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Cognitive mechanisms of the defer-speedup and date-delay framing effects in intertemporal choice

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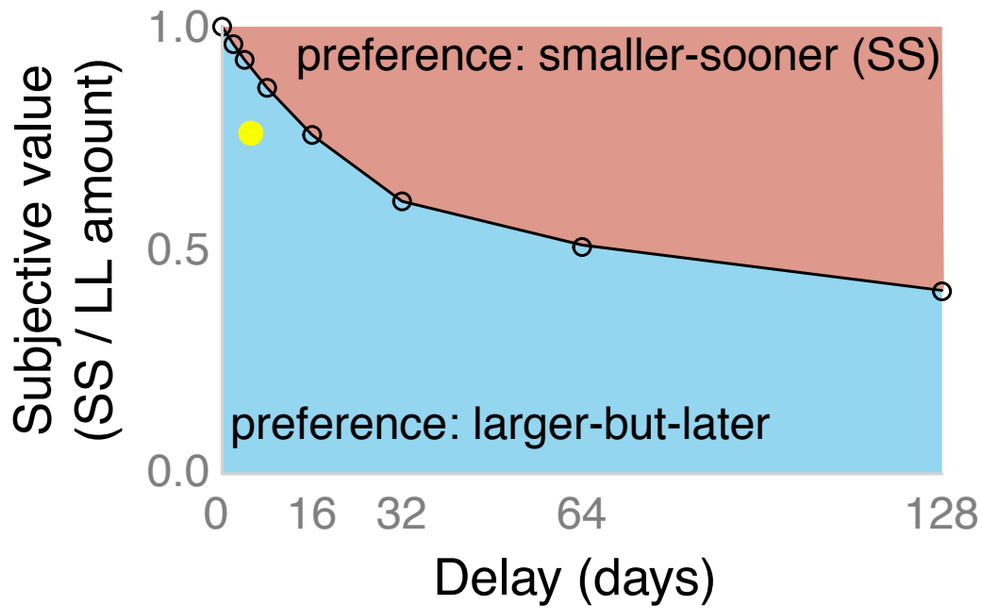
Time framing matters in intertemporal choice

Intertemporal choice

Subjective value of rewards declines with delay



€30 now vs. €40 in 2 d

€30 now vs. €40 in 64 d

€20 now ≈ €40 in 64 d

€30 now ≈ €40 in 16 d

Time framing shifts preferences: defer-speedup and date-delay effects

(neutral) delay frame

Choose between:

€21.76 today ≈ €43.52 in 32 days

defer frame

You are scheduled to receive €21.76 today.
Choose between:

As planned: €21.76 today

Defer: €43.52 in 32 days

speedup frame

You are scheduled to receive €43.52 in 32 days.
Choose between:

Speedup: €21.76 today

As planned: €43.52 in 32 days

delay frame

Choose between:

€21.76 today ≈ €43.52 in 32 days

date frame

Choose between:

€21.76 September 27, 2018

€43.52 October 29, 2018

What cognitive mechanism explains time framing effects?

Hypotheses

	Framing influences outcome valuation	Framing influences time perception
Defer-speedup effect	Adaptation to expected outcome Loewenstein & Prelec, *Q J Econ*, 1992; Scholten & Read, *J Exp Psychol LMC* 2013	Adaptation to expected timing Scholten & Read, *J Exp Psychol LMC*, 2013
Date-delay effect	Outcomes are assigned greater value for dates (precise) than delays (vague) Read et al., *Manag Sci*, 2005; Dshemuchadse et al., J Exp Psychol Gen, 2013	Date intervals appear shorter than delay intervals Read et al., *Manag Sci*, 2005; Zauberman et al., *J Mark Res*, 2009

Aim

To test whether defer-speedup and date-delay framing effects can be explained in terms of outcome valuation, time perception, or both, using computational modeling of choices and response times

Modeling intertemporal choice and framing effects

model architecture

inputs €21.76 €43.52 0 d 32 d

step 1
outcome valuation
and
time perception

$u(v_s)$ $u(v_L)$ $p(t_s)$ $p(t_L)$

-1 1 -1 1

Δu Δp

step 2
comparison of weighted
differences in utility
and perceived time

w -(1-w)

d

step 3
decision-making by
accumulation of noisy
preferences

1

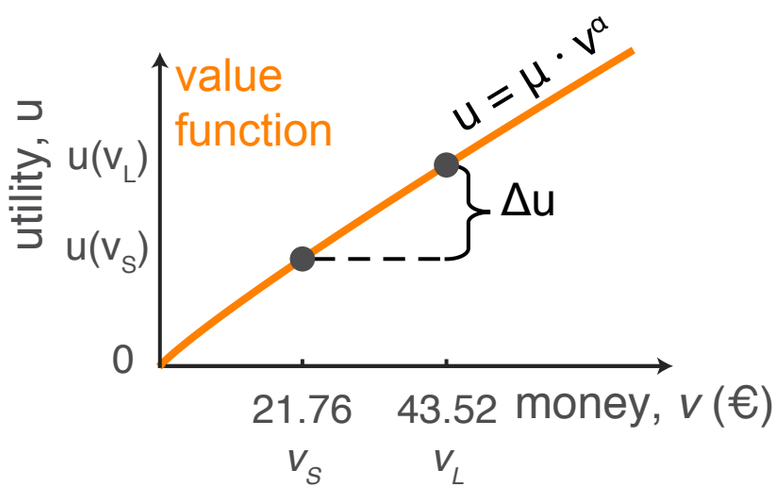
$$d = w\Delta u - (1-w)\Delta p$$

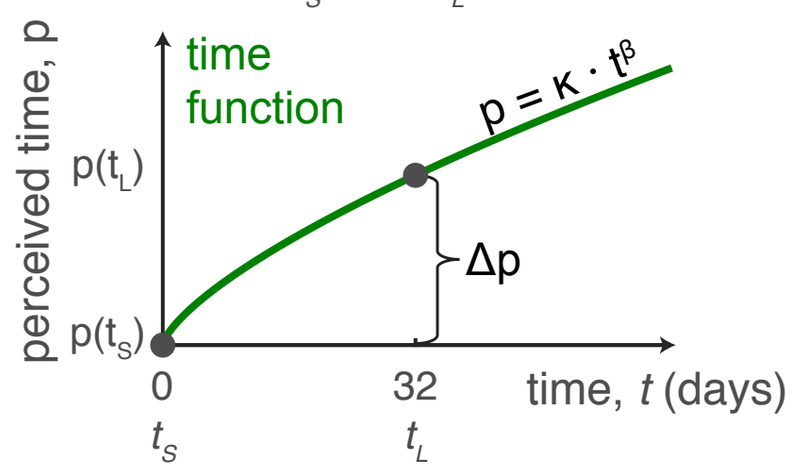
pref

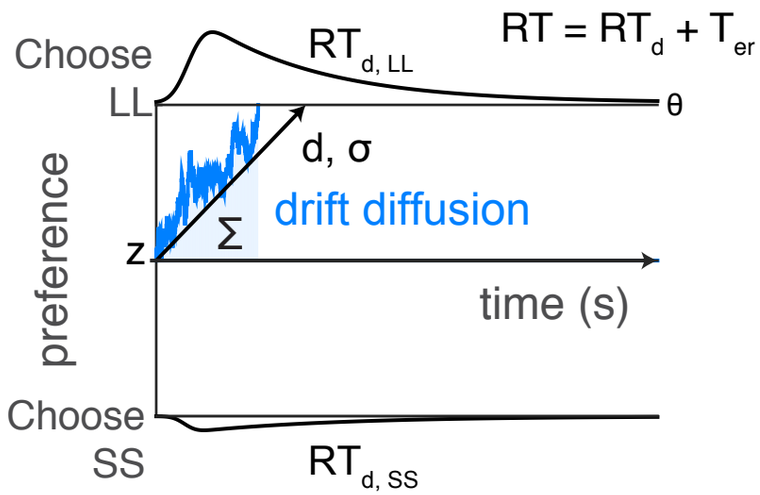
choice, RT_d

outputs

model dynamics



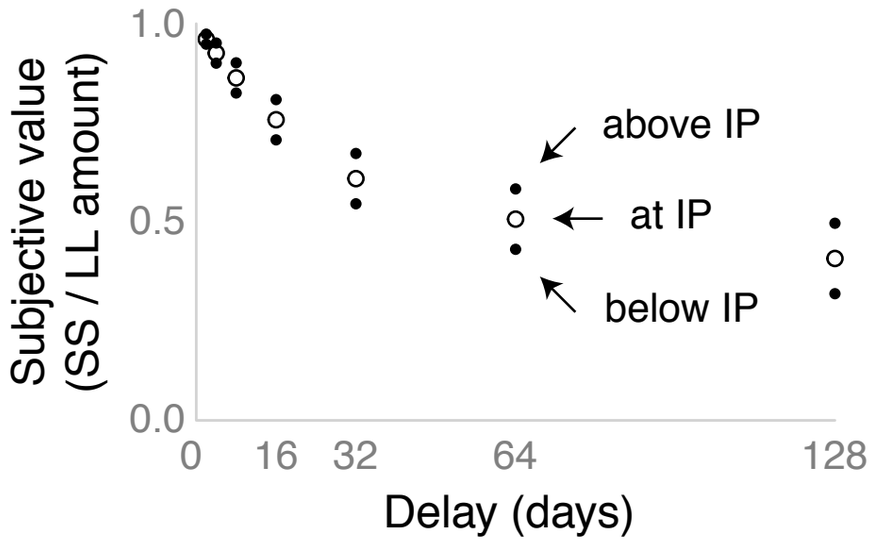




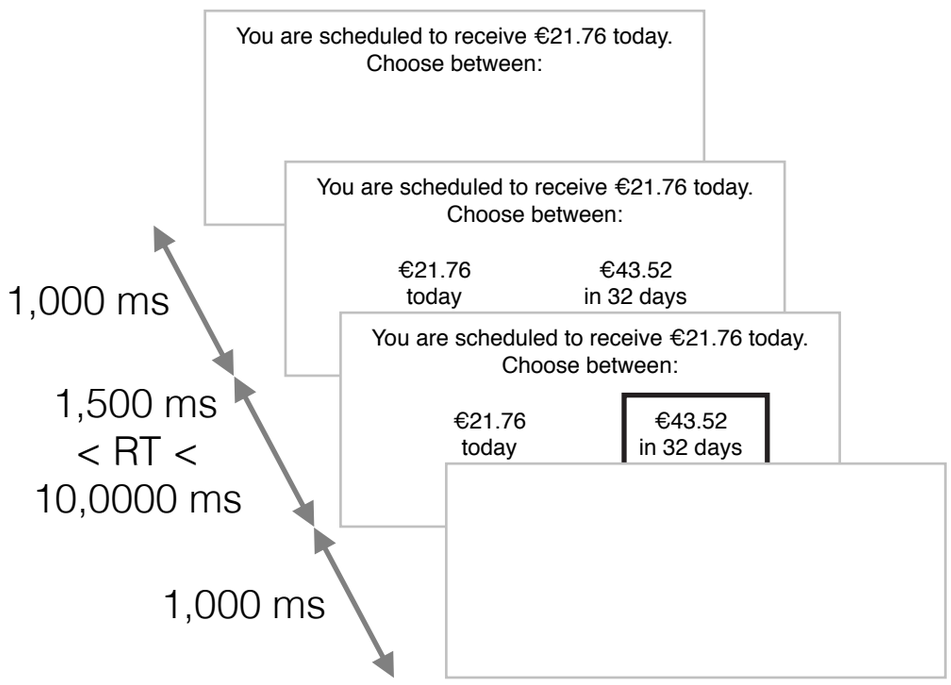
Scholten & Read, *Psych Rev*, 2010; Scholten & Read, *J Exp Psychol Learn Mem Cogn*, 2013; Dai & Busemeyer, *J Exp Psychol Gen*, 2014

Intertemporal choice tasks and procedure

SS amounts are based on IPs



Trial timings



Calibration task: determine indifference points (IPs)

- Motivation: framing effects largest around IPs

Defer-speedup & date-delay tasks: data for modeling

- Fixed variables:
  - SS delay (0 days),
  - LL amount (€43.52)
- Manipulated variables:
  - Frame (defer, speedup, neutral / date, delay)
  - LL delay (2, 4, 8, 16, 32, 64, 128 days)
  - SS amount (above, at, below IP)

4 x

- Number of trials:
  - Defer/speedup: 276 trials (9% catch), 45 min. total
  - Date/delay: 184 trials (9% catch), 30 min. total

Sample size estimation: max. 120 hrs of lab time

- Model recovery: 94% accuracy with 4 repetitions
- Bayes factor design analysis: N_{max} = 96 per task (incl. 20% dropout), based on $\delta = 0.55$. N_{mean} = 30.

Koffarnus et al., *J Exp Anal Behav*, 2013

Computational modeling & control analyses

Models to be tested

- Core models
  - outcome valuation model: μ varies between frames
  - time perception model: κ varies between frames
  - combination model: μ and κ vary between frames

Model fitting approach

- Outcome measures: choices & response times
- Algorithm: constrained differential evolution
- Cost function: negative log-likelihood
- Model comparison: Bayesian Information Criterion
- Visualization: observed & predicted choice probabilities and response time distributions

Control analyses

- Task compliance & comprehension: accuracy on catch trials and instruction manipulation check trials (>75%)
- Replication of framing effects: one-sided Bayesian paired t-test of area under the curve

Relevance and impact

How the outcomes are relevant to the central issue

- Computational modeling results:
  - will identify whether time framing in intertemporal choice alters outcome valuation, time perception, or both.
- Control analyses:
  - will verify that modeling analysis provides a fair test of the research question

Broader impact

- The results may:
  - further our understanding of contextual effects in decision-making
  - inspire new models of decision-making
  - inspire new ‘nudging’ strategies (e.g. taking advantage of time perception)
- The open materials, code and data:
  - enable others to build on this work (e.g. re-use of task & model, re-analysis of the data)