Time Preferences

Exponential discounting, present bias

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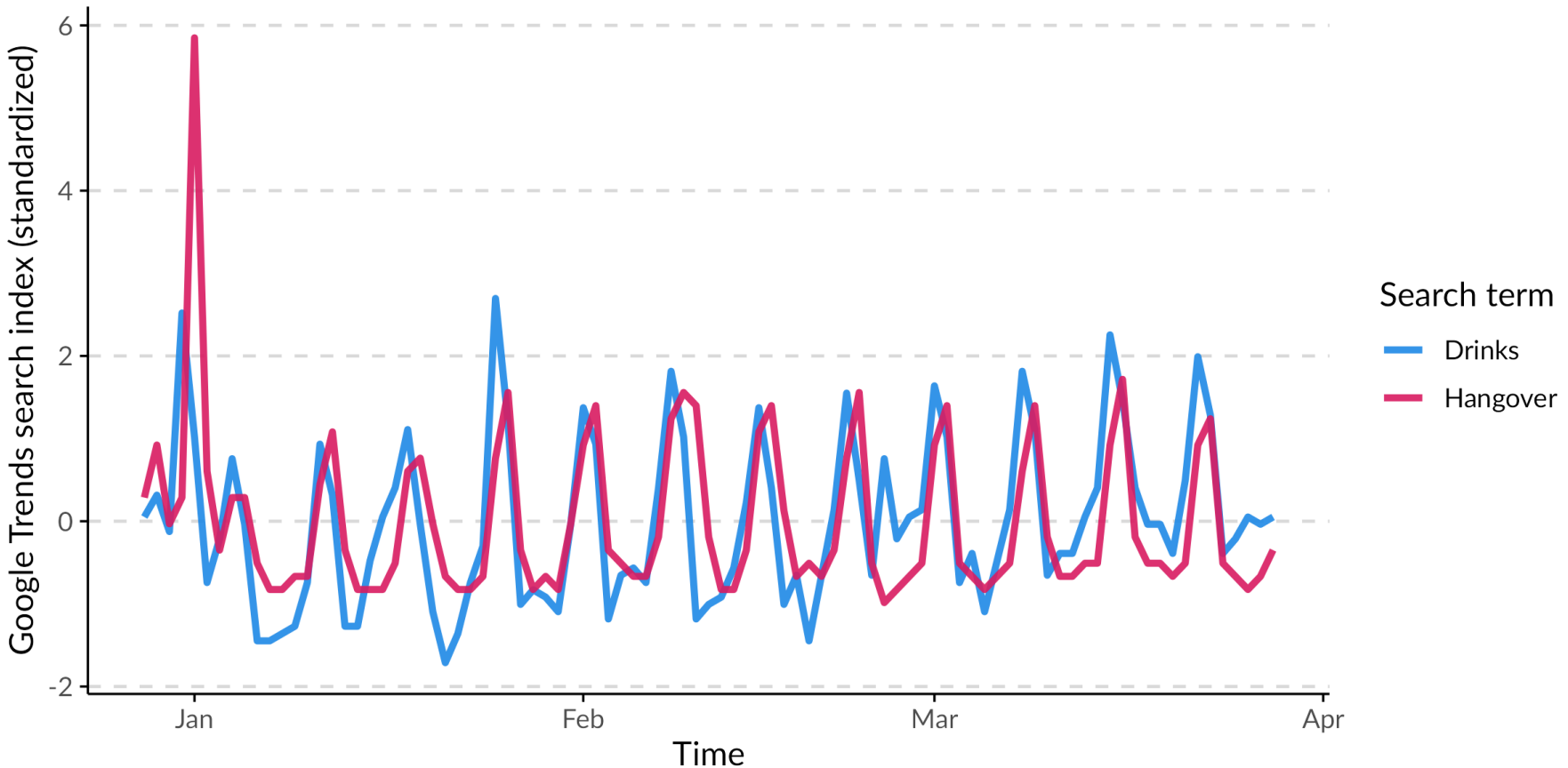
Choice over time

The costs and benefits of decisions often occur at different point in time.

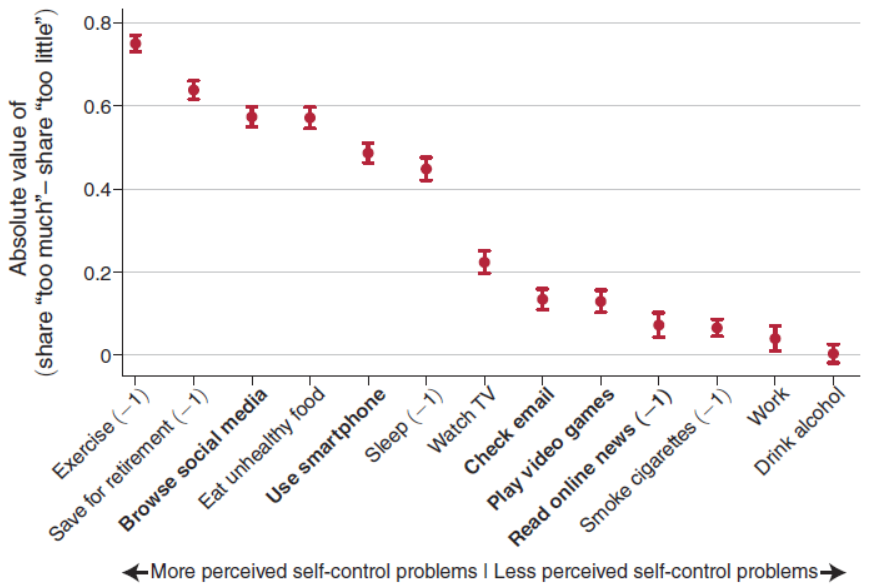
Studying, *exercising*, *investing* today bring future rewards, but present costs.

Borrowing, *sin foods*, *recreational drugs* bring present rewards but future costs.

The distribution of costs and benefits over time is often highly predictable…



…but that doesn't lead to easily navigable decisions



In Allcott et al. (AER, 2022) most students say they *exercise too little, waste time online, eat junk, save too little, etc.*

Formalizing choice over time

Consider an agent with preferences over outcomes $\mathbf{z}$.

We have discrete time periods $t = 0, \ldots, T$.

In every t, the agent receives **instantaneous utility** $u_t = u(z_t)$.

- This results in an overall **utility stream** $\mathbf{u} = (u_0, \ldots, u_T)$.

Preferences at time t: $\succ_t$

Time discounting

We assume that utility is *time-separable*. This implies that we can write utility from the vantage point of t as

$$U_t(u) = \sum_{k=0}^{T-t} D(k) u_{t+k} = D(0) + D(1)u_{t+1} + \cdots + D(T-t)u_T.$$

- Above, $D(k)$ is a **discount factor.**

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Standard economic models use exponential discounting. An arbitrary choice?

> *"It is completely arbitrary to assume that the individual behaves as to maximize an integral envisaged in [the exponential discounting model]"* — Paul Samuelson (1937), in the article introducing the concept.

A better (?) reason for exponential discounting

Suppose we believe that human behavior is time-consistent. By this, we mean that individuals carry through with their plans.

> For all t and $\tau > t$ an agent is **time-consistent** if
> $\boldsymbol{z} \succ_t \boldsymbol{z}' \iff \boldsymbol{z} \succ_\tau \boldsymbol{z}'$
> whenever $\boldsymbol{z}_t = \boldsymbol{z}'_t$ for $t < \tau$.

Time-consistency: Example

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Consider the outcome vectors $\boldsymbol{z} = (\text{relax}, \text{gym})$ and $\boldsymbol{z}' = (\text{relax}, \text{relax})$.

Time consistency says that if

- today, I prefer going to the gym tomorrow ($\boldsymbol{z} \succ_0 \boldsymbol{z}'$),
- then, tomorrow, I will still prefer going to the gym ($\boldsymbol{z} \succ_1 \boldsymbol{z}'$)

Exponential Discounting implies time consistency (and vice versa)

Proposition. An agent with utility function $U_t(u) = \sum_{k=0}^{T-t} D(k) u_{t+k}$ is time-consistent if and only if the discount function is exponential.

(proof on board)

Therefore, if time consistency is important to us, we should assume exponential discounting.

Conversely, if we do not believe that humans are time-consistent, we should not assume exponential discounting.

Testing for time consistency?

Early evidence – Thaler (EL, 1980)

Thaler asks participants the following question:

> How much would you require in `[one month / one year / ten years]` to make you indifferent to receiving $15 now?

	1 mo	**1 yr**	**10 yrs**
Median answer	$20	$50	$100
Implied monthly δ	.75	.90	.98

- δ depends on the time horizon → violates ED.
- People demand a big premium to delay by *one* month, smaller extra premium for later delays.

The β-δ model (Present Bias)

$$U_t^{\beta,\delta}(\mathbf{u}) = u_t + \beta \sum_{k=1}^{T-t} \delta^k u_{t+k}, \qquad 0 < \beta \leq 1.$$

- δ : standard exponential discount factor
- $\beta < 1$: **present bias** – all future periods are devalued by a common factor

With $\beta = 0.8$ Thaler's answers give roughly **constant** $\delta \approx .94$.

Problems with Thaler (EL, 1980)

Thaler's experiment did not use real incentives. Thus, the answers may not have been chosen carefully.

For example, the implied discount rate is high.

- At such high δ, study participants should borrow generously by taking on consumer credit, more than people usually do.

But incentivizing may be difficult.

- Logistics of paying someone in 10 years.
- Hassle costs for participants if they have to return to the lab for cash payments...

Stationarity vs. Present Bias

Modern tests of time discounting often test for stationarity. Denote an option generating outcome z in t as (z, t) . Then:

> **Stationarity**: $\succ$ depends only on *delay difference*, not on calendar date
>
> $$(z, t+\Delta_1) \sim_t (z', t+\Delta_2) \implies (z, t'+\Delta_1) \sim_{t'} (z', t'+\Delta_2),$$
>
> for $\Delta_1, \Delta_2 > 0$.

- ED ⇒ stationarity.

Stationarity vs. Present Bias

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- **Present bias** breaks stationarity: “X€ now vs. Y€ in a week” ≠ “X€ tomorrow vs. Y€ in eight days”.

Andreoni and Sprenger (AER, 2012): Convex Time-Budget (CTB) experiment

A&S provide a comprehensive empirical description of choice over time.

Participants have to allocate a budget of 100 tokens between two dates (e.g., today or in 10 weeks).

- These tokens will be converted to dollars and paid out (incentives).
- The exchange rates may differ between two dates → trace demand curves.

Andreoni and Sprenger (AER, 2012): Convex Time-Budget (CTB) experiment

They include a host of measures to convince participants that:

- They will be paid at the specified date.
- There are no hassle costs involved with delayed payments.
  - Payments are delivered by a mailed check, even today's.

A&S: Decision screen

University of California San Diego, Economics Department

Decision

January 2009						
			1	2	3	
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

February 2009						
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

March 2009						
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

April 2009						
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

May 2009						
				1	2	
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

June 2009						
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

July 2009						
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

August 2009						
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

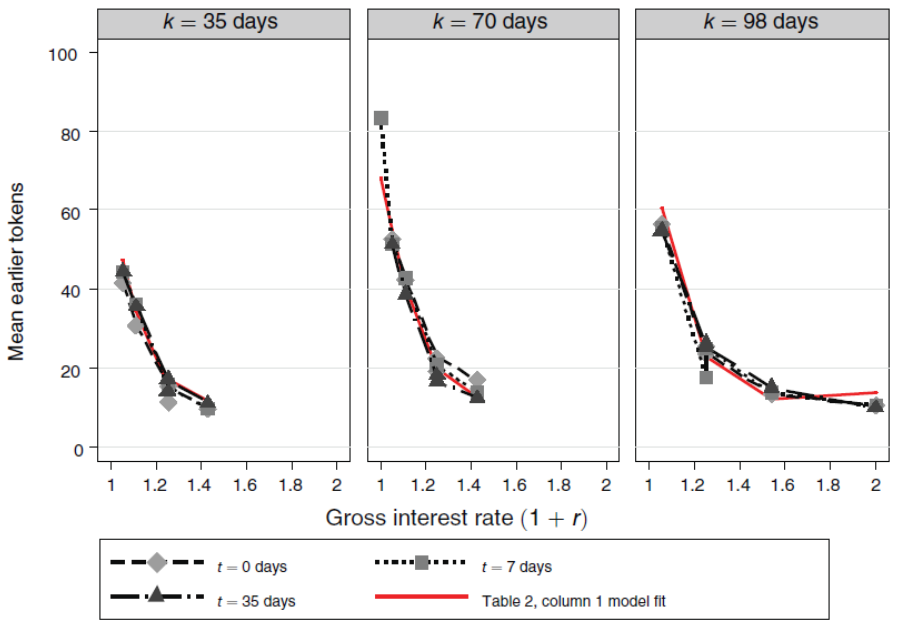
Please, be sure to complete the decisions behind each group-size tab before clicking submit.
You can make your decisions in any order, and can always revise your decisions before submitting them.

January 21, February 25 | January 21, April 1 | January 21, April 29 | January 28, March 4 | **January 28, April 8** ▶

	Divide Tokens between January 28 (1 week(s) from today), and April 8 (10 week(s) later)						January 28	April 8
1	Allocate 100 tokens:	83	tokens at $0.20 on January 28, and	17	tokens at $0.20 on April 8		$16.60	$3.40
2	Allocate 100 tokens:	51	tokens at $0.19 on January 28, and	49	tokens at $0.20 on April 8		$9.69	$9.80
3	Allocate 100 tokens:	43	tokens at $0.18 on January 28, and	57	tokens at $0.20 on April 8		$7.74	$11.40
4	Allocate 100 tokens:	21	tokens at $0.16 on January 28, and	79	tokens at $0.20 on April 8		$3.36	$15.80
5	Allocate 100 tokens:	14	tokens at $0.14 on January 28, and	86	tokens at $0.20 on April 8		$1.96	$17.20

Submit Decisions <--Clicking this button will submit ALL your decisions behind every tab

A&S: Choices over time are stationary



- Allocations between t and $t+k$ do not depend on t $\Rightarrow$ they are **stationary**.
- Estimated $\beta \approx 1$, annual $\delta \approx .7$.

What gives?

The experiment of A&S seems like a resounding success of the exponential discounting model. It can fit the data extremely well.

Maybe A&S overcontrolled for potential confounds:

- Participants did not receive any immediate payment, even today's earnings were delivered by mail to their postbox.
- Thus there may still be scope for present bias not between today vs. future but between *right now* vs. later.

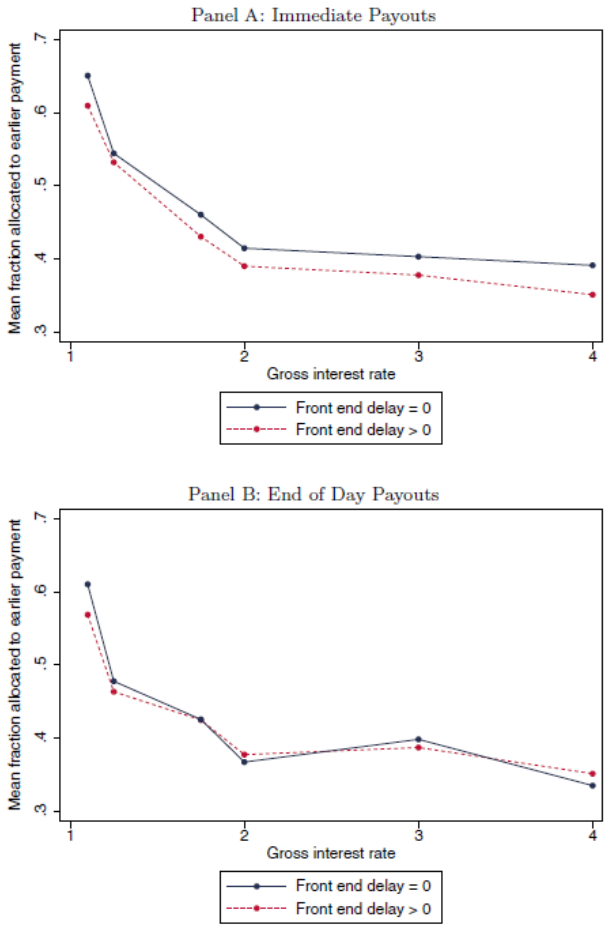
How soon is now?

Balakrishnan, Haushofer, Jakiela (ExpEcon, 2020) conduct a CTB experiment where they vary the “now” payout.

All participants receive money via mobile payment.

They either pay the “now” payout immediately or at the end of the day.

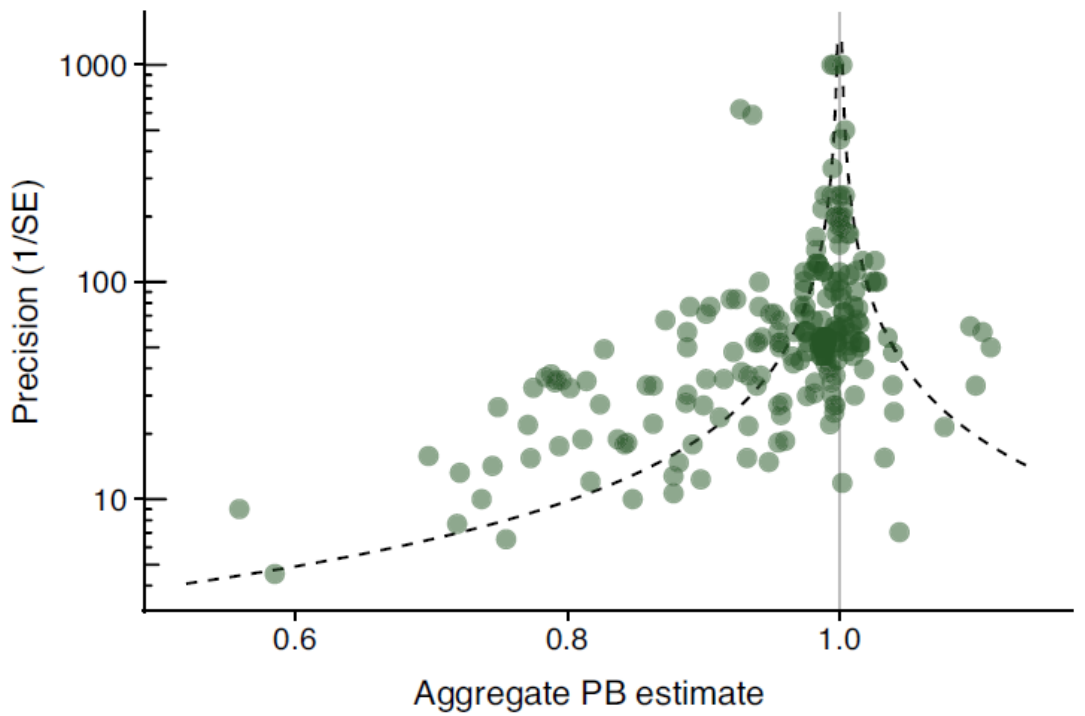
BHJ (2020): Now is not this evening



- Today-payment **immediate** $\Rightarrow \beta \approx 0.91.$
- Today-payment **this evening** $\Rightarrow \beta \approx 1.$
- Suggests that present bias is about *right now* vs. *later*, not today vs. tomorrow.

Meta-analysis of CTB studies

Imai, Rutter, Camerer (EJ, 2021) provide a **meta study** of CBT experiments. Each dot below is a β-estimate coming from a separate study.



IRC: Findings

In experiments following A&S (allocate money over time, get today's payment this evening), $\beta \approx 1.$

In experiments where participants have to work during experimental sessions and can allocate how much to work at different points in time, $\beta \approx 0.88$ $\rightarrow$ people postpone work.

- This coheres well with BHJ, as participants usually conduct today's work directly after making the allocation choice.
- Therefore, the decision over work is also a decision about *right now* vs. *later*.

Back to the $\beta - \delta$ model

The $\beta - \delta$ model can describe intertemporal choice rather well, if the "now" period is sufficiently narrowly defined.

A question coming out of this model is whether agents are aware of their bias.

Example: Smoking

Consider an agent who considers whether to smoke or not. The agent is present biased ($\beta < 1$). For simplicity, assume that $\delta = 1$.

Smoking gives the agent an immediate consumption joy j but carries some cost c in a future time period.

Suppose that $c > j > \beta c$.

- The agent prefers smoking right now over not smoking ($j > \beta c$).
- But the agent prefers to quit smoking later ($c > j$).

Example: Smoking

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- The agent prefers smoking right now over not smoking ($j > \beta c$).
- But the agent prefers to quit smoking later ($c > j$).

If the agent is aware of their bias, they might try to stop themselves from smoking later: go to rehab, do not buy tobacco, etc.

If the agent is unaware, they will naively expect to quit smoking.

- Because of this, they *underinvest* in mitigation.

Sophistication in the $\beta - \delta$ model

The example illustrates how **sophistication** about present bias plays a key role for the welfare implications of the $\beta - \delta$ model.

If individuals are aware of their bias, they might get proactive to stop them from being short-sighted:

- Avoid restaurants with “tempting” menu options.
- Install screen time blockers on their phone.
- ...

Sophistication in the $\beta - \delta$ model

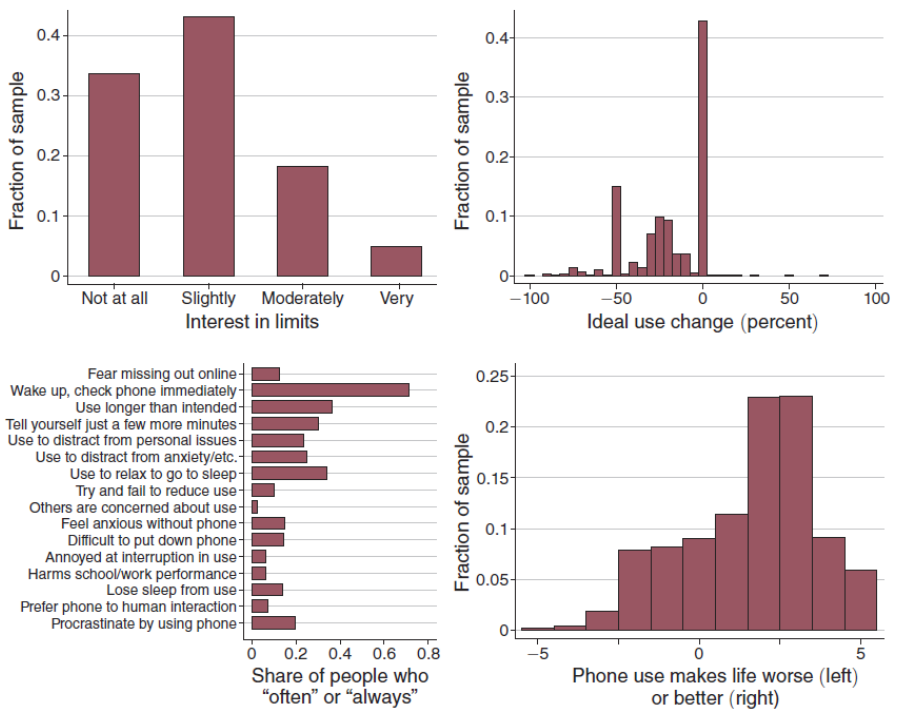
The example illustrates how **sophistication** about present bias plays a key role for the welfare implications of the $\beta - \delta$ model.

If they fully or partially neglect their bias, private initiative will not be enough.

- This then motivates various corrective taxes on alcohol, soda, cigarettes, etc.
- It calls for regulation of "addictive" social media algorithms.
- Public programs to improve sleep hygiene.

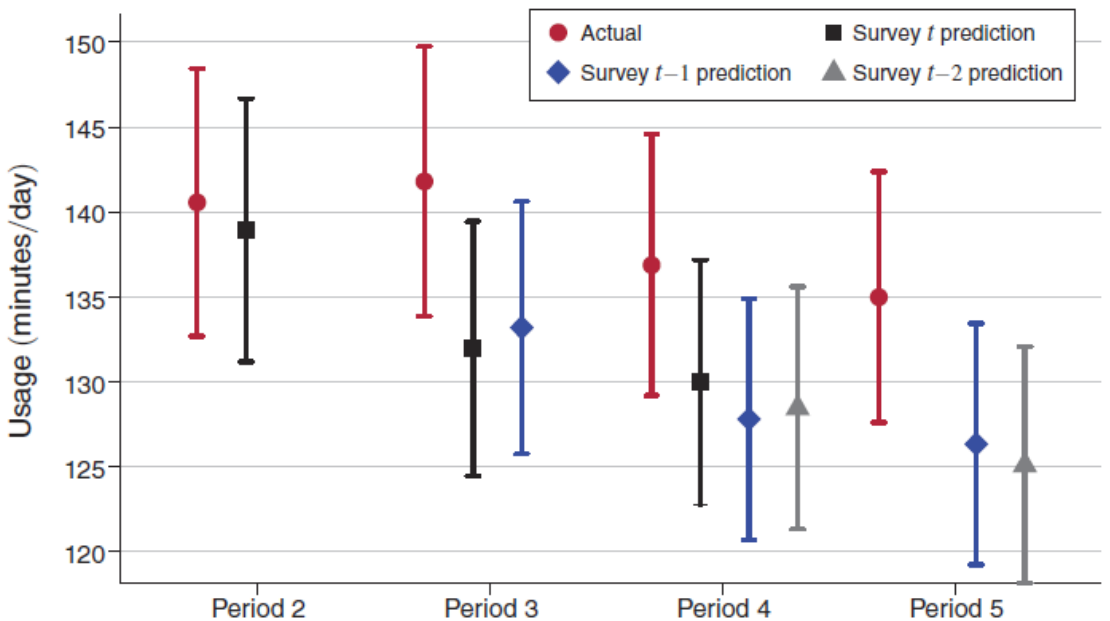
Empirical evidence on sophistication

Alcott, Gentzkow, Song (AER 2022) document that individuals would like to limit their social media use, so they are generally aware of the problem.



Empirical evidence on sophistication

But individuals systematically underestimate their future use. This points to only partial sophistication.



Takeaways

In dynamic decisions, humans disproportionately prefer the right now to the later.

- This causes **dynamic inconsistency.**
- A model combining exponential discounting with a **present bias** factor ($\beta - \delta$ model) can describe empirical data well.
  - But only if the “now” period in the model means “right now”, not “today” or “this week”.

The $\beta - \delta$ model raises questions about sophistication.

- Humans are only partially sophisticated.