to a new city
- Buying an apartment
- Saving for retirement
- Getting a preventive health check
- Getting a tattoo

Quiz

https://bit.ly/3IPGSz0

Outline

The standard model

Evidence on discounting

Quasi-hyperbolic discounting

Evidence on quasi-hyperbolic discounting

Doing it now or later

Example exam-type questions

The standard model

The Exponential Discounted Utility (EDU) model, due to Samuelson (1937).
For a sequence of consumption outcomes $\boldsymbol{c} = (c_0, c_1, \ldots, c_T)$

$$
\begin{aligned}
U(\boldsymbol{c}) &= \sum_{t=0}^{T} \delta^t u(c_t) \\
&= u(c_0) + \delta u(c_1) + \delta^2 u(c_2) + \delta^3 u(c_3) + \ldots + \delta^T u(c_T)
\end{aligned}
$$

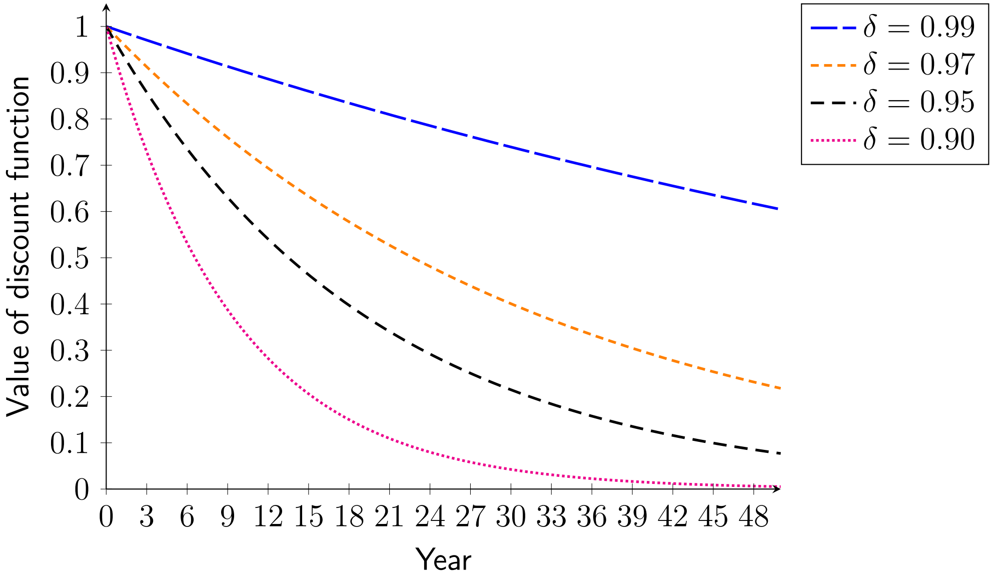
δ is known as the **discount factor**.

Usually we think $\delta < 1$, which means:

- Good outcomes: sooner is better than later
- Bad outcomes: later is better than sooner

Do you find that intuitive?

Discount function examples



Time consistency

The most important feature of the EDU model is that decisions are **time consistent**.[2]

Assuming that the utility function $u(\cdot)$ doesn't change:

- If I prefer A today over B tomorrow, I **also** prefer A in 7 days over B in 8 days.
- If I prefer A in period t over B in period s, I will **also** prefer A in period $t + \tau$ over B in period $s + \tau$.

[2] In fact, it's the **only** time consistent discounting function

Let's check

I prefer A today over B in period 1:

$$\underbrace{u(A)}_{\text{A today}} > \underbrace{\delta u(B)}_{\text{B tomorrow}}$$

Rearrange:

$$\frac{u(A)}{u(B)} > \delta$$

Check if I also prefer A in period t over B in period $t+1$:

$$\underbrace{\delta^t u(A)}_{\text{A in t periods}} > \underbrace{\delta^{t+1} u(B)}_{\text{B in t+1 periods}}$$

Rearrange:

$$\frac{u(A)}{u(B)} > \frac{\delta^{t+1}}{\delta^t} = \delta \qquad \checkmark$$

Implications of time consistency

Suppose I have to choose between movies to watch in period $T+1$.

I have to make the decision in some prior period $t \in \{0, 1, \ldots, T\}$.

So long as circumstances don't change (e.g., information, mood, preferences):

- It **doesn't matter when** I make the choice (any time in $0, ..., t$).
- If I make a choice and you later ask me if I want to **change my mind**, I'll say no.

So

- If I plan to go to the gym tomorrow, I do it.
- If I decide to stop eating sugar, I stick to it.
- If I want to have a comfortable retirement, I save for it.

Is that realistic?

Outline

Let's have a look at the quiz results

2025 results

2022–2024 results

Common findings from experiments like these

- People seem very impatient between **now** and **later**
- People seem less impatient between **later** and **(even) later**
- We say: people exhibit **decreasing impatience**
  - They "discount more" between period 0 and period t than between τ and $t + \tau$.
- If we extrapolate from short-term decisions, we'd predict people don't care at all about outcomes 1–2 years from now.
- But in reality people make all kinds of sacrifices in pursuit of long-run goals.

Frederick, Loewenstein, O'Donoghue (2002)

- Frederick, Loewenstein, O'Donoghue collect evidence from many studies of time discounting behavior.
- Most of these involve choices between amounts of money now or later.
- For each study they estimate the annual discount factor δ implied by participants' choices

Estimating discount factors is hard!

- Suppose we know that someone is equally happy to get \$100 today or \$110 in one year. Can we figure out their discount factor δ?

- Tempting to write:

$$u(100) = \delta u(110)$$
$$\delta = \frac{u(100)}{u(110)}$$

- Problems:
  1. We know when the person will get the money, but not when they will actually consume it. E.g. they might not consume the \$100 for six months.
  2. Utility depends on **all** consumption, not just the money from the experiment. $u(w + 100)$ not $u(100)$.
  3. And we don't even know the utility function $u(.)$.

Frederick, Loewenstein, O'Donoghue (2002)

- Frederick, Loewenstein, O'Donoghue use a simple approximation to estimate δs
- If equally happy between \$100 today and \$110 in a year, discount factor is approximately:

$$\delta \approx \frac{100}{110} = 0.91$$

- Overall the evidence suggests decreasing impatience: annual discount factors get bigger over longer time horizons.

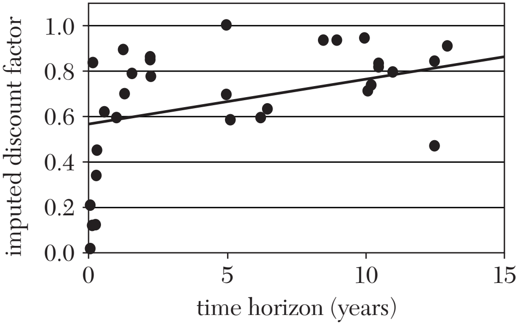


Figure 1a. Discount Factor as a Function of Time Horizon (all studies)

Frederick, Loewenstein, O'Donoghue (2002)

- In fact, if we remove the studies with very short time horizons, the discount factor looks pretty constant.

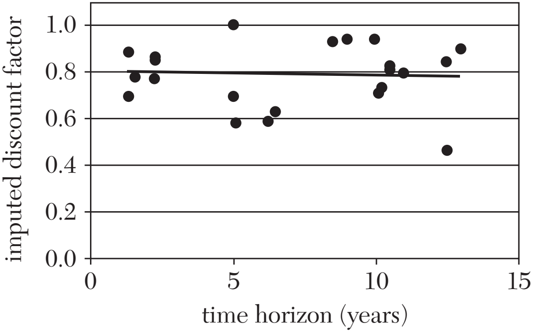


Figure 1b. Discount Factor as a Function of Time Horizon (studies with avg. horizons > 1 year)

More evidence

- A lot of evidence against the exponential discounted utility model comes from people giving in to temptation, changing their plans, or generally behaving inconsistently over time.
- We'll briefly look at some famous examples.

More evidence

Read and van Leeuwen (1998): Choosing between snacks

Fruit or chocolate?

- Choosing for next week: about 50% choose unhealthy snacks
- Choosing for today: about 80% choose unhealthy snacks
- Most people who chose a healthy snack for next week changed their mind when the time arrived

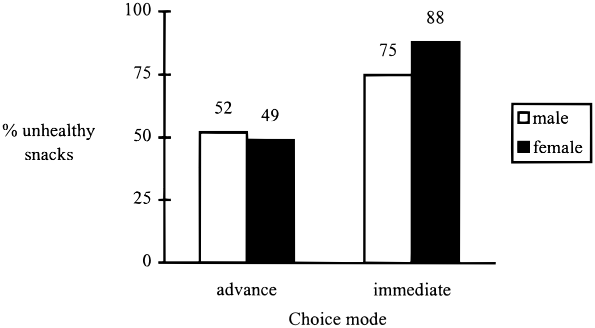


FIG. 2. Percentage of unhealthy snacks chosen as a function of sex and choice type.

More evidence

McClure et al. (2007): Juice?

- Experimental participants made extremely thirsty
- Choose between, e.g., 2ml juice now or 3ml in 5 minutes
- Extreme impatience in the short run (50% discounting over 5 min)
- Much more patient over future rewards

More evidence

DellaVigna and Malmendier (2006): "Paying not to go to the gym"

- Monthly subscribers paying \$70/month visit 4.3 times – average cost: \$17 per visit
- Could have just bought day-passes for \$10 each
- People take 2.3 months to cancel membership after last visit

What might be going on here?

- People buy the monthly pass enticed by the potential for low average cost.
- But fail to follow through on their plans.
- And they also procrastinate the task of canceling their plan later on.

Outline

Quasi-hyperbolic discounting (Laibson, 1997)

(Drawing on Strotz, 1956)

Also known as the $\beta - \delta$ ("beta-delta") model

- Between **two dates in the future**, discounting is standard: exponential discount per period δ
- Between **now** and **future**, an additional discount: β.

$$U(c) = u(c_0) + \beta\delta u(c_1) + \beta\delta^2 u(c_2) + \beta\delta^3 u(c_3) + \dots$$

we can write this as:

$$U(c) = u(c_0) + \beta \sum_{t=1}^{T} \delta^t u(c_t)$$

Quasi-hyperbolic discounting (Laibson, 1997)

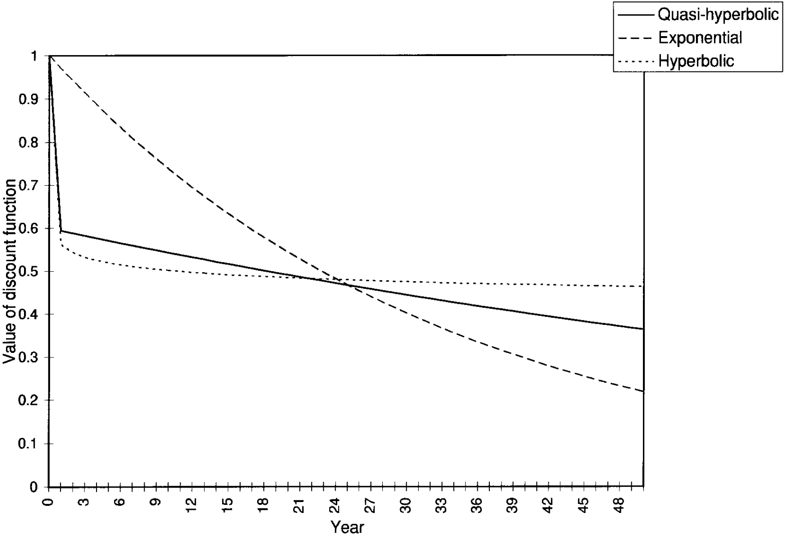
$$\begin{aligned} U(c) &= u(c_0) + \beta\delta u(c_1) + \beta\delta^2 u(c_2) + \beta\delta^3 u(c_3) + \dots \\ &= u(c_0) + \beta \sum_{t=1}^{T} \delta^t u(c_t) \end{aligned}$$

Remember the Exponential discounting model:

$$\begin{aligned} U(c) &= u(c_0) + \delta u(c_1) + \delta^2 u(c_2) + \delta^3 u(c_3) + \dots \\ &= u(c_0) + \sum_{t=1}^{T} \delta^t u(c_t) \end{aligned}$$

- The $\beta - \delta$ model coincides with the EDU model when $\beta = 1$.
- But empirically, we normally find $\beta < 1$

A quasi-hyperbolic discount function



A simple illustrative example

Let's assume

- Utility is linear in money: $u(\pounds x) = x$.
- $\delta = 0.999$ per week
- $\beta = 0.7$

This decision maker would rather have £70 now than £100 in 1 week:

$$\underbrace{70}_{u(\pounds 70)} > \underbrace{0.7}_{\beta} * \underbrace{0.999}_{\delta} * \underbrace{100}_{u(\pounds 100)}$$

But they would reject £70 in 52 weeks if they could instead get £70.09 in 53 weeks.

$$\underbrace{0.7}_{\beta} * \underbrace{0.999^{52}}_{\delta^{52}} * 70 < \underbrace{0.7}_{\beta} * \underbrace{0.999^{53}}_{\delta^{53}} * 70.09$$

Quasi-hyperbolic preferences are generally time inconsistent

Suppose I prefer A in period 0 to B in period 1 (i.e., I'm impatient).

$$u(A) > \beta\delta u(B) \implies \frac{uA}{u(B)} > \beta\delta$$

Does that mean I prefer A in period t to B in period $t+1$? Not necessarily:

$$U(A \text{ in } t) = \beta\delta^t u(A)$$
$$U(B \text{ in } t+1) = \beta\delta^{t+1} u(B)$$

I switch to preferring the patient option if

$$\beta\delta^t u(A) < \beta\delta^{t+1} u(B) \implies \frac{u(A)}{u(B)} < \frac{\beta\delta^{t+1}}{\beta\delta^t} = \delta$$

So, I prefer the impatient option now and the patient option later if:

$$\delta > \frac{u(A)}{u(B)} > \beta\delta$$

Outline

Neurological foundations of quasi-hyperbolic discounting

Quasi-hyperbolic discounting in a nutshell

1. Immediate versus Future – heavy discounting, impatient choices
2. Future versus Future – little discounting, patient choices

Maybe Immediate and Future payoffs are processed differently in the brain?

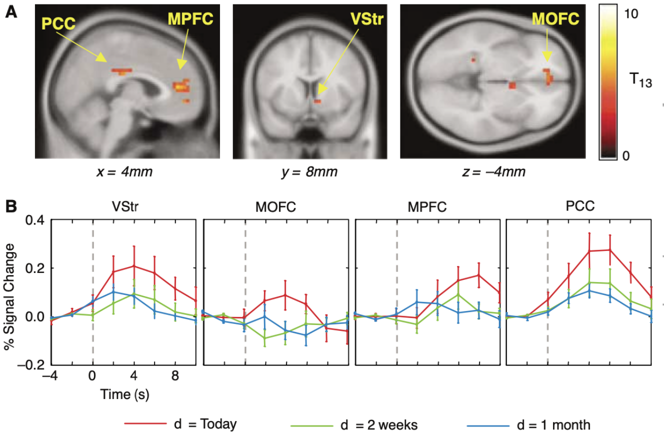
McClure et al (Science, 2004)

- The standard part: each participant makes choices between
  1. Immediate versus Future payoffs
  2. Future versus Future payoffs

- The novel part: participant is in an FMRI scanner
  - Do different types of decision "activate" different parts of the brain?

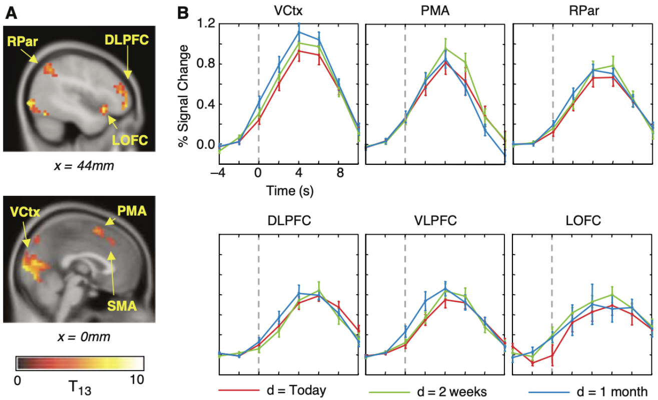
- Caution: interpretation of FMRI data is difficult
  - We observe correlations but causality is tricky. Does the brain activity we observe cause the decision, or does the decision cause the brain activity?
  - Lively debate within economics about usefulness of "neuroeconomics"
  - Risk of false positives especially in older papers

Some brain regions are sensitive to immediate rewards



- Parts of the "limbic system" (associated with the midbrain dopamine system)
- Often associated with reward processing, impulsive behavior

Others activate similarly no matter what the time horizon



- Regions include lateral prefrontal cortex and posterior parietal cortex
- "implicated in higher level deliberative processes and cognitive control, including numerical computation"

McClure et al (Science, 2004)

Interpretation

[the findings] suggest that human behavior is often governed by a competition between **lower level, automatic processes** *that may reflect evolutionary adaptations to particular environments, and the more recently evolved, uniquely human capacity for abstract, domain-general* **reasoning and future planning**.

Time inconsistency creates a self control problem

- I want to make patient choices in the future
  - Go to the gym
  - Stick to the diet
  - Finish my problem sets

- But I know that when the future arrives, I'll switch to preferring impatient choices
  - Skip the gym
  - Binge on potato chips
  - Procrastinate the problem sets

Time inconsistency creates a self control problem

- Some people use **commitment devices** to try to stick to their plans
  - Buy a gym membership so that each visit is “free”
  - Throw away all the tempting foods
  - Join a study group to create social pressure

- Other people seem blissfully unaware of their self control failures
  - Buy the gym membership but never go
  - The diet always starts tomorrow
  - Procrastinate homework until the deadline bites

- (Possible relationship to yesterday’s lecture: they are *overconfident* about their future self control)

The first commitment device

- Odysseus, hero of Homer's Odyssey (8th c. BCE)
- Warned by Circe about the deadly Sirens, whose enchanting song lures sailors to their deaths.
- Odysseus wants to hear the song, but not die.
- Makes the crew plug their ears with wax, and tie him to the mast so he can't interfere with ship's course.

Evidence on commitment

Ashraf, Karlan and Yin (2006) “Tying Odysseus to the mast”

- Field experiment offering a “commitment savings” account in the Philippines.
- Money can’t be withdrawn until a target balance or date is reached.
- 28.4% take up the offer
- Takeup correlated with survey measures of present bias
- Treatment increases savings by 81%

Evidence on commitment

Kaur, Kremer & Mullainathan (2010, 2015)

Clark (1994) theory of the firm: firms exist partly to help their workers overcome a self-control problem (temptation to shirk).

Kaur et al. ask: will workers accept self-disciplining labor contracts?

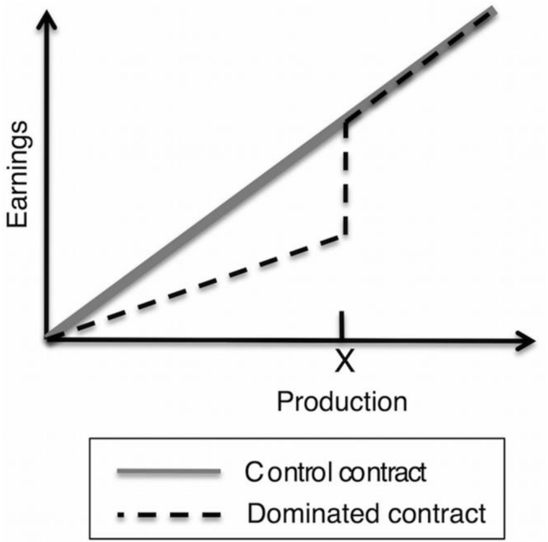
Evidence on commitment

Kaur, Kremer & Mullainathan (2010, 2015)

- Context: full-time data entry workers in India, paid by piece rate.
- Workers randomly offered an alternative contract
  - Set yourself a target.
  - If you exceed the target, paid according to the normal piece rate
  - But if you fall short, paid **half** the normal piece rate.

Evidence on commitment

Kaur, Kremer & Mullainathan (2010, 2015)



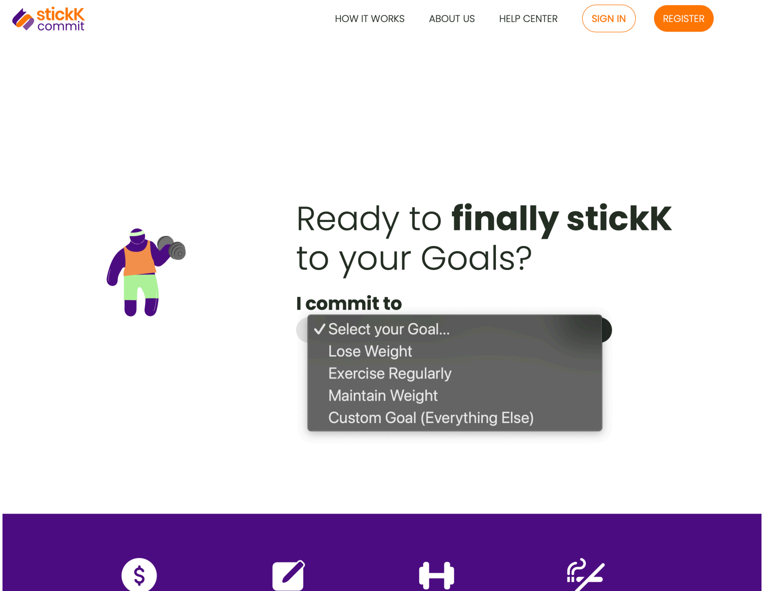
Evidence on commitment

Kaur, Kremer & Mullainathan (2010, 2015)

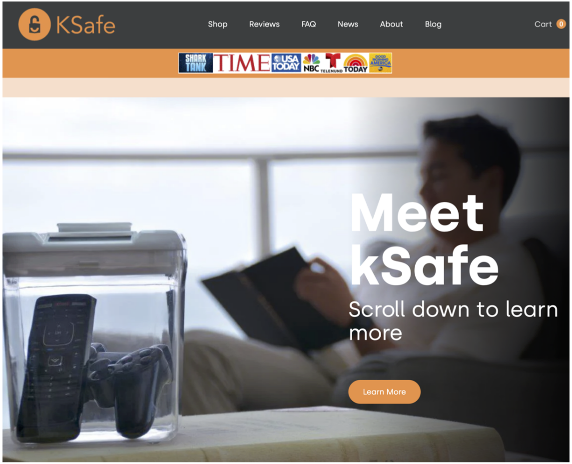
The new contract is **dominated** by the old (it never pays more, sometimes pays less) yet workers accept it 36 percent of the time and increase output by 6 percent.

To achieve the same performance effect via standard incentives requires an 18% increase in the piece rate.

Products and services based on demand for commitment



Products and services based on demand for commitment



A powerful tool to build good habits

Once the timer is set, and the button is pressed,
the safe will remain locked until the timer reaches zero.

No overrides!

Products and services based on demand for commitment

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At Cambridge nearly all of my peers used apps to stop procrastinating online, but smartphones are central to everyday life

Flora Bowen

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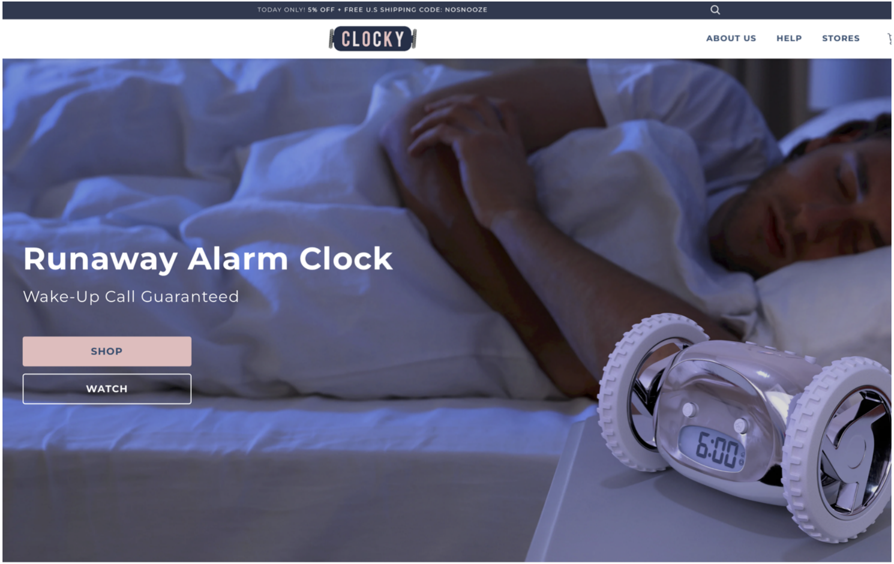
My fingers are itching. Has my friend texted about brunch tomorrow? I have to

Products and services based on demand for commitment



Outline

Doing it now or later

O'Donoghue & Rabin (1999)

O'Donoghue & Rabin's model helps us understand how a $\beta - \delta$ decision maker behaves.

The key distinction in the model is between:

- **sophisticated** people that know they are present biased
- **naive** people, that do not

The structure of the model is similar to the Benabou-Tirole motivated beliefs model we saw yesterday. We'll spend the rest of the lecture unpacking it.

Sophisticates

- A sophisticated agent maximizes:

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

- **but** she knows that next period she will maximize the same function.

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

- She is meta-rational – aware of her own behavioral bias and how it will affect her in the future.

Naifs

- A naive agent maximizes the usual present biased utility function:

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

- **but** she believes that in all future periods she will be time-consistent, maximizing

$$\sum_{\tau=0}^{T} \delta^\tau u(c_{t+\tau})$$

- **Next period, she is surprised to find that her preferences change...**

Solving the model

O'Donoghue & Rabin (1999)

A key difference between naive and sophisticated decision-makers is how they treat delayed costs and benefits.

Setup:

- There are T periods, and an activity (e.g. completing a problem set, eating a cake) that must be completed once.
- If it is not done in $t \leq T - 1$, you must do it in period T.
- We assume $\beta \leq 1$ and $\delta = 1$.

Solving the model

- Some activities (solve problem set) have immediate costs and delayed benefits.
- Some activities (eat cake) have immediate benefits and delayed costs.
- Assume that the delayed cost/benefit occurs in period $T+1$.
  Because $\delta = 1$, it is just discounted by β.

Solving the model

- Just like the chosen-beliefs model from yesterday, we will solve the model by backward induction.
- Model one decision maker for each period t.
- They decide whether to do it in period t, or wait.
- If they wait they have to predict what their future selves will do, and evaluate that according to their period-t preferences.
- From the perspective of the period t self, the payoff from doing it in period τ is:

$$U^t(\tau)$$

Solving the model

Immediate costs

- If you do it in period τ, you immediately pay cost c_τ.
- In period $T+1$, you receive benefit $\bar{v}$.[3]

$$U^t(\tau) = \begin{cases} -c_\tau + \beta\bar{v} & \tau = t \\ -\beta c_\tau + \beta\bar{v} & \tau > t \end{cases}$$

Immediate benefits (problem set)

- If you do it in period τ, you immediately get benefit v_τ.
- In period $T+1$, you pay cost $\bar{c}$.

$$U^t(\tau) = \begin{cases} v_\tau - \beta\bar{c} & \tau = t \\ \beta v_\tau - \beta\bar{c} & \tau > t \end{cases}$$

[3] In the full model, $\bar{v}$ and $\bar{c}$ could depend on τ.

Let's solve the immediate costs case

Let $(c_1, c_2, c_3, c_4) = (3, 5, 8, 13)$. Benefit $\bar{v}$ in period 5.

For example, you need to submit a problem set by Thursday, and your schedule is increasingly busy through the week.

Doing it now or later

O'Donoghue & Rabin (1999)

Let $(c_1, c_2, c_3, c_4) = (3, 5, 8, 13)$. Benefit $\bar{v}$ in period 5.

First, consider a time-consistent agent (TC),

- Defined by $\beta = 1$.
- So $U^t(\tau) = \bar{v} - c_\tau$ for all t, τ.
- No internal conflict of interest, so does the task in period 1 when cost is lowest.

Doing it now or later

O'Donoghue & Rabin (1999)

Let $(c_1, c_2, c_3, c_4) = (3, 5, 8, 13)$. Benefit $\bar{v}$ in period 5.

Now, consider a **sophisticated** agent, with $\beta = .5$.

- From the perspective of period 4, if she does it in period 4, she receives $U^4(4) = .5\bar{v} - 13$.
- From the perspective of period 3, if she does it in period 3, she receives $U^3(3) = .5\bar{v} - 8$. If she waits, she anticipates payoff $U^3(4) = .5\bar{v} - .5 * 13$.
- This is larger than $U^3(3)$, so she prefers to wait.
- From the perspective of period 2, if she does it in period 2, she receives $U^2(2) = .5\bar{v} - 5$. So she thinks "what happens if I wait?"
- Because she is sophisticated, she knows that if she waits she will not do it until period 4.
- Therefore she considers whether $U^2(2) \gtreqless U^2(4)$ i.e. $.5\bar{v} - 5 \gtreqless .5\bar{v} - .5 * 13$. She prefers to do it now.

Doing it now or later

O'Donoghue & Rabin (1999)

Let $(c_1, c_2, c_3, c_4) = (3, 5, 8, 13)$. Benefit $\bar{v}$ in period 5.

- Now, from the perspective of period 1, if she does it in period 1 she receives $U^1(1) = .5\bar{v} - 3$. What if she waits?
- She knows that she will do it in period 2, as we showed above.
- Considering whether $U^1(1) \gtrless U^1(2)$ i.e. $.5\bar{v} - 3 \gtrless .5\bar{v} - .5 * 5$, she decides to do it later.

Summary: she procrastinates in period 1, knowing she will do it in period 2.

Doing it now or later

O'Donoghue & Rabin (1999)

Let $(c_1, c_2, c_3, c_4) = (3, 5, 8, 13)$. Benefit $\bar{v}$ in period 5.

Now, consider a **naive** agent, with $\beta = .5$.

- From the perspective of period 4, if she does it in period 4, she receives $U^4(4) = .5\bar{v} - 13$.
- From the perspective of period 3, if she does it in period 3, she receives $U^3(3) = .5\bar{v} - 8$. If she waits, she anticipates payoff $U^3(4) = .5\bar{v} - .5 * 13$.
- This is larger than $U^3(3)$, so she prefers to wait. Now it gets interesting.
- From the perspective of period 2, if she does it in period 2, she receives $U^2(2) = .5\bar{v} - 5$. So she thinks "what happens if I wait?"
- Because she is naive, she believes that in period 3 and 4 she will act as if $\beta = 1$. **That means she believes she will do it in period 3**, because $\bar{v} - 8 > \bar{v} - 13$.
- Therefore she considers whether $U^2(2) \gtrless U^2(3)$ i.e. $.5\bar{v} - 5 \gtrless .5\bar{v} - .5 * 8$. She decides to do it later.

Doing it now or later

O'Donoghue & Rabin (1999)

Let $(c_1, c_2, c_3, c_4) = (3, 5, 8, 13)$. Benefit $\bar{v}$ in period 5.

- Now, from the perspective of period 1, if she does it in period 1 she receives $U^1(1) = .5\bar{v} - 3$. What if she waits?
- She believes that her future selves will act as if $\beta = 1$. So **she believes she will do it in period 2**, because $\bar{v} - 5 > \bar{v} - 8 > \bar{v} - 13$.
- Considering whether $U^1(1) \gtrless U^1(2)$ i.e. $.5\bar{v} - 3 \gtrless .5\bar{v} - .5 * 5$, she decides to do it later.

Summary: she procrastinates in period 1, expecting to do it in period 2. In period 2, she surprises herself by procrastinating again, and again, eventually doing it in period 4.

Doing it now or later

O'Donoghue & Rabin (1999)

Summary: Sophisticates procrastinate, naifs procrastinate severely.

Proposition (1)

(1) if costs are immediate, naifs do it later than TCs ("procrastination")
(2) if rewards are immediate, naifs do it sooner than TCs ("preproperation")

Doing it now or later

O'Donoghue & Rabin (1999)

Also:

Proposition (2)

Sophisticates always do it sooner than naifs.
i.e. they procrastinate less severely, but preproperate more severely

See problem set for the immediate rewards case

Partial naiveté

O'Donoghue & Rabin (2001)

- O'Donoghue & Rabin (2001) also allow for *partial naiveté*. A partially naive agent believes that in future periods she will maximize

$$U(c) = u(c_t) + \hat{\beta} \sum_{\tau=1}^{T} \delta^{\tau} u(c_{t+\tau})$$

where $\hat{\beta} \in (\beta, 1)$ (boundaries correspond to fully naive/sophisticated alternatives).

Self-awareness

How can we tell whether people are (partially) naive?

- Sophisticates don't make plans they don't expect to carry out.
  - "The majority of smokers say they want to quit, often try to quit, but continuously fail in their quit attempts." (See Bryan et al., 2010 for more)
- Naifs don't demand commitment devices: they don't believe they will need help in the future.
- Partial naifs might underestimate the strength of commitment required, and default on their commitments (Anett John, 2018)
  - Access to commitment devices might actually be harmful
- Also evidence of imperfect learning about self-control (Le Yaouanq and Schwardmann, JEEA)

Wrapping up

- We began by reviewing the standard model – time consistent exponential discounting.
- Introduced the idea of time-inconsistent preferences, particularly the $\beta - \delta$ model.
- Reviewed some evidence.
- Solved a simple model to highlight its properties.

Outline

Example

Alex, Benny, and Claudia are members of the bridal party for an upcoming wedding, and need to book their flight tickets. The wedding will happen in period 5, so they have four periods in which they could buy the ticket (period 1, 2, 3, or 4). If they buy the ticket in period τ, they pay cost c_τ. We will model this decision as an example of "immediate costs" (the cost of buying a ticket). Costs are increasing over time because the price keeps increasing the longer they wait:

$$(c_1, c_2, c_3, c_4) = (50, 60, 80, 130).$$

Assume that the benefit of going to the wedding is fixed and equal to $\bar{v}$.
Recall that for a Beta-delta decision maker (with $\delta = 1$), the utility from the perspective of period t, if the task is done in period τ, is:

$$U^t(\tau) = \begin{cases} \beta\bar{v} - c_\tau, & \text{if } \tau = t \\ \beta\bar{v} - \beta c_\tau, & \text{if } \tau > t \end{cases}$$

Example

$$(c_1, c_2, c_3, c_4) = (50, 60, 80, 130).$$

Q1. Alex is a time-consistent decision maker, so her value of $\beta = 1$. When will she buy the ticket? Show how you arrived at your answer. Can you explain in words why she buys it then?

P4. *Must buy: cost is -130*

P3. *if Alex waits he will buy in P4. So cost is -80 if do it today, -130 if wait. Do it today.*

P2. *if Alex waits he will buy in P3. So cost is -60 if do it today, -80 if wait. Do it today.*

P1. *if Alex waits he will buy in P2. So cost is -50 if do it today, -60 if wait. Do it today.*

Conclusion: Alex always does the task as soon as possible, because costs are increasing and he does not discount the future. This leads him to do it in period 1.

Example

$$(c_1, c_2, c_3, c_4) = (50, 60, 80, 130).$$

Q2. Suppose Benny has $\beta = 0.5$ and is sophisticated. When will he buy the ticket? Show how you arrived at your answer. Can you explain in words why he buys it then?

P4. *Must buy: cost is -130*

P3. *if Benny waits he will buy in P4. So cost is -80 if do it today, -0.5*130 if wait. Decide to wait.*

P2. *if Benny waits he will buy in P4. So cost is -60 if do it today, -0.5*130 if wait. Decide to do it today.*

P1. *if Benny waits he will buy in P2. So cost is -50 if do it today, -0.5*60 if wait. Decide to do wait.*

Therefore Benny procrastinates for one period, knowing that in period 2 he will buy. Because he is sophisticated, this prediction is correct.

Example

$$(c_1, c_2, c_3, c_4) = (50, 60, 80, 130).$$

Q3. Suppose Claudia has $\beta = 0.5$ and is naïve. When will she buy the ticket? Show how you arrived at your answer. Can you explain in words why she buys it then?

- P4. *Must buy: cost is -130. [Same as Benny]*
- P3. *if Claudia waits she will buy in P4. So cost is -80 if do it today, -0.5*130 if wait. Decide to wait. [Same as Benny]*
- P2. *if Claudia waits she believes she will be time consistent tomorrow. TCs always do the task immediately. So, cost is -60 if do it today, -0.5*80 if wait. Decide to wait.*
- P1. *if Claudia waits she believes she will be time consistent tomorrow. TCs always do the task immediately. So, cost is -50 if do it today, -0.5*60 if wait. Decide to wait.*

*Claudia procrastinates every period because she (**wrongly**) predicts her future self will do the task immediately. She ends up waiting until period 4, which is a surprise.*

Example

Q4. The airline knows its customers tend to procrastinate buying their tickets, so it offers a special deal. In period 1, customers can choose to "commit" to buy the ticket in period 3. If they choose to do so, this guarantees that they will buy the ticket in period 3 and guarantees that they will pay a price of 80 in period 3 (i.e., they will no longer have any choice). If they choose not to commit, they just continue as before.
Who will choose the commitment contract?

- *Alex will not commit as TCs don't need commitment. Alex just does the task in period 1.*
- *If Benny chooses the commitment contract, he'll do the task in period 3, paying -0.5*80. If he does not choose the commitment contract, he knows he'll do the task in period 2, paying -0.5*60. So he doesn't choose it.*
- *Claudia* **thinks** *she will buy in period 2, so also turns down the contract. Later, she is surprised to find she does not buy until period 4.*