Professorship for Economics
TUMCS for Biotechnology and Sustainability & TUM School of Management
Technical University of Munich

Decisions under Uncertainty from Description & Experience

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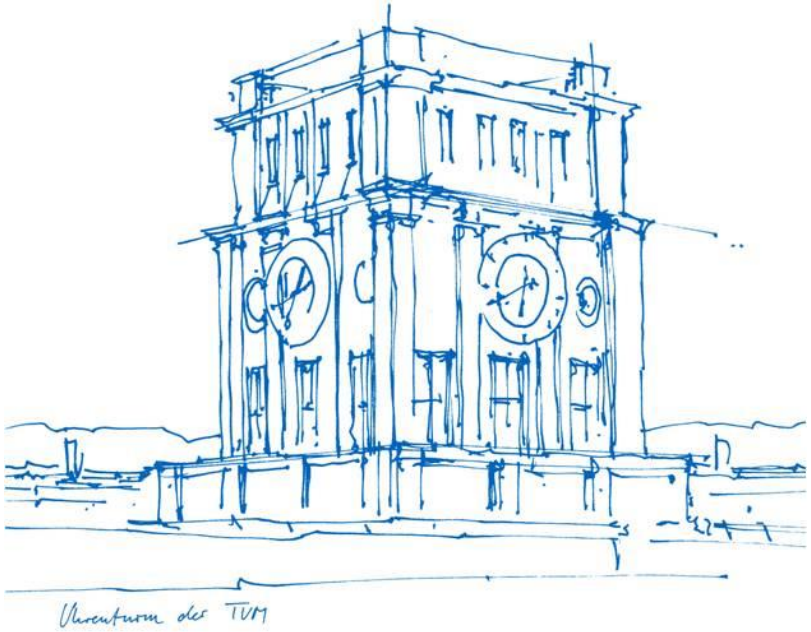
Summer 2020/21



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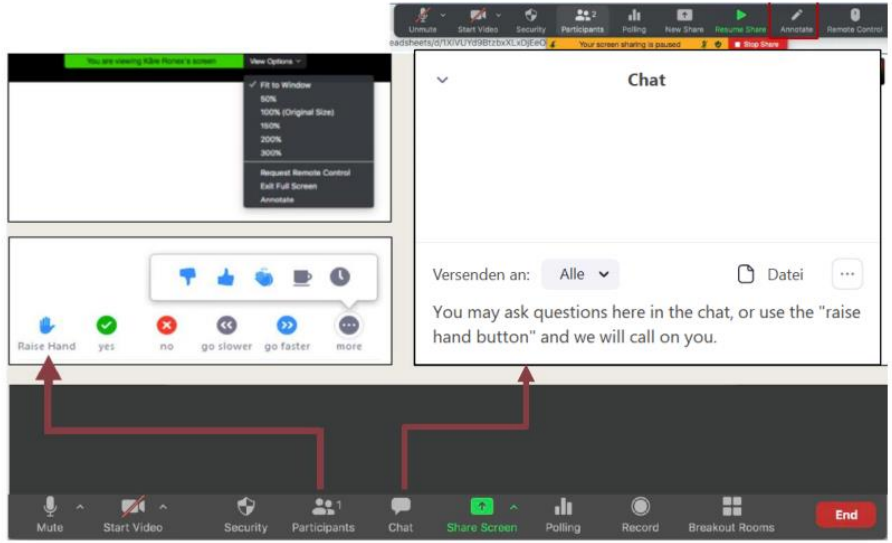
- Turn your camera on
- Mute your microphone when not speaking
- Use the „raise hand“ function
- Do not multi-task and avoid distractions

Zoom Functions



About Me

Dr. Orestis Kopsacheilis (just call me Orestis)

Postdoctoral Researcher

Research interests

- Behavioral and Experimental Economics
- Decisions under uncertainty
- Behavior in social dilemmas

More info: https://kopsacheilis.com/

Contact: Orestis.Kopsacheilis@tum.de

About You

Introduce yourself briefly to the cohort

My name is…
I am from
I studied… during my undergraduate studies and now do a Master's in…
In my thesis I plan to focus on…

Recording Starts

- No need to turn off your cameras – the participants' screen will be hidden from the upload

Today’s agenda

I. Overview of Seminar Topics and organizational Issues
II. Introduction to Decisions under Risk and Uncertainty
III. An overview of research in the Description – Experience gap

Goal of Presentation & Seminar Paper

- Pick a topic of interest (see following slides)
- Identify your Research Question(s) related to this topic
  - See examples of research questions throughout lecture notes in red. Example:
    - ***Q. What other factors may be driving the Description – Experience gap?***
- Conduct a literature review on the topics that relate to this research question
- Formulate your hypotheses and identify ways to test it
  - If your investigation is theoretical, develop a model (or extend an existing one)
  - If your approach is empirical:
    - Either identify an existing data-set that you can use or
    - Design an experiment that can test your hypotheses
      - due to lab-restrictions this period, experiments (surveys) will be online

Topics and relevant literature

A	**Complexity**		
	Iyengar, S. S., & Kamenica, E. (2010). Choice proliferation, simplicity seeking, and asset allocation. Journal of Public Economics, 94(7-8), 530-539.	Zilker, V., Hertwig, R., & Pachur, T. (2020). Age differences in risk attitude are shaped by option complexity. *Journal of Experimental Psychology: General*, *149*(9), 1644.	Glöckner, A., Hilbig, B. E., Henninger, F., & Fiedler, S. (2016). The reversed description-experience gap: Disentangling sources of presentation format effects in risky choice. *Journal of Experimental Psychology: General*, *145*(4), 486.
B	**Search**		
	Iyengar, S. S., Wells, R. E., & Schwartz, B. (2006). Doing better but feeling worse: Looking for the "best" job undermines satisfaction. *Psychological Science*, *17*(2), 143–150.	Sonnemans, J. (1998). Strategies of search. *Journal of economic behavior & organization*, *35*(3), 309-332.	Hertwig, R., & Pleskac, T. J. (2010). Decisions from experience: Why small samples?. *Cognition*, *115*(2), 225-237
C	**Belief updating**		
	Taber, C. S., & Lodge, M. (2006). Motivated skepticism in the evaluation of political beliefs. *American journal of political science*, *50*(3), 755-769.	Golman, R., Hagmann, D., & Loewenstein, G. (2017). Information avoidance. *Journal of Economic Literature*, *55*(1), 96-135.	Aydogan, I. (2021). Prior Beliefs and Ambiguity Attitudes in Decision from Experience. *Management Science*.
D	**Heuristics and biases**		
	Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), 1124-1131.	Gigerenzer, G. (1991). How to make cognitive illusions disappear: Beyond "heuristics and biases". *European review of social psychology*, *2*(1), 83-115.	Hau, R., Pleskac, T. J., & Hertwig, R. (2010). Decisions from experience and statistical probabilities: Why they trigger different choices than a priori probabilities. *Journal of Behavioral Decision Making*, *23*(1), 48-68.
E	**Individual vs. social uncertainty**		
	Bohnet, I., Greig, F., Herrmann, B., & Zeckhauser, R. (2008). Betrayal aversion: Evidence from brazil, china, oman, switzerland, turkey, and the united states. *American Economic Review*, *98*(1), 294-310.	Fetchenhauer, D., & Dunning, D. (2012). Betrayal aversion versus principled trustfulness—How to explain risk avoidance and risky choices in trust games. *Journal of Economic Behavior & Organization*, *81*(2), 534-541.	Isler, O., Kopsacheilis, O., & van Dolder, D. (2020). The description–experience gap in cooperation. *Manuscript in preparation*.
F	**Time Pressure**		
	Roth, A. E., & Ockenfels, A. (2002). Last-minute bidding and the rules for ending second-price auctions: Evidence from eBay and Amazon auctions on the Internet. *American economic review*, *92*(4), 1093-1103.	Kocher, M. G., Pahlke, J., & Trautmann, S. T. (2013). Tempus fugit: time pressure in risky decisions. *Management Science*, *59*(10), 2380-2391.	Madan, C. R., Spetch, M. L., & Ludvig, E. A. (2015). Rapid makes risky: Time pressure increases risk seeking in decisions from experience. *Journal of Cognitive Psychology*, *27*(8), 921-928.

Topic allocation

- The objective is to form small groups of 2
- Learning how to work and conduct research in a team is very valuable
- I will post on Moodle a list of topics on Thursday the 22nd of April.
- You will then vote on your topic of preference from this list.
- Each student has one vote and each topic can receive at most two votes (one for each group member)

Dates and Deadlines

16th April 2021, 11 A.M	Kick-off lecture
16th April 2021 – 23rd April 2021	Topic allocation & group formation
23rd April 2021– 23rd May 2021	Individual meetings with lecturer
24th May 2021	Send in presentation slides by mail to: Orestis.Kopsacheilis@tum.de
Friday 28th May 2021, 10 A.M. – 3 P.M	Seminar presentations (on-line presentations)
21st of July	Submission of seminar paper (one PDF per group) via Moodle upload

Task 1: Presentation

- 1/3 of final grade
- 20 minutes per person/group
  - If in group: presentation time should be approximately equal
- Group discussion after each presentation for 15 minutes
- Format:
  - Powerpoint or PDF
  - Clear, understandable and legible slides
  - TUM templates can be found here (not mandatory): link

See also “**Guidelines for presentations**” on Moodle

Task 2: Seminar Paper

- 2/3 of final grade
- Page Limit/ Word Count: ~6000 words or less (independent of single or group work)
- Format:
  - Main text: Font sze: 12 pt (e.g. Arial), Line spacing: 1.5, Typographic alignment: justified
  - Footnotes: Font size: 10pt, Line spacing: 1.0, Typographic alignment: justified
  - Margins: 3cm, left/top/bottom: 2.5cm

See also “**Guidelines for seminar paper**” on Moodle

II. Decisions under Uncertainty (Description)

The Standard Economics account

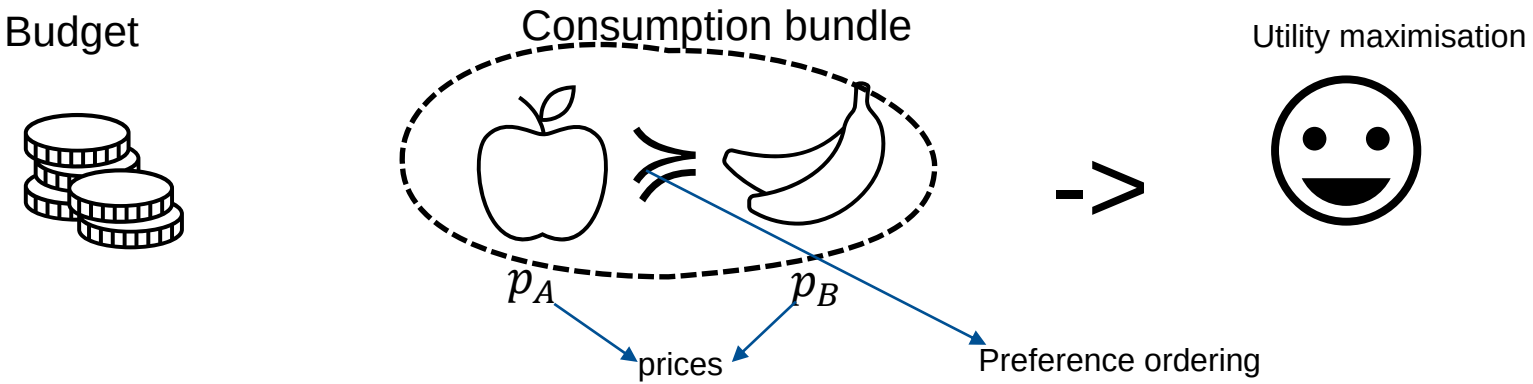
- Preliminaries (notation and how to set up the problem)
- Expected Value and Expected Utility Theory
- Risk aversion
- Limitations of Expected Utility Theory (Allais' Common Ratio effect)

Prospect Theory: a behavioral approach to decisions under uncertainty

- Introduction to Behavioral Economics and Prospect Theory
- Probability Weighting

Decisions under certainty

Given a budget and prices what combination of goods makes a consumer the happiest?
Everything is known and there is no uncertainty about how actions lead to outcomes



But.. Uncertainty pervades our decisions

Should I buy a brand new phone (safe but expensive) or a second hand one (risky but saves money)?

Should I buy an extended warranty or will the phone prove robust?

Should I schedule a hike trip in the weekend or will it rain?

Our decisions are almost always involving some degree of uncertainty

In this lecture we introduce some tools that will help us tame it

A simple case study

- Every day he has to decide which product to sell the next day.
- His earnings depend on the next day's weather. In a rainy day, he earns more if he sells umbrellas. In a sunny day he earns more if he sells hats.
- The decision has to be made the previous day, so there is uncertainty regarding the weather.
- ***What should the vendor do?***

Step 1: Express the problem in matrix form

Net profits obtained from merchandise, depending on weather

	Sunny	Rain
Sell Umbrellas	$36	$81
Sell Hats	$144	$0

Street vendors payoff table

- Net profits obtained from merchandise, depending on weather

	Sunny	Rain
Sell Umbrellas	$36	$81
Sell Hats	$144	$0

- **Question**: What should the vendor do?
- **MaxiMin**: Choose the action that maximises the worst possible payoff
  - Sell always umbrellas: Can be too pessimistic…
- **MaxiMax**: Choose the action that maximizes the best possible payoff
  - Sell always hats: Can be too optimistic
- **Question**: What information are we missing?

Street vendors payoff table with probabilities

- Net profits obtained from merchandise, depending on weather

	Sunny ($p_{sunny} = 0.5$)	**Rain ($p_{rain} = 0.5$)**
Sell Umbrellas	$36	$81
Sell Hats	$144	$0

Decisions under ***risk***: where **probabilities** and **outcomes** are well known. It is a special case of decisions under ***uncertainty***.

The matrix representation of the decision is also called: “state contingent representation”

Prospect notation

- ‘Prospects’ (often referred to as ‘lotteries’ or ‘gambles’): probability distributions over (monetary) outcomes.
- $L = (x_1, p_1; x_2, p_2; \dots; x_i, p_i; \dots; x_n, p_n)$, where x_i is the ith outcome and p_i the probability corresponding to the event associated with this outcome. We also impose that $p_i > 0 \; \forall i$ and $\Sigma p_i = 1$.
  - For convenience, we order outcomes so that $x_1 > x_2 > \cdots > x_n$
  - Binary prospects of the type: $(x, p; y, 1 - p)$ are often simply notated as: $(x, p; y)$

Certainty equivalent

- Certainty Equivalent (CE): The certain amount of money that makes an agent indifferent between the prospect or the certain amount.
- We write CE(L)= $x and read: the amount of money that makes someone indifferent between keeping or selling the lottery
- You can think of the CE(L) is equivalent to the minimum price you would be willing to sell lottery: L if you previously owned it (i.e. “willingness to accept”).
- You can also think of it as the maximum price you would be willing to pay in order to buy the lottery, if you did not own it before (“willingness to pay”).
- In principle, willingness to accept should be equal to your willingness to pay (we will return to this point)

The vendor's problem in prospect notation

- The street vendor chooses between:
  - Sell umbrellas: $\mathrm{L}_{Umb} = (\$81{,}0.5; \$36{,}0.5)$, or simply $\mathrm{L}_{Umb} = (\$81{,}0.5; \$36)$
  - Sell hats: $\mathrm{L}_{\mathrm{Hat}} = (\$144, 0.5; \$0{,}0.5)$, or simply $\mathrm{L}_{\mathrm{Hat}} = (\$144, 0.5; \$0)$

- Notice that in prospect notation, states are no longer represented. Under the standard model, only outcomes matter, not the state in which they are realised.

- How does he decide which option he prefers?
- $L_{Umb} \succ L_{Hat}$ *or* $L_{Hat} \succ L_{Umb}$ *or* $L_{Umb} \sim L_{Hat}$???

- **Approach 1: choose the option with the highest Expected Value**

Expected Value

- The expected value **EV(L)** of prospect L is the probability weighted sum of outcomes.
- $EV(L) = \Sigma_i p_i x_i = p_1 x_1 + \cdots + p_n x_n$
- $\$EV(Umbr) = 0.5 * 81 + 0.5 * 36 = 40.5 + 18 = 58.5$
- $\$EV(Hat) = 0.5 * 144 + 0.5 * 0 = 72 + 0 = 72$
- $EV(Hat) > EV(Umbr) \Rightarrow L_{Hat} \succ L_{Umb} \Rightarrow$ sell hats.

- **Question**: Is this the only legitimate advice? Would the vendor be “wrong” if he chose to sell umbrellas instead?

Thought experiment

- Question: Which option do you prefer?
  - $R = (\$1000, 0.51; \$0, 0.49)$ or $S = (\$500, 1)$?
  - In words: do you prefer option R, offering $1000 with 51% chance and $0 otherwise, or option S, offering $500 for sure?

- The EV of $R = 0.51 * 1000 + 0.49 * 0 = 510 > 500$. Therefore, according to EV, one "should" choose R. Nonetheless, most people "prefer" the safe (S) option.

The St. Petersburg paradox

- A fair coin is tossed until Tails appear.
- You receive 2^n dollars if the first tail occurs on trial n
- ***Question***: How much are you willing to pay in order to participate?
- In other words, what is your CE of this lottery?
- EV: $\frac{1}{2} * 2^1 + \frac{1}{2^2} * 2^2 + \frac{1}{2^3} * 2^3 + \cdots = 1 + 1 + 1 \ldots = \infty$
- Yet, most people are not willing to pay more than $5 to participate.

The birth of a new theory

"*The determination of the value of an item must not be based on the price, but rather on the utility it yields…. There is no doubt that a gain of one thousand ducats is more significant to the pauper than to a rich man though both gain the same amount*."

Daniel Bernoulli (1700-1782)

Expected Utility Theory (EUT)

- Bernoulli: Instead of monetary values (x) he proposed to use intrinsic values (***utilities, u(x)***) of these monetary values.
  - Note: $x = wealth + outcome\ of\ the\ lottery$; for simplicity, we take wealth=0 from now on.
- Therefore, people valuate prospect, $\mathrm{X} = (\mathrm{x}_1, \mathrm{p}_1; \mathrm{x}_2, \mathrm{p}_2; \ldots x_i, p_i, \ldots x_n, p_n)$, not as:

$$\mathrm{EV(X)} = \Sigma_i p_i x_i$$

- but as

$$\mathrm{EU(X)} = \Sigma_i p_i u(x_i)$$

  - Notice: expected value theory is a special case of expected utility theory, where $u(x) = x$

EUT and diminishing marginal utility

- **Diminishing marginal utility**: Intrinsic worth of money always increases with money, **but at a diminishing rate**.

- **Question**: what type of function has this property?

- Concave functions:
  - $\frac{d(U(x))}{dx} > 0 \;\&\; \frac{d^2(U(x))}{dx} < 0$

EUT and St. Petersburg Paradox

- Bernoulli suggested a logarithmic utility function: $\mathrm{u}(x) = \ln(x)$
  - $U'(x) = \frac{1}{x}; U''(x) = -\frac{1}{x^2}$, in (0,∞)
- EV is replaced by expected utility. So instead of: EV: $\frac{1}{2} * 2^1 + \frac{1}{2^2} * 2^2 + \frac{1}{2^3} * 2^3 + \cdots =$
- We now write:

$$
\begin{aligned}
E[U(X)] &= \frac{1}{2}U(2) + \frac{1}{4}U(2^2) + \frac{1}{8}U(2^3) + \ldots + \frac{1}{2^n}U(2^n) + \ldots \\
&= \frac{1}{2}ln(2) + \frac{1}{4}ln(2^2) + \frac{1}{8}ln(2^3) + \ldots + \frac{1}{2^n}ln(2^n) + \ldots \\
&= \frac{1}{2}ln(2) + \frac{1}{4}(2ln(2)) + \frac{1}{2}(3ln(2)) + \ldots + \frac{1}{2^n}(nln(2)) + \ldots \\
&= (\frac{1}{2} + \frac{2}{4} + \frac{3}{2^3} + \frac{4}{2^4} + \frac{5}{2^5} + \ldots)ln2 \\
&= (\sum_{n=1}^{\infty} \frac{n}{2^n})ln2
\end{aligned}
$$

  - Where we used the result that $\ln(x^n) = nln(x)$

EUT and St. Petersburg Paradox (continued)

- $\sum_{n=1}^{\infty} \frac{n}{2^n} = 2$ (convergent series).
- Therefore the expected utility of this expression is finite: $EU(X) = 2ln2 = ln2^2 = ln4$.

- What about the CE? We know that $u(x) = lnx$, so we need to solve:
- $u(CE) = ln4 \Rightarrow \ln(CE) = ln4 \Rightarrow CE = \$4$
- This calculation matches empirical data!!

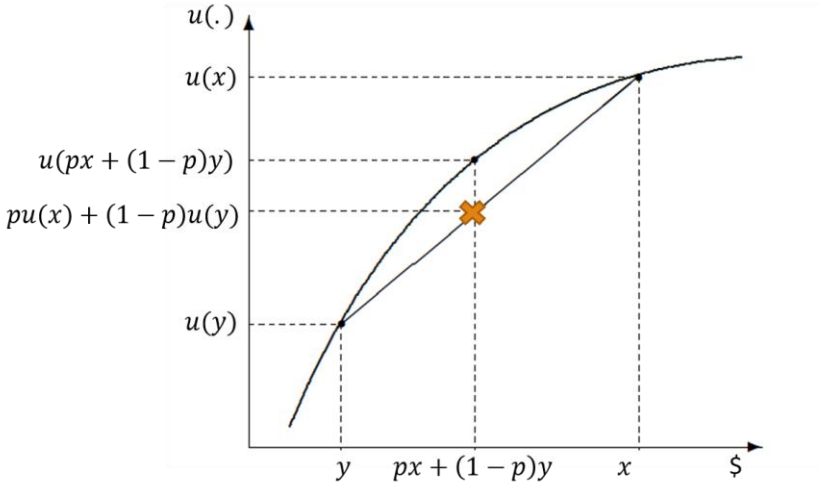
Expected Utility Theorem (von Neumann and Morgestern, 1947)

- If $\succcurlyeq$ is complete, transitive, continuous and satisfies the independence axiom then there exists a function $EU()$ such that for every lotteries: $\mathrm{Q},\ L$

$$\mathrm{Q} \succcurlyeq L \Leftrightarrow \mathrm{EU}(\mathrm{Q}) \geq EU(L),$$
$$where\ EU(X) = \Sigma_i p_i u(x_i)$$

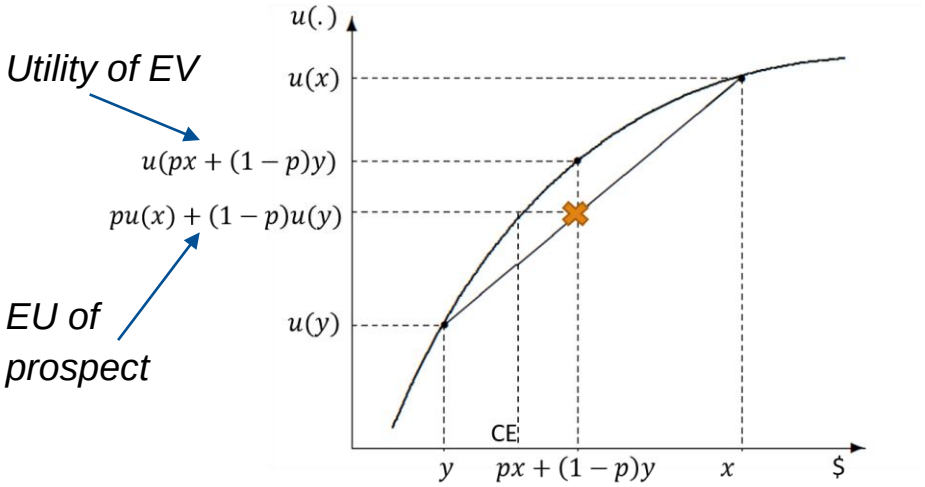
Left: Oscar Morgenstern (1902-1977)
Right: John von Neumann (1903-1954)

Diminishing marginal utility and risk aversion



Consider the prospect: $\mathrm{L} = (x, p; y)$
What is the Certainty Equivalent of a person with a utility function with diminishing marginal utility?

Risk aversion in EUT



- Consider the lottery: $(x, p; y)$
- The EV of this lottery is $px + (1-p)y$
- The expected utility of a prospect is lower than the utility of its expected value
- Therefore:

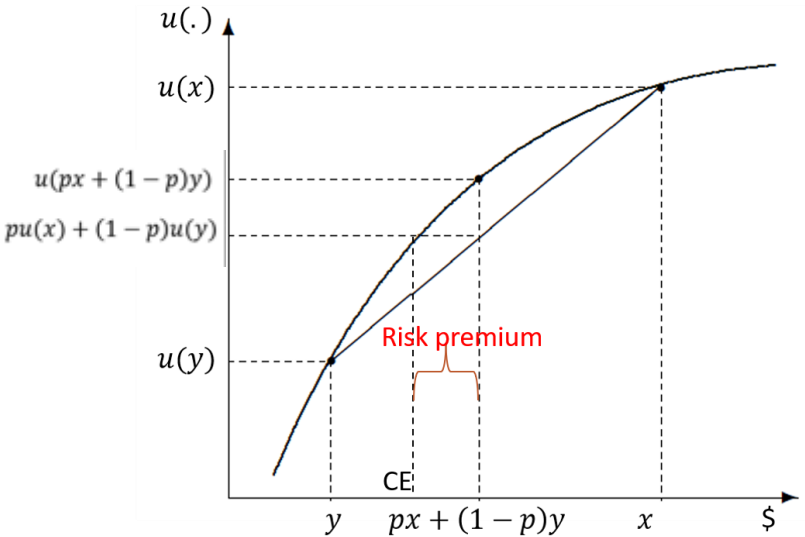
$$CE(x, p; y) < EV(x, p; y)$$

- This is why insurance companies make profits

Risk premium

- The risk premium is the amount that a risk-averse person would pay to avoid taking a risk.
- For example, an individual may buy insurance to avoid risk.
- Equivalently, the risk premium is the minimum extra compensation (premium) that a decision-maker would require to willingly incur a risk.
- The risk premium is the difference between the expected wealth from the risky stock and the certainty equivalent.

Risk preferences in EUT



Risk Aversion: CE(L)<EV(L)

- Willing to pay “risk premium” to insure and avoid risk

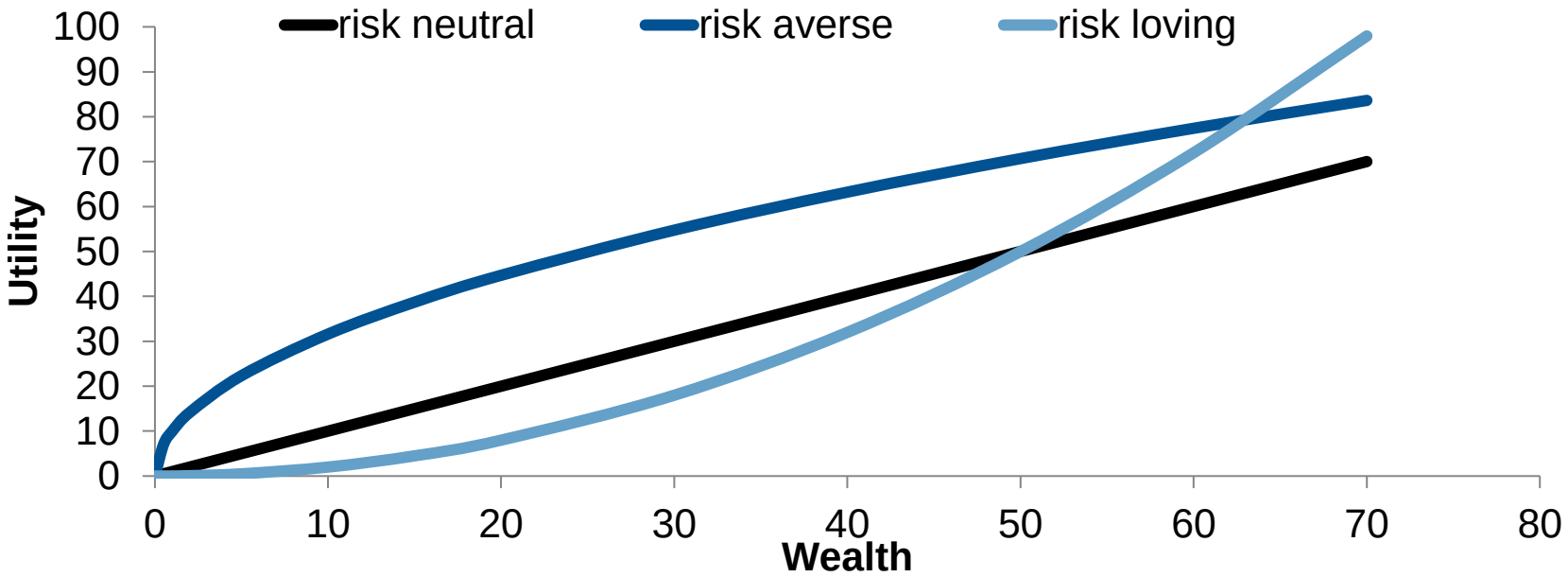
Risk Neutrality: CE(L)=EV(L)

- Indifferent between buying insurance or not

Risk Seeking: CE(L)>EV(L)

- Will not buy insurance

Different risk preferences under EUT



Allais' paradox (common ratio)

Prospect 1.A

$4 with probability 0.80
$0 with probability 0.20

Prospect 1.B

$3 for sure

Scenario 1

Prospect 2.A

$4 with probability 0.20,
$0 with probability 0.80

Prospect 2.B

$3 with probability 0.25,
$0 with probability 0.75

Scenario 2

- Most people choose 1.B over 1.A in scenario 1 (suggesting risk averse behavior) but…
- Most people choose 2.A over 2.B in scenario 2 (suggesting risk seeking behavior).
- According to Expected Utility Theory: people cannot be simultaneously risk seeking AND risk averse

Allais' paradox (common ratio)

Preferring Prospect 1.B over Prospect 1.A implies that $EU(1.B) > EU(1.A) \Rightarrow$

$$u(3) > 0.8 * u(4) + 0.2 * u(0) \Rightarrow$$

$$u(3) \geq 0.8 * u(4) \qquad (I)$$

Preferring Prospect 2.A over Prospect 2.B implies that $EU(2.A) > EU(2.B) \Rightarrow$

$$0.2 * u(4) + 0.8 * u(0) > 0.25 * u(3) + 0.75 * u(0) \Rightarrow$$

$$u(3) \leq \frac{0.20}{0.25} * u(4) \Rightarrow u(3) < 0.8 * u(4) \qquad (II)$$

- Clearly, I and II cannot be true at the same time, therefore, there is a problem with EUT
- But this is not the only instance where the predictions of EUT are systematically violated

Preference for lotteries and insurance

Prospect 3.A 5,000 with probability 0.001 0 with probability 0.999	**Prospect 3.B** 5 for sure	Scenario 3 (lottery)
Prospect 4.A $-5,000$ with probability 0.001, 0 with probability 0.999	**Prospect 4.B** -5 for sure	Scenario 4 (insurance)

- According to EUT:
  - Risk averse people should choose 3.B and 4.B
  - Risk seeking people should choose 3.A and 4.A
  - But, this is not how people typically behave

Behavior inconsistent with EUT

- Multiple risk preferences (E.g. simultaneous preference for lotteries and insurance)
- Probability distortions
- Losses loom larger than gains
- Endowment effect: people value something more just because they own it
- …

II. Decisions under Uncertainty (Description)

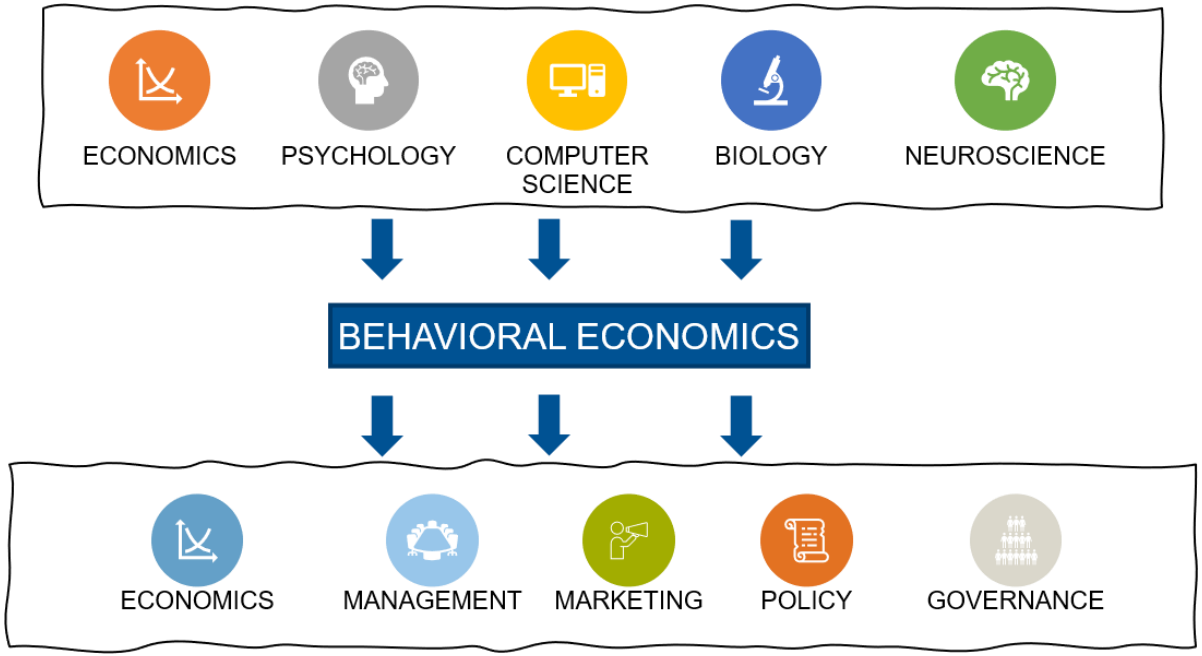
The Standard Economics account

- Preliminaries (notation and how to set up the problem)
- Expected Value and Expected Utility Theory
- Risk aversion
- Limitations of Expected Utility Theory (Allais' Common Ratio effect)

Prospect Theory: a behavioral approach to decisions under uncertainty

- Introduction to Behavioral Economics and Prospect Theory
- Probability Weighting

BEHAVIORAL ECONOMICS



Experimental Economics

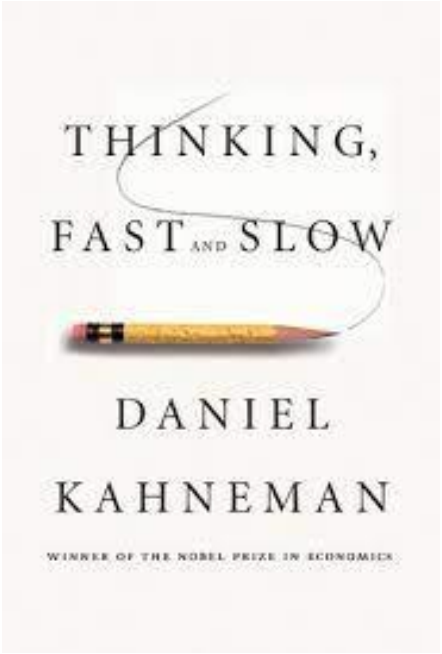
- Experimental Economists test theories and use findings to develop new ones
- This is how a physical lab usually looks like…
- See supplementary matterial for more insights related to Experiments in Economics

Prospect Theory (Kahneman and Tversky, 1979)

- Kahneman and Tversky (1979) discuss a series of “problems” with EUT and propose a theory that can account for these choice patterns.
- Introduced 3 psychological principles to the standard model
  - Reference dependence
  - Loss aversion
  - Diminishing sensitivity
- Revolutionised economics and established behavioral economics
- Resulted in a Nobel prize and thousands of citations

Prospect theory: An analysis of decision under risk
D Kahneman, A Tversky - Handbook of the fundamentals of financial …, 2013 - World Scientific
This paper presents a critique of expected utility **theory** as a descriptive model of decision making under risk, and develops an alternative model, called **prospect theory**. Choices among risky prospects exhibit several pervasive effects that are inconsistent with the basic …
☆ 99 Cited by 63786 Related articles All 85 versions »

Prospect Theory

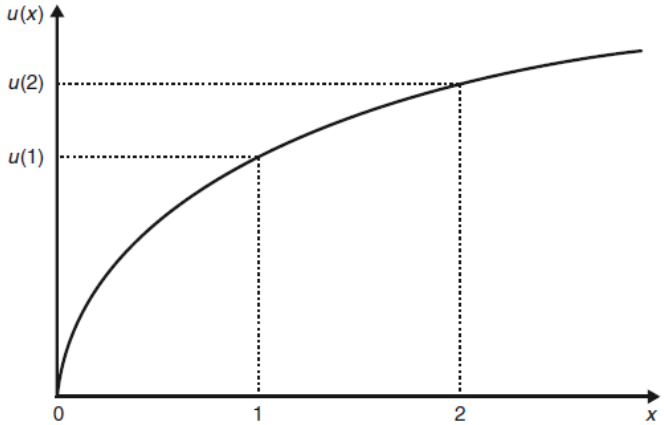


- “Thinking fast and slow” Kahneman, D. (2011): an excellent and very approachable account of this research.
- Prospect Theory accommodates a variety of behavioral phenomena: endowment effect, simultaneous preference for lotteries and insurance, probability distortions, violations of independence and the Alais-paradoxes, loss aversion…
- It departs from EUT by introducing modifications to the value function and probability weighting.
- In this seminar we focus on probability weighting

Prospect Theory: reference dependent utility

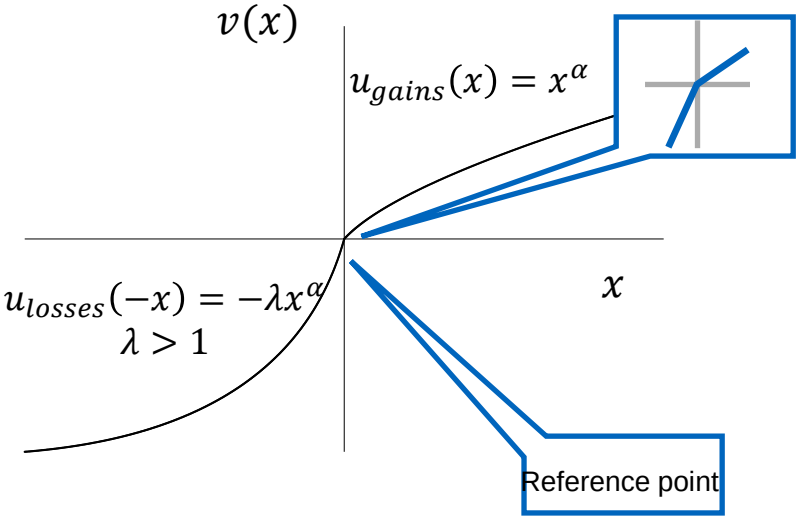
Standard model

e.g. $u(x) = x^{\alpha}, 0 < \alpha < 1$



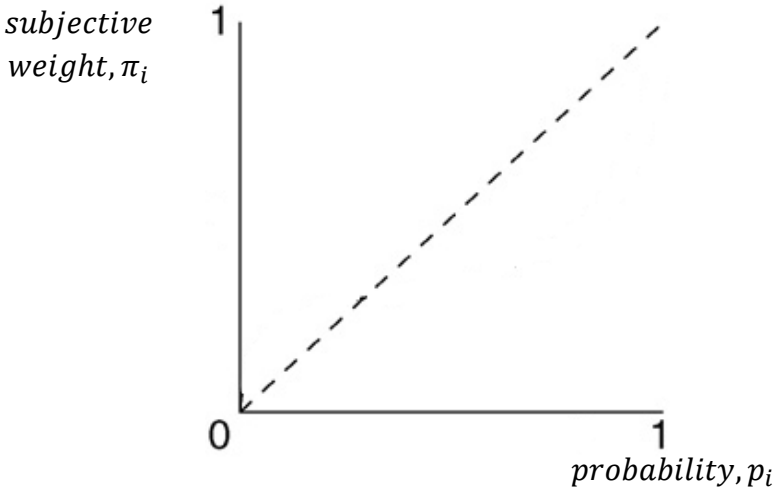
Prospect Theory

kink in reference point

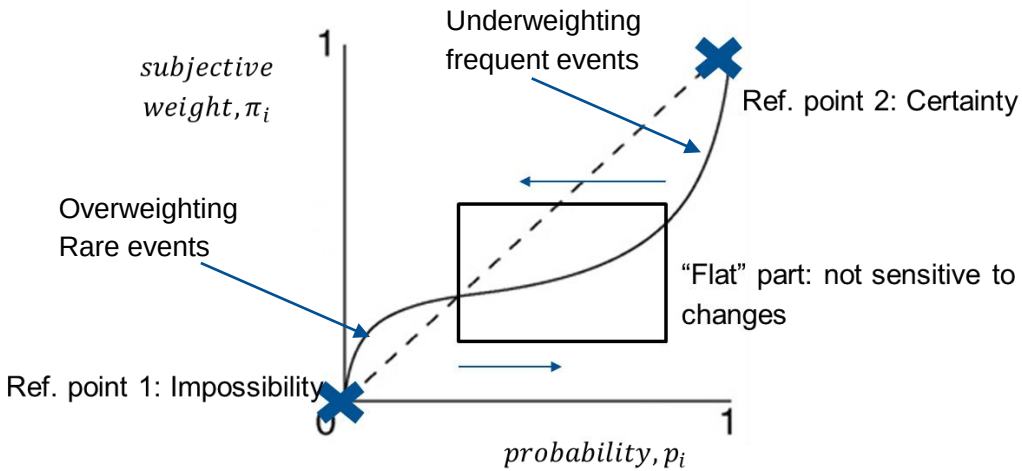


Prospect theory: probability weighting

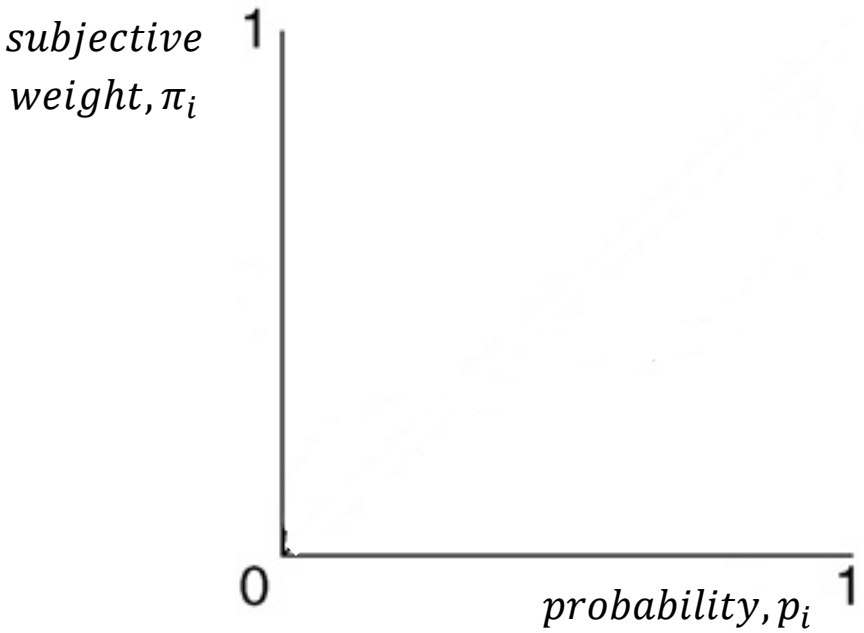
Standard model



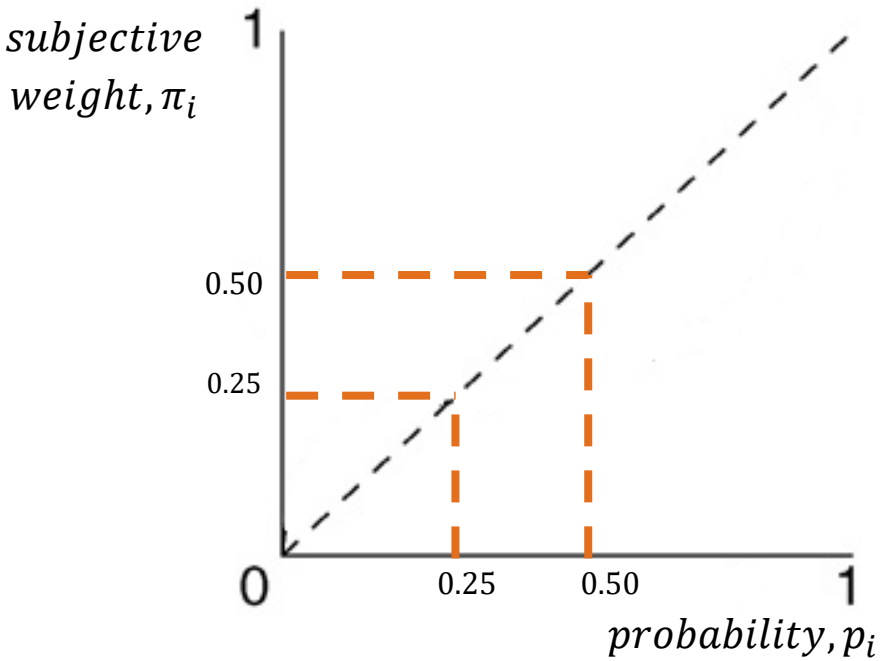
Prospect Theory



How do people treat probabilities in their decisions?



Standard model



$$\Sigma\pi_i = 1$$
$$p_i = \pi_i, \forall\, i$$
$$\pi(0.50) = 2 * \pi(0.25)$$

Example 1: Disease

- Suppose that you go to your primary care physician and you are told that, because of your genetic profile, there is a chance of contracting a serious form of disease in the next five years.
- There is a drug treatment that is expensive and has side effects, but it reduces the probability of developing the disease. Do you begin the drug treatment if the probability is reduced…

- **Scenario 1**: from 5% down to 0%?
- **Scenario 2**: from 45% down to 40%?

- Most people would begin the drug treatment in Scenario 1 **but not** in Scenario 2.

Example 2: Russian roulette

- Suppose that you are forced to play Russian roulette, but that you have the option to pay to remove one bullet from the loaded gun before pulling the trigger.
- How much would you pay to reduce the number of bullets in the cylinder:

- **Scenario 1**: from four to three?
- **Scenario 2**: from one to zero?

- According to Kahneman and Tversky most people would pay more to reduce the number from one to zero than from four to three.
  - Fortunately they used hypothetical incentives!

Implications of examples the standard model

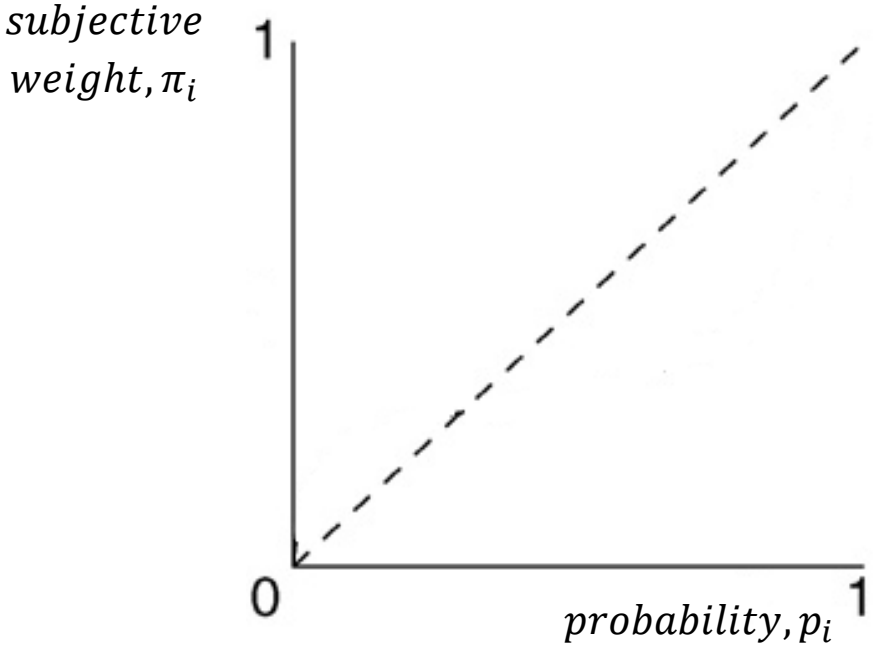
- Our subjective sense of probability doesn’t match the objective reality
- In example 1, the reduction from 5% to 0% is treated by most people as more important than from 45% to 40%
- Notice, the probability changed exactly by 5% in both cases. Therefore, according to the standard model, the answer should had been the same in both scenarios
- However, people treat some changes in probability as more important than others

Implications of examples the standard model

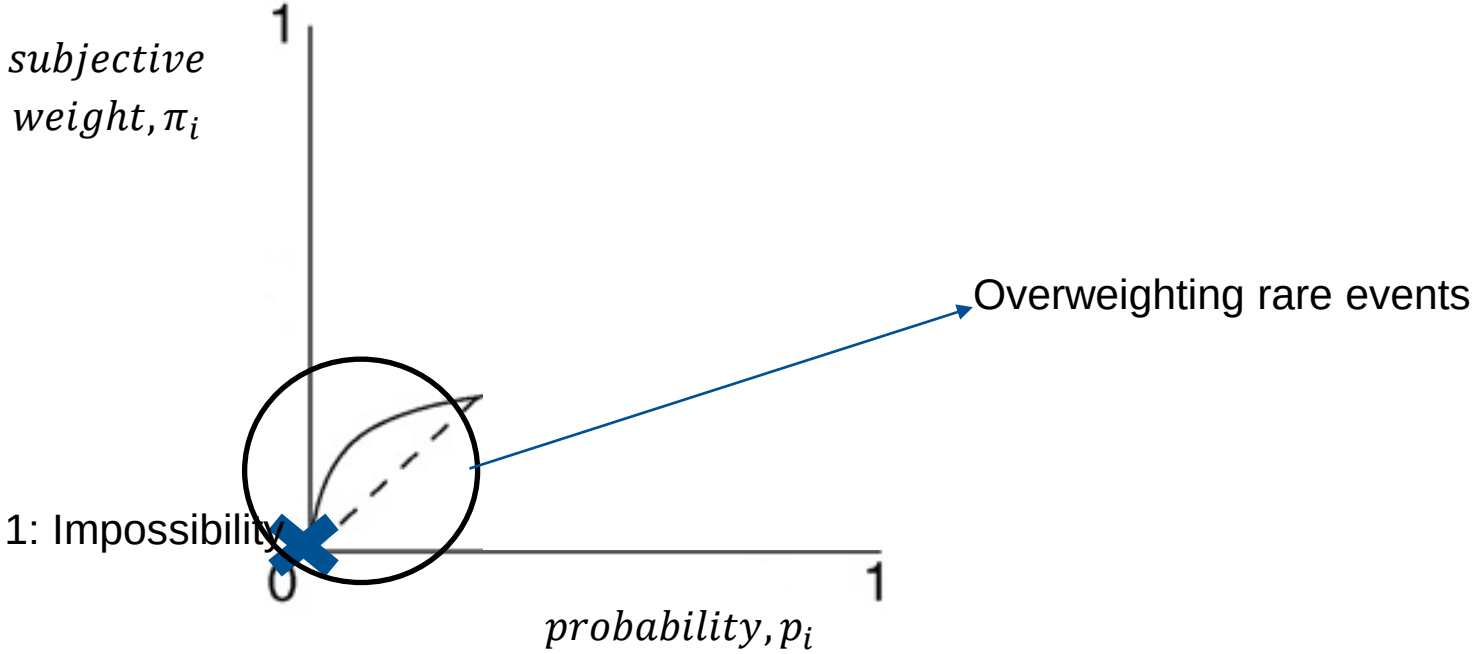
- Similarly, in example 2, 1 bullet is more important when that is the only bullet in the cylinder than when there are 3 more.

- Therefore, the reduction from 1/6 (approx. 16%) to 0 is more important than from 4/6 (approx. 66%) to 3/6 (50%). Again, the change in prob. was 16% in both cases.
  - Notice that we have seen two ways of expressing probabilities:
  - Natural frequencies: e.g. 3 out of 6
  - Percentages: 50%
  - In theory the two formats ought to have the same effect…

The standard model: no probability weighting

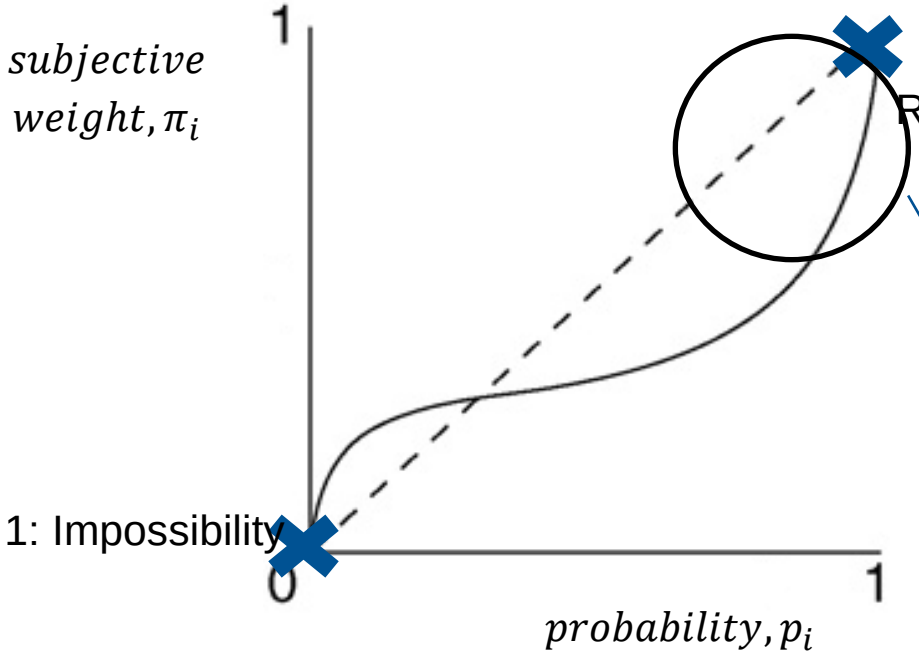


Probability weighting: reference points + dim. sensitivity



Ref. point 1: Impossibility

Probability weighting: reference points + dim. sensitivity

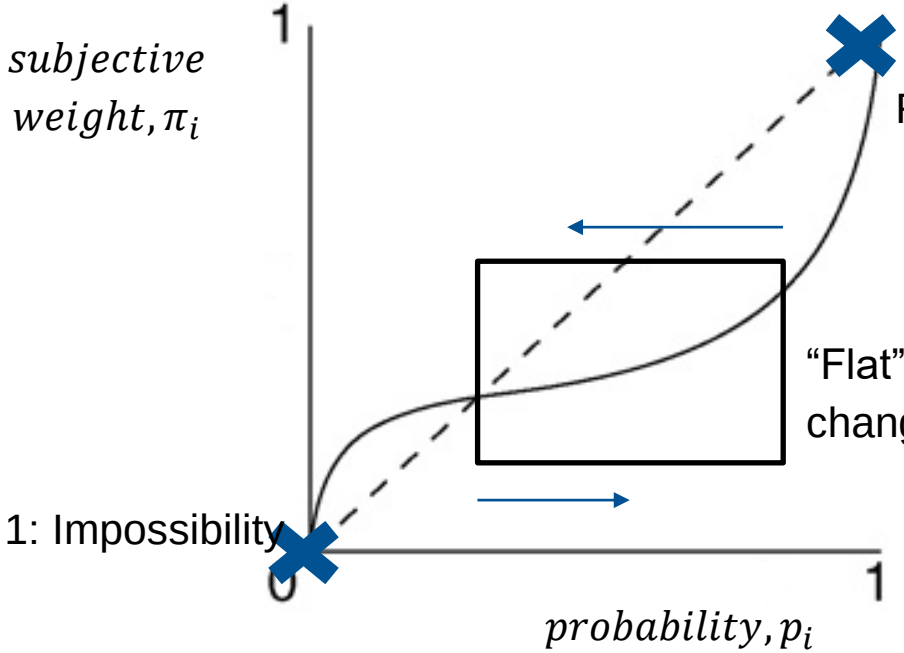


Ref. point 2: Certainty

Underweighting frequent events

Ref. point 1: Impossibility

Probability weighting: reference points + dim. sensitivity



Ref. point 2: Certainty

"Flat" part: not sensitive to changes

Ref. point 1: Impossibility

Allais' paradox with Prospect Theory

Preferring Prospect 1.B over Prospect 1.A implies that $PT(1.B) > PT(1.A) \Rightarrow$

$$\pi(1)v(3) > \pi(0.8) * v(4) + \pi(0.2) * v(0) \Rightarrow$$

$$v(3) > \frac{\pi(0.8)}{\pi(1)} * v(4) \quad (I)$$

Preferring Prospect 2.A over Prospect 2.B implies that $PT(2.A) > PT(2.B) \Rightarrow$

$$\pi(0.2) * v(4) + \pi(0.8) * v(0) > \pi(0.25) * v(3) + \pi(0.75) * u(0) \Rightarrow$$

$$v(3) < \frac{\pi(0.20)}{\pi(0.25)} * u(4) \quad (II)$$

- (I)& (II) are now jointly possible as long as: $\frac{\pi(0.20)}{\pi(0.25)} \gg \frac{\pi(0.8)}{\pi(1)}$ (III)
- An inverse S-shaped probability weighting function can satisfy this condition.

Preference for lotteries and insurance with Prospect Theory

Prospect 3.A

5,000 with probability 0.001
0 with probability 0.999

Prospect 3.B

5 for sure

Scenario 3 (lottery)

Prospect 4.A

$-5,000$ with probability 0.001,
0 with probability 0.999

Prospect 4.B

-5 for sure

Scenario 4 (insurance)

- According to Prospect Theory, choosing 3.A in Scenario 3 and choosing 4.B in Scenario 4 is possible as long as people overweight sufficiently small probabilities:

$$\pi(0.001) \gg 0.001$$

III. Decisions under Uncertainty (Experience)

Decisions from Experience

- What are decisions from Experience?
- Studying decisions from Experience in the lab
- The Description – Experience gap
- Drivers of the Description – Experience gap

Extensions of the paradigm

- Optimal stopping and information search
- The role of Complexity
- Social uncertainty

Decisions from Experience

- Descriptive and numerical summaries of uncertainty are not always available.
- Will you back-up your PC? Where should you park your bike? Should you take a mortgage loan?
- Very often people rely on direct or indirect experience to inform their decisions

Key elements of decisions from Experience

- Decision maker is initially completely unaware of the outcomes and/or their probability distribution
- Knowledge about outcomes and their probability can be obtained through a sequential sampling process
- Differences with decisions from Description: Information is numerical and simultaneous in description but analogical and sequential in experience.
- Key question:

Is there a Description – Experience gap?

Studying the Description - Experience gap in the lab

- The sampling paradigm (Hertwig et al., 2004): the most popular set-up for studying the phenomenon in the lab
- Two treatments:
  - Description: numerical and simultaneous information
  - Experience: participants find out outcomes and probabilities by sequential sampling

Description in the lab

Option A

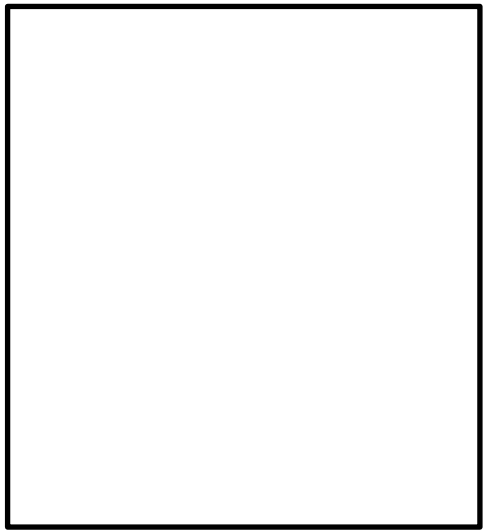
$4 with probability 0.80
$0 with probability 0.20

Option B

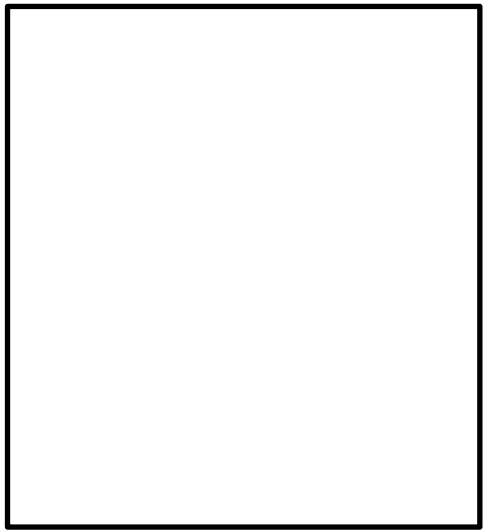
$3 with probability 100%

Experience in the lab

Option A

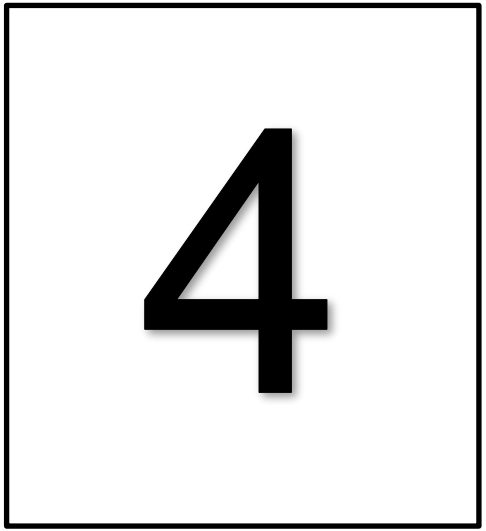


Option B

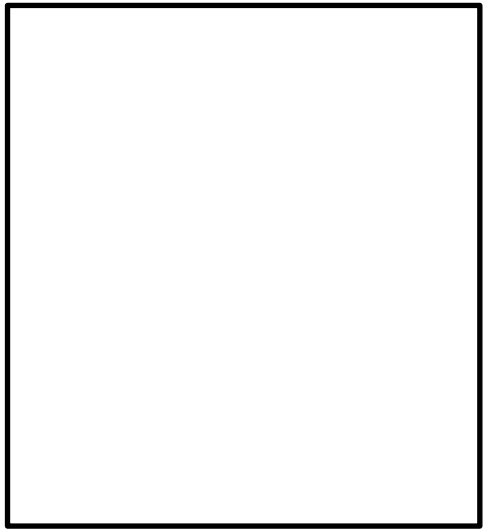


Experience in the lab

Option A

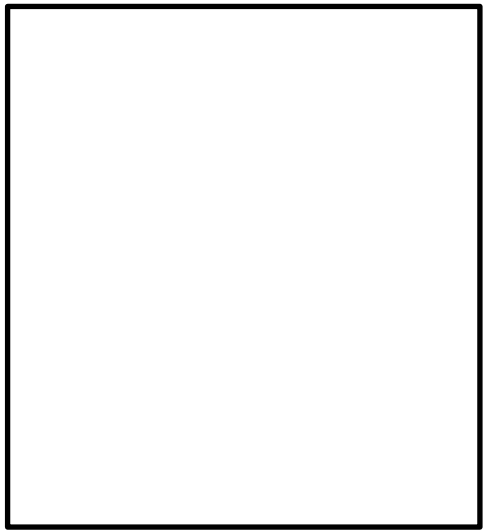


Option B

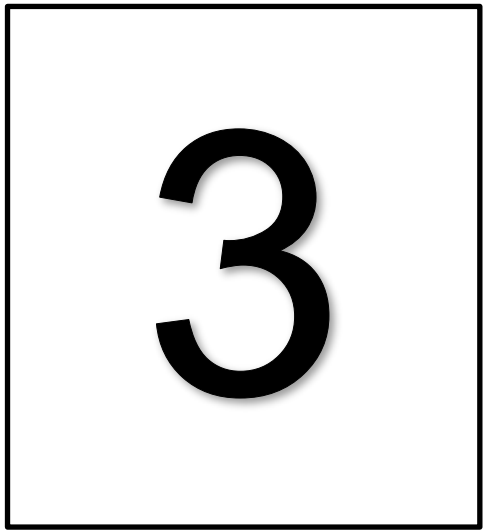


Experience in the lab

Option A

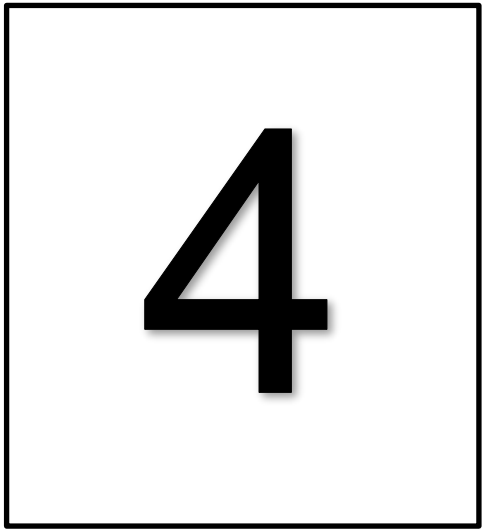


Option B

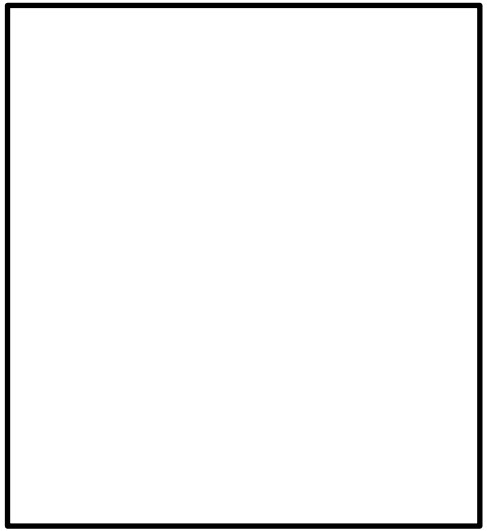


Experience in the lab

Option A

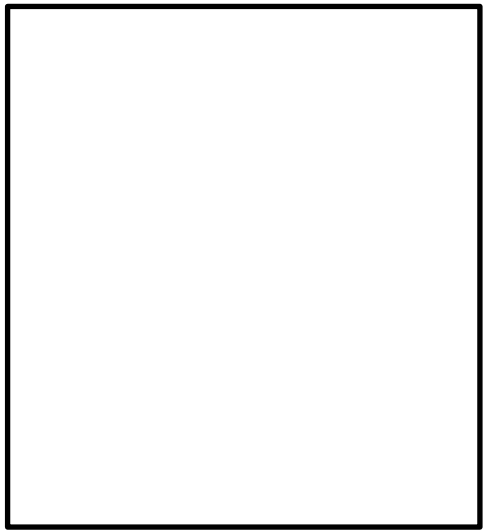


Option B

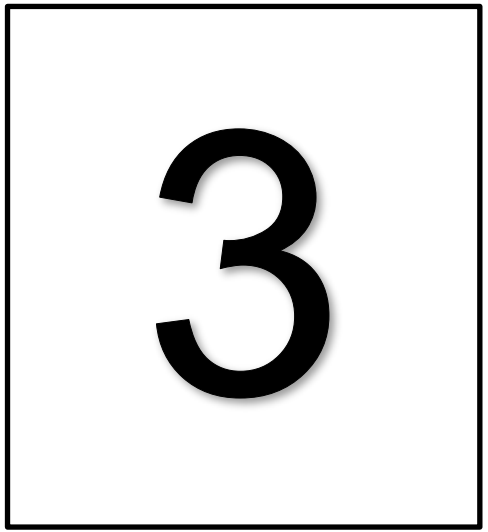


Experience in the lab

Option A

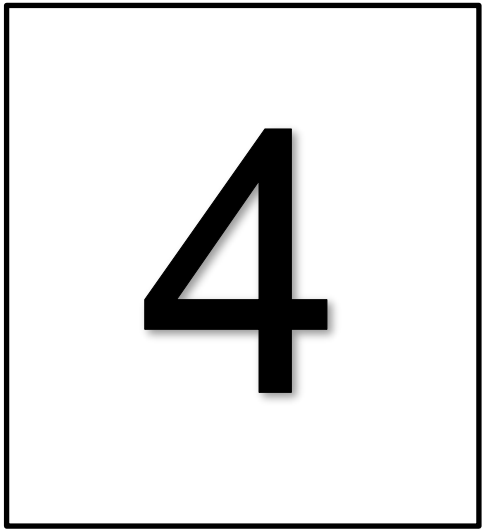


Option B

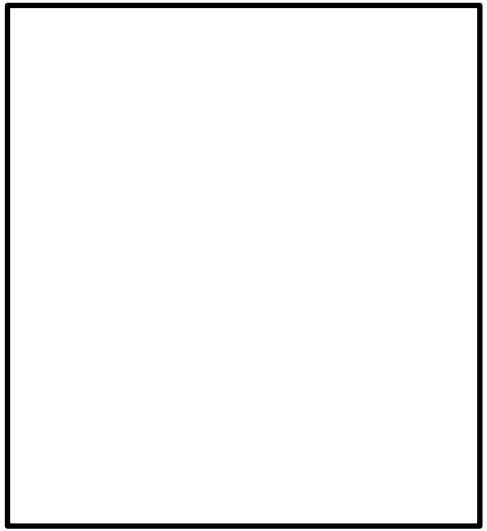


Experience in the lab

Option A

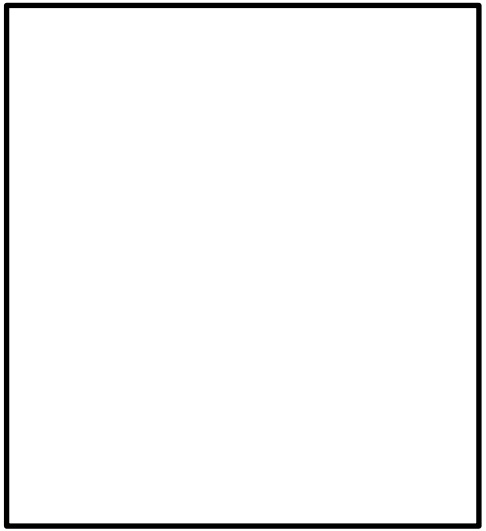


Option B

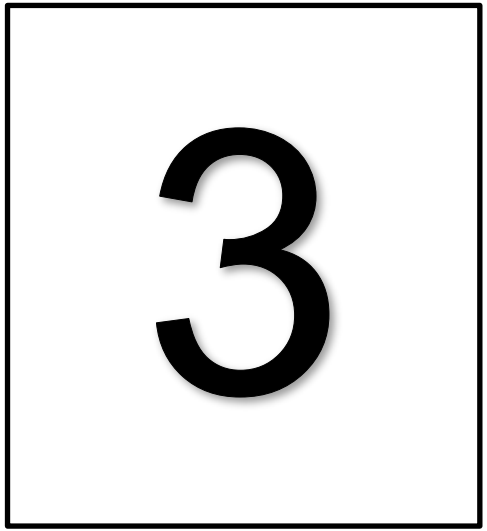


Experience in the lab

Option A

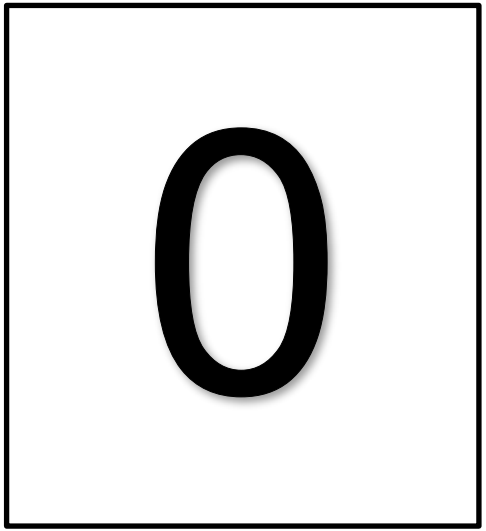


Option B

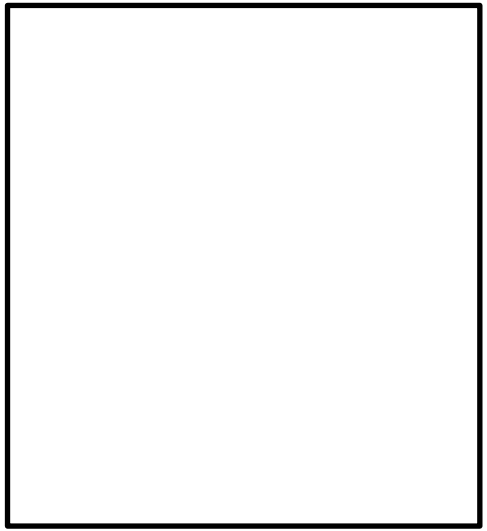


Experience in the lab

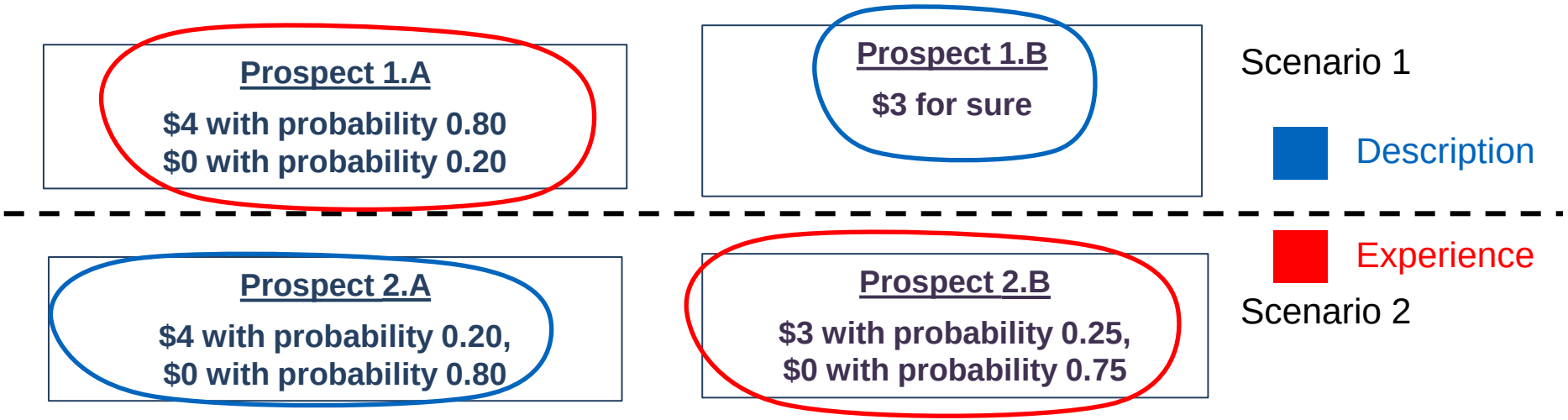
Option A



Option B

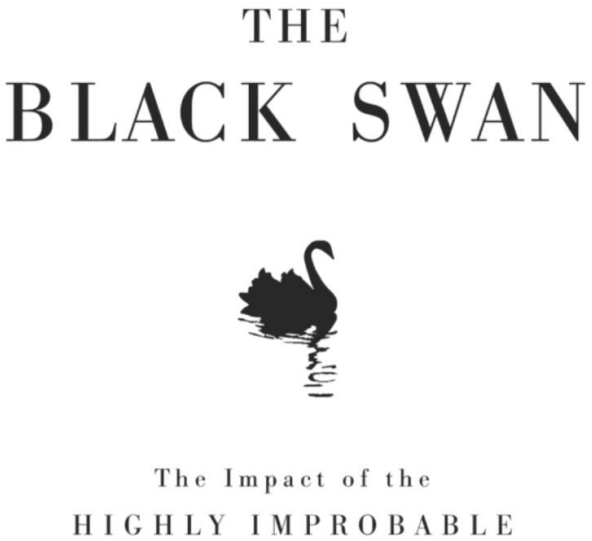


Findings



- Choice pattern reverses in Experience compared to Description
- Choices in Experience still not consistent with EUT
- Interpretation?

Rare events at the centre of the debate



- Black swan events is a metaphor that describes a **rare event** (and is typically very consequential).
  - The name derives from a Latin expression; at the time all swans were thought to be white…
  - An example of a recent “Black Swan” is the 2008 financial crisis.
  - The discussion about the difference between Decisions from Description and Decisions from Experience has (thus far) been focused on such rare events.

Taleb (2007)

The Description – Experience gap

- Description: people behave as if **over**weighting *rare events*

- Experience: people behave as if **under**weighting *rare events*

Drivers of the Description – Experience gap

- Factors that may be contributing:
  - Sampling Bias
  - Memory
  - Ambiguity preferences
  - …

Q. What other factors may be driving the Description – Experience gap?

Sampling Bias

- People collect relatively small samples (typically 8 samples per option).
- The binomial distribution is positively skewed for small samples.
- This means that the sampling error is not symmetrically distributed around the true, underlying frequency
- An implication of this is that in small samples, rare events tend to be under-represented (and even completely ignored).

Sampling Bias: rare events tend to be under-represented

- Binomial distribution:

$$P(x) = \binom{n}{x} p^x (1-p)^{n-x} = \frac{n!}{(n-x)!\,x!} p^x (1-p)^{n-x}$$

- This formula allows us to answer the question: what is the probability of x success in n (independent) trials if the probability of success in every trial is p.
- For example, what is the probability of flipping a fair (so $p = 0.5$) coin $n = 6$ times and landing exactly $\mathrm{x} = 2$ on heads?

Sampling Bias: rare events tend to be under-represented

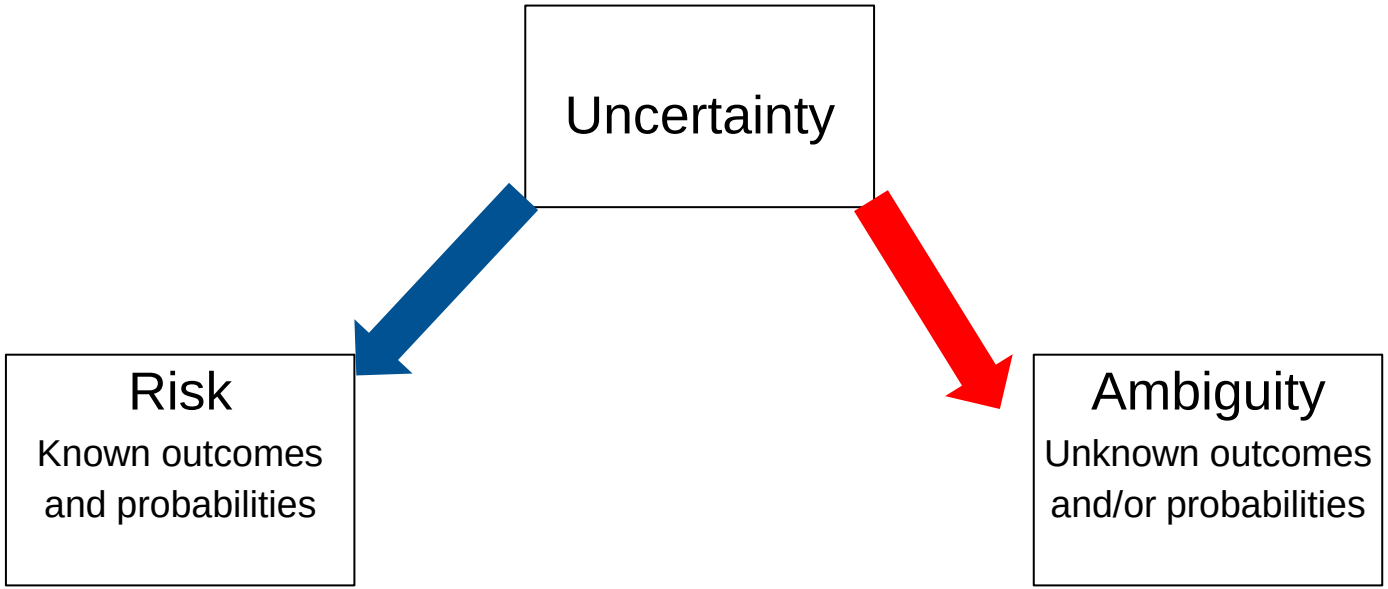
- Consider Lottery A=($100, p=0.05; $0)
- The $100 outcome occurs with 5% probability while the $0 outcome with 95% probability.
- The $100 is considered a rare event.
- What is the probability of never observing the rare outcome in a sample of 8 draws?
- $P(x = 0) = \binom{8}{0} 0.05^0 * 0.95^{8-0} = 66.3\%$
- So the most likely scenario is to never observe (or under-represent) the rare outcome.
- If people under-represent rare events it is natural to behave as if they under-weight them.

- ***Q: What drives people's search strategy?***

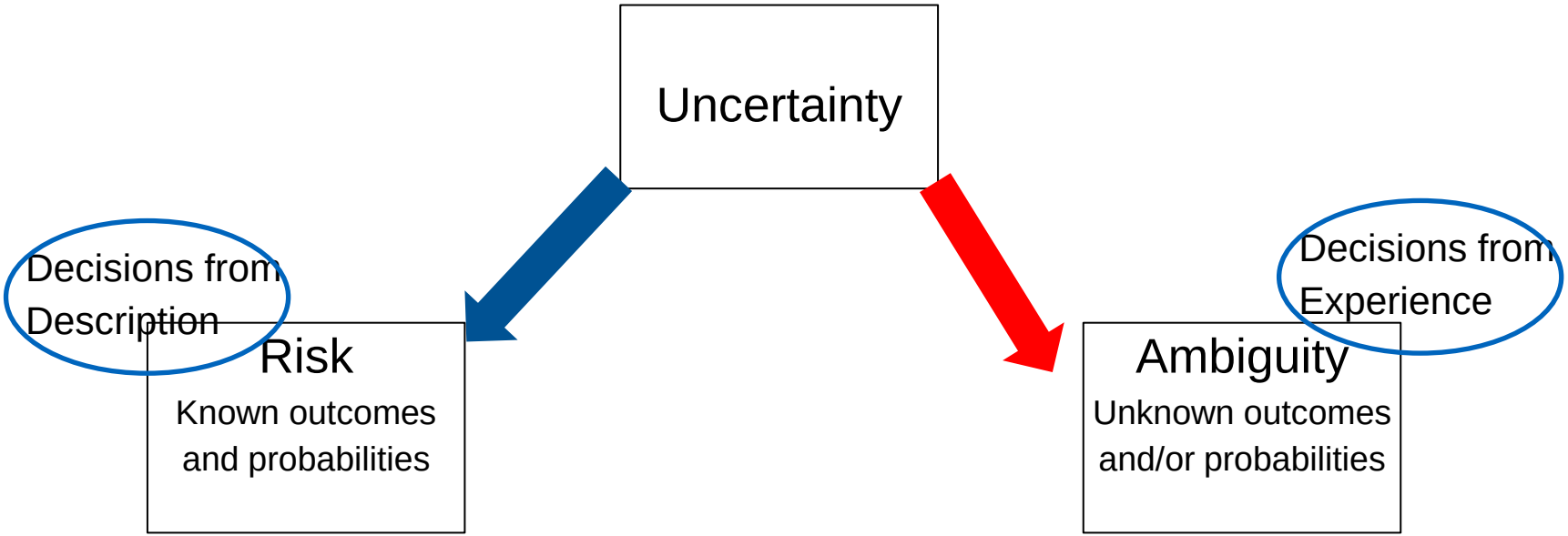
Memory limitations

- Even if people sample a lot they might mis-represent observed frequency in their memory
- If people do not keep notes they might mis-represent the observed frequency
  - Consider the observed frequency: {4,4,0,0,**4,4,4,4,4,0,4**,4,4,4,4}
  - If they can only recollect the bold part of their experience, their remember experience under-represents the likelihood of the 0 outcome (1/7 chance instead of 1/5)
  - Another memory distortion is the “recency effect” according to which, only the last observations remain in memory: {4,4,0,0,4,4,4,4,4,0,4**,4,4,4,4**}. Again, in this case, the 0 outcome will be under-represented (in this case, ignored).
- Memory limitations may act as a type of sampling bias (in the brain).

Ambiguity preferences

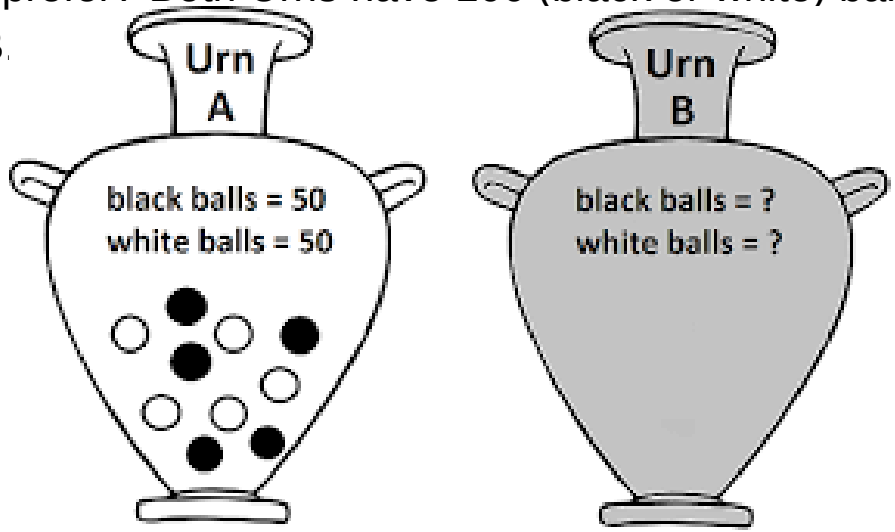


Ambiguity preferences



Ambiguity Preferences: Ellsberg Urns

Scenario 1: “Draw a ball from an Urn. White Ball->$100; Black Ball->$0.
Which Urn do you prefer? Both Urns have 100 (black or white) balls. But, the distribution is unknown for Urn B.



Ambiguity Preferences: Ellsberg Urns

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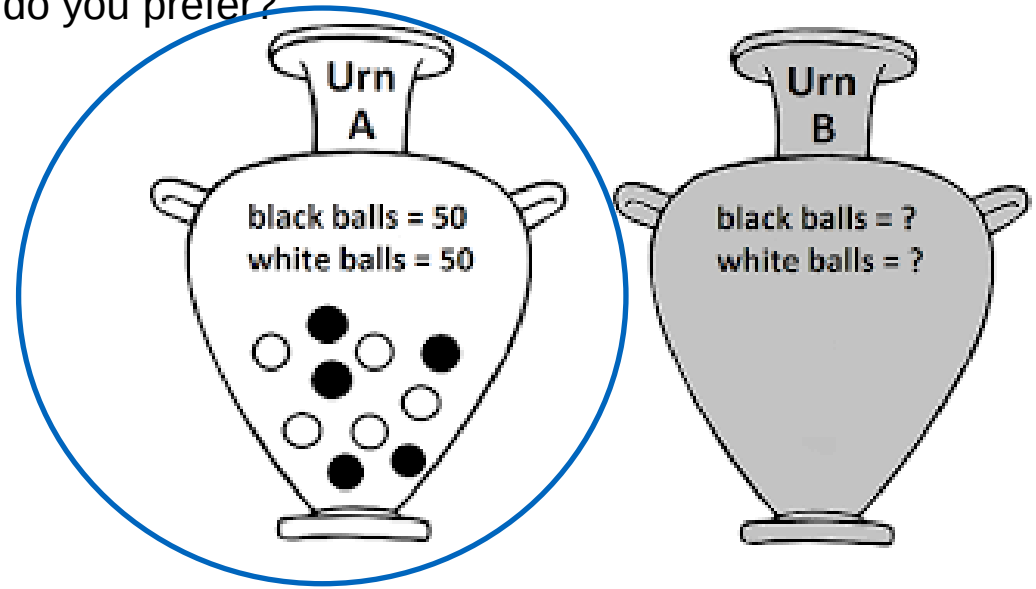
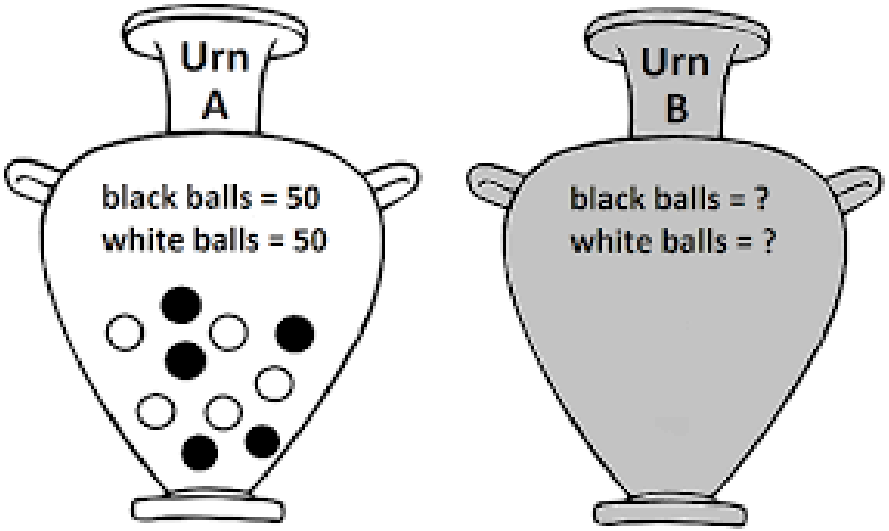


People prefer Urn A (known distribution). Logical implication: they must think that Urn B has less than 50 White balls.

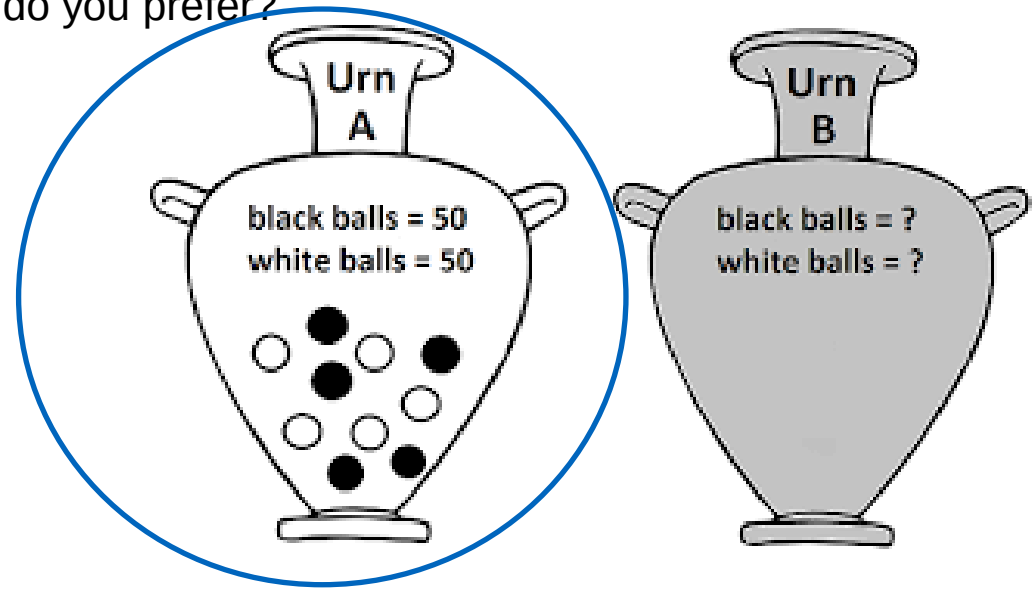
Ambiguity Preferences: Ellsberg Urns

Scenario 2: “Draw a ball from an Urn. Black Ball->$100; White Ball->$0.
Which Urn do you prefer?
Since people preferred Urn A in scenario 1,
They must prefer Urn B now. But…



Ambiguity Preferences: Ellsberg Urns

Scenario 2: “Draw a ball from an Urn. Black Ball->$100; White Ball->$0.
Which Urn do you prefer?



- People prefer Urn A again.
- Urn B cannot have more white than black AND more black than white at the same time.
- Interpretation: people are ambiguity averse.

Ambiguity Preferences

- Ellsberg (1961) experiments suggest that people are ambiguity averse.
- Decisions from Experience are decisions under ambiguity.
- Therefore, ambiguity aversion can appear as underweighting of rare desirable events.
- But what about rare undesirable events?
- Also, recent findings suggest that people are not universally ambiguity averse (e.g. Dimmock, Kouwenberg, Wakker, 2016)

I. Decisions under Uncertainty (Experience)

Decisions from Experience

- What are decisions from Experience?
- Studying decisions from Experience in the lab
- The Description – Experience gap
- Drivers of the Description – Experience gap

Extensions of the paradigm

- Optimal stopping and information search
- The role of Complexity
- Social uncertainty

Optimal Stopping: the secretary problem

Problem description

- Anna runs a promising start-up company.
- She wants to hire a secretary to help her with day-to-day organisation.
- She advertises the position and receives n CVs.
- Over the following days she will conduct 1-1 interviews with candidates.
- Is there a strategy that allows Anna to maximise the chance of hiring the best person for the job?

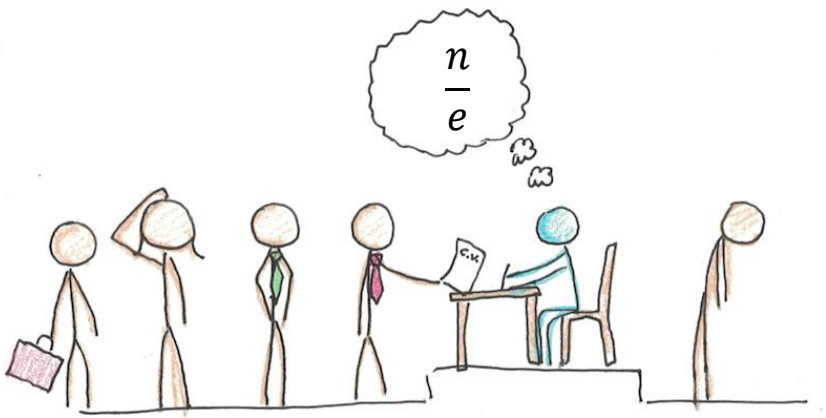
Assumptions

1. Only one position available
2. The number of applicants n, is known
3. Sequential sampling (without replacement but random order) of candidates
4. Options are rankable (no ties). Decision to reject is based only on relative ranks.
5. No recall: cannot return to a previous option
6. Only the best option in the set matters.

Optimal Stopping: the secretary problem

- There exists an optimal strategy:
  - Always reject the n/e applicants, where
    - $n = total\ number\ of\ candidates,$
    - $e = base\ of\ natural\ logarith$
  - Accept the first candidate who is better than every applicant interviewed so far…
  - Or continue until the last candidate and hire him/her
  - The probability of ending up with the best candidate is $1/e$, irrespective of number of candidates!!

Optimal Stopping: the secretary problem



Questions

- How do people actually search in such settings?
  - Do they follow optimal strategies?
  - If not are there heuristics that approximate optimality?

Complexity

- Most of the choice settings that were used for the Description-Experience gap comprised of a choice between a risky (2-outcome) option and a safe (1-outcome) option.
- Glöckner et al. (2016), observe than when the complexity of the safe option increases (e.g. by increasing the number of outcomes) the gap shrinks or is even reversed!
- ***Q. How does complexity influence the Description – Experience gap?***

Beyond individual risk: uncertainty in social dilemmas

- So far we have assumed that uncertainty derives from impersonal sources (e.g. nature, or the stock market going up or down). But what if uncertainty depends upon the actions (and intentions) of fellow people? Consider the Prisoner's Dilemma game.

		Prisoner 2	
		Cooperate	Defect
Prisoner 1	Cooperate	3,3	0,5
	Defect	5,0	1,1

Beyond individual risk: uncertainty in social dilemmas

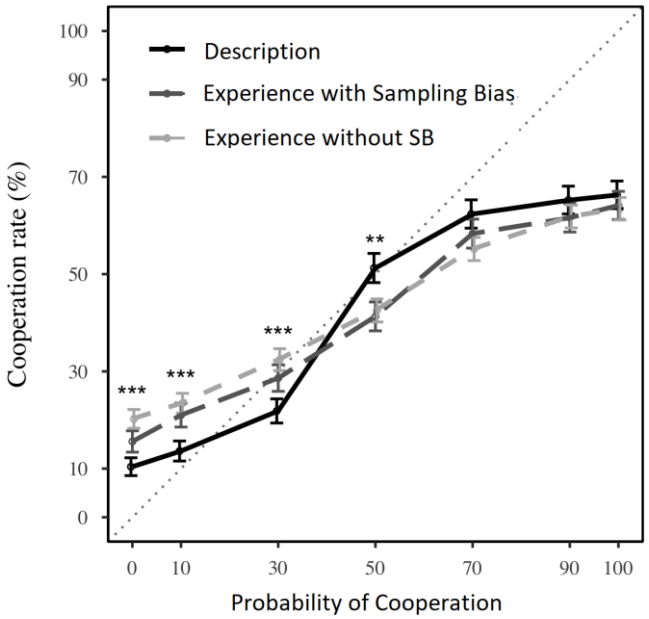
		Prisoner 2	
		Cooperate	Defect
Prisoner 1	Cooperate	3,3	0,5
	Defect	5,0	1,1

- The standard model predicts that the rational agent acts selfishly and defects.
- The fact that mutual cooperation is better for society but not the individually optimal strategy makes this game a “social dilemma”.
- Social dilemmas such as the Prisoner’s Dilemma and its generalisation for n players: the Public Goods Game have been used by economists to study applications such as taxation.

		Prisoner 2	
		Cooperate	Defect
Prisoner 1	Cooperate	3,3	0,5
	Defect	5,0	1,1

- Decades of research in Behavioral and Experimental Economics suggests that people are often conditional cooperative: they want to cooperate when their match cooperates and defect otherwise.
- But, when others' intentions are unknown, conditional cooperators make a decision under uncertainty
- Is there a Description – Experience gap in situations of social uncertainty?

The Description – Experience gap in Cooperation



- When uncertainty depends on others' intentions the Description – Experience gap is reversed:
- Rare events of cooperation are more influential in Experience rather than in Description
- ***RQ: Why?***

Isler, Kopsacheilis, van Dolder (2021)

List of open questions

- How do people search in the sampling paradigm? How do they decide when to stop? How do they update their beliefs?
- What (and how) other factors may be contributing to the Description – Experience gap?
- How does complexity of the choice environment affect the Description – Experience gap?
- How do people decide when to stop and commit in optimal stopping problems? Are there heuristics that approximate the optimal solution?
- …?