Behavioral Economics

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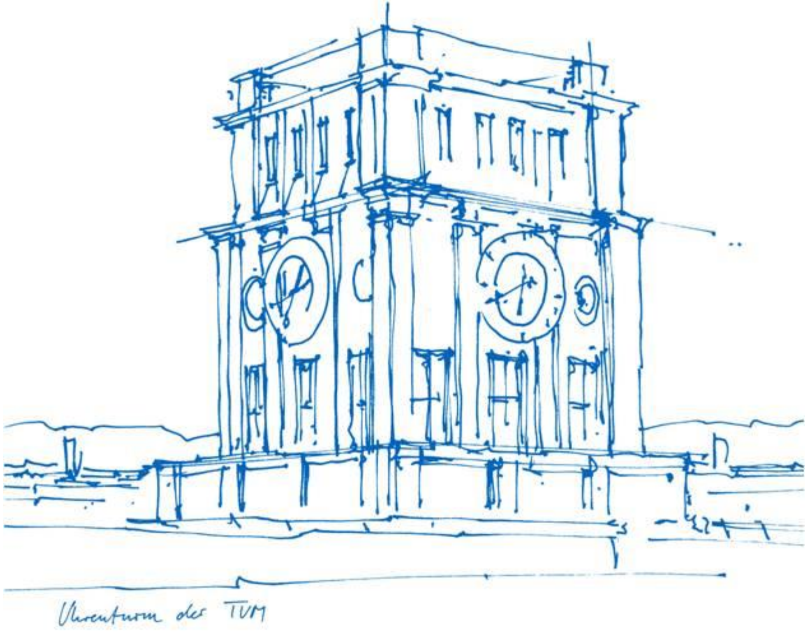

Semester Plan

Course Overview

I. What is Behavioural Economics
II. Principles of Experimental Economics
III. The Standard Economic Model: Consumer Theory
IV. Decisions Under Risk: Expected Utility Theory
V. Beyond Expected Utility Theory: Prospect Theory
VI. Intertemporal Choice
VII. Interaction with others: Game Theory
VIII. Interaction with others: Social Preferences

Today

Beyond the standard model: Prospect Theory

- Overview
- Value function and reference dependence
- Simple probability weighting
- Cumulative decision weights
- Overview and applications
- Challenges and limitations
- Beyond Prospect Theory: e.g. Regret Theory

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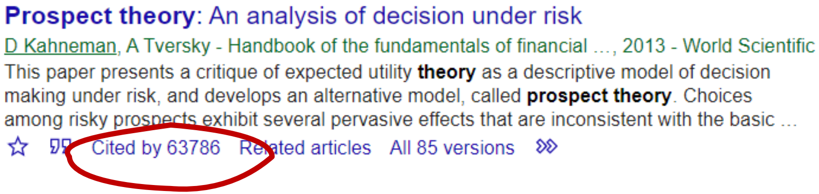
Prospect Theory (Kahneman and Tversky, 1979)

- 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
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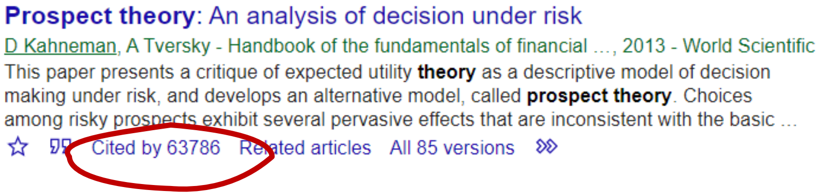
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Status Quo Bias

Knetsch (1989)

Experimental Design:

- Random classes of students receive a mug or chocolate
- Subjects are then asked whether they would like to keep their current good or change

What does this experiment measure:

- How the status quo affects preferences over two goods (chocolate and mugs)

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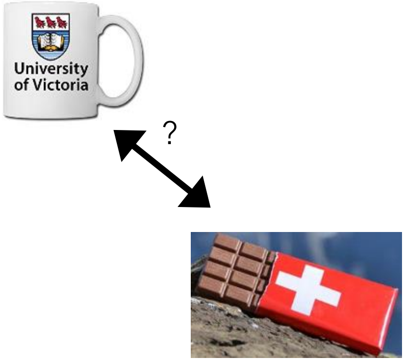
Status Quo Bias

Knetsch (1989)

Class 1	Class 2	Class 3
Student receives mug. Can change to chocolate	Student receives chocolate. Can change to mug	Student can choose between mug and chocolate



Status Quo Bias

Knetsch (1989)

Class 1	Class 2	Class 3
Student receives mug. Can change to chocolate	Student receives chocolate. Can change to mug	Student can choose between mug and chocolate
		
↓ ?	↓ ?	↔ ?
		
89% chose mug	**10%** chose mug	**59%** Chose mug

Status Quo Bias

Cognitive bias which results in people preferring that things stay as they are. The current status quo serves as a reference point, and any change from that baseline is perceived as a loss.

The Status Quo Bias

Apparently humans prefer the status quo and are reluctant to make decisions that might change the current situation.

Samuelson and Zeckhauser (1988) call this the *Status Quo Bias*.

Samuelson and Zeckhauser (1988) demonstrate that this effect does not only exist for relatively unimportant decisions like the choice between chocolate and mugs, but also in situations with large financial consequences.

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Example: Harvard University Clinic offered in the 80s a new optional health insurance for its employees. Already employed personnel had to choose between the new or the old insurance plan. Newly employed personnel also had to chose between the two insurance plans. New employees were significantly more likely to pick the new plan, while the other employees remained mostly in the old plan.

Similar effects have been observed for retirement and investment plans

The Endowment Effect

Kahneman,Knetsch and Thaler (1990)

You have *m* Euro and *0* mugs. How much do you value the mug?

How many *p Euros* would you be willing to pay for *one mug*? (**WTP**=willingness to pay)

$$(m-p,1) \sim (m,0)$$

The Endowment Effect

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(m-p,1)~(m,0)

You have *m Euro* and *1 mug*. How much do you value the mug?

How many *q Euro* would you accept as a price to sell *one mug*? (**WTA** = willingness to accept)

(m,1)~(m+q,0)

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WTA and **WTP** should be the same (no market power, no wealth effect)

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How many given *q Euro* would be equivalent to *one mug*?

(m+q,0)~(m,1)

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(m,1)~(m+q,0)

Obviously, the last two should be the same!

The Endowment Effect

Kahneman,Knetsch and Thaler (1990)

Experimental Design:

- Random classes of students receive a mug
- Subjects are then asked how much they value the mug

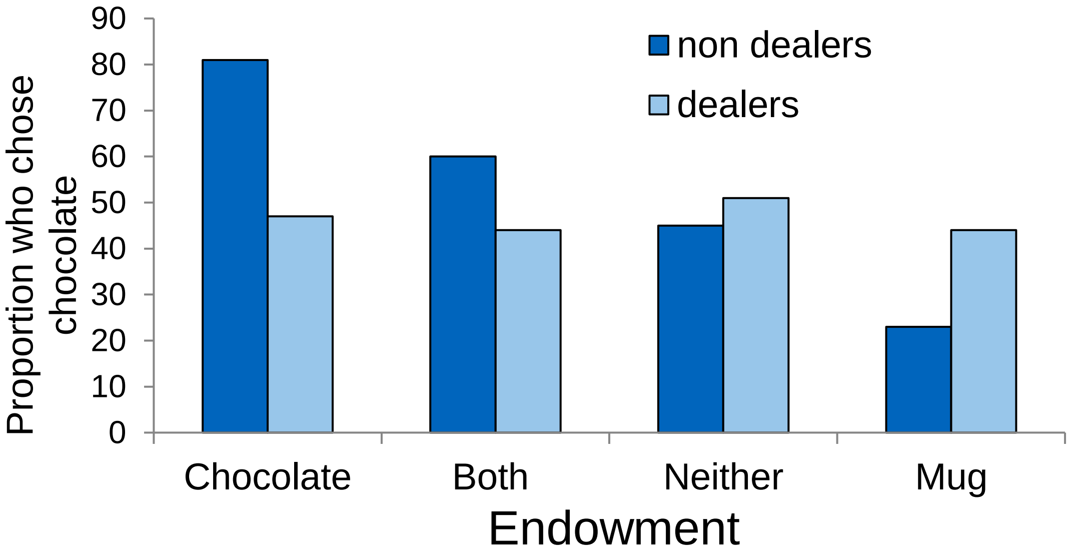
What does this experiment measure:

- How the possession changes the evaluation of a good

Endowment effect

List (2004)

People value more highly goods over which they have some sense of ownership.



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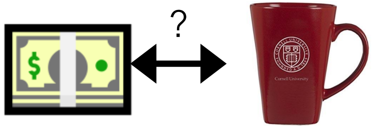
The Endowment Effect

Kahneman,Knetsch and Thaler (1990)

1/3 Students	1/3 Students	1/3 Students recive mug
How much are you willing to pay for this mug? (WTP) 	For different prices you have to decide between the money or the mug 	For wich amount are you willing to sell the mug? (WTA) 

What do you think happens? What should happen?

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The Endowment Effect

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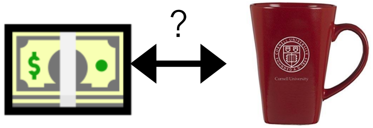
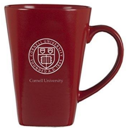
		
Median Price: **$2**	Median Price: **$3.5**	Median Price: **$7**

The Endowment Effect

One of the fundamental puzzles in decision theory. Decisions are not based on final material outcomes, but also on current endowments.

Richard Thaler (1980) coins this the Endowment Effect.

- Replicable with other goods (e.g., mugs, chocolate, pens,…)
- Replicable with non-market resources (e.g., clean environment, clean air,…)
- Replicable with chimpanzees
- Meta-study (Horowitz & McConell, 2002) finds big differences between WTP & WTA:

$$\text{Median}\left(\frac{\text{Mean } WTA}{\text{Mean } WTP}\right) = 2.6$$

Status Quo Bias

Cognitive bias which results in people preferring that things stay as they are. The current status quo serves as a reference point, and any change from that baseline is perceived as a loss.

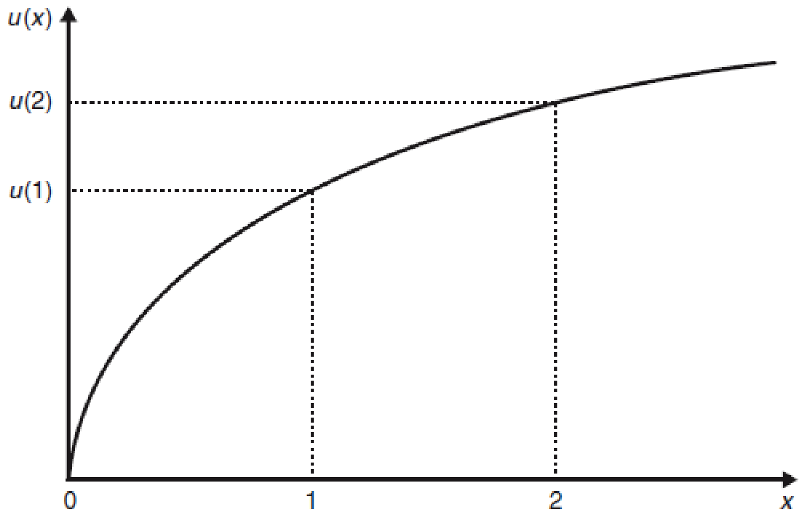
Endowment Effect

When people ascribe more value to things just because they own them.

Implications to the standard model

Can the standard model accommodate the endowment effect?

Thus, owning one mug gives you u(1) units of utility. When you move from zero to one mug (rightwards along the x-axis), your utility increases from….



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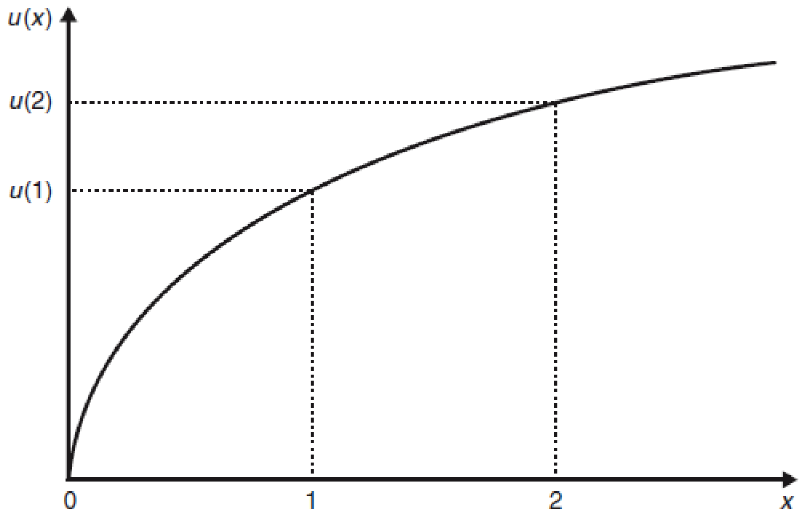
Implications to the standard model

Numerical example:

Suppose $u(x) = 3\sqrt{x}$…



Reference Points

Need a different theory to account for these phenomena

A possible explanation for Endowment Effect and Status Quo Bias is that humans value things relative to a reference point.

Reference point and loss aversion

Losses compared to a reference point weigh heavier than gains of the same size

- Endowment Effect: Selling the mug is associated with the loss of the mug and the gain of the money
- Status Quo Bias: Giving up the mug is a loss, the traded chocolate is a gain

Reference dependent utility

How to incorporate this into an utility function?

We can use a value function to measure gains and losses. The reference dependent utility of getting x when the reference level is r is given by

$$u^r(x) = \eta u(x) + v(x - r).$$

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Reference dependent utility

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First part of the utility function is the direct utility from consuming x, the second part is the utility derived from meeting/exceeding/falling short of the reference point.

A person is loss averse if a loss causes a bigger fall in utility than a similar sized gain causes an increase in utility. So, losing $\$g$ is worse than not gaining $\$g$.

$$-v(-g) > v(g).$$

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Big implications for markets and individuals

- Health insurance, retirement savings (previous example)
- Housing market (later)
- Labor market (later)

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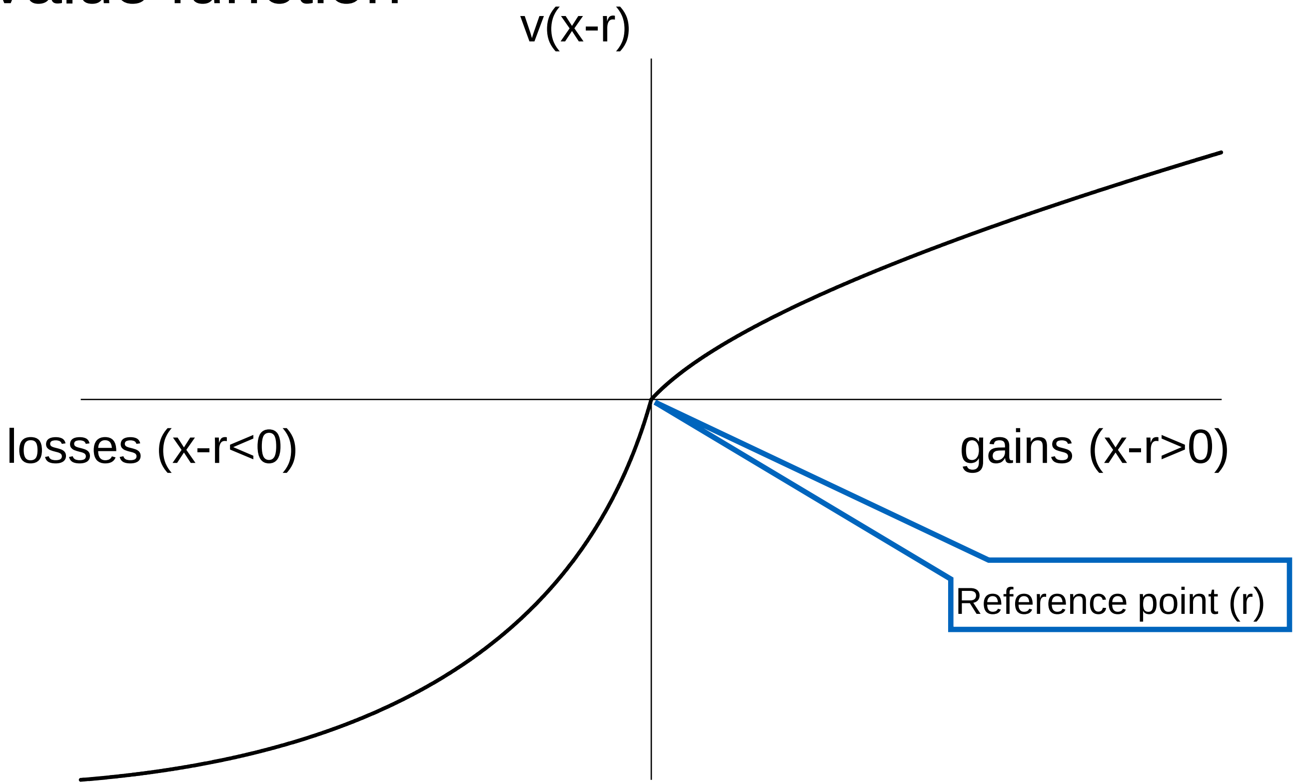
Value function



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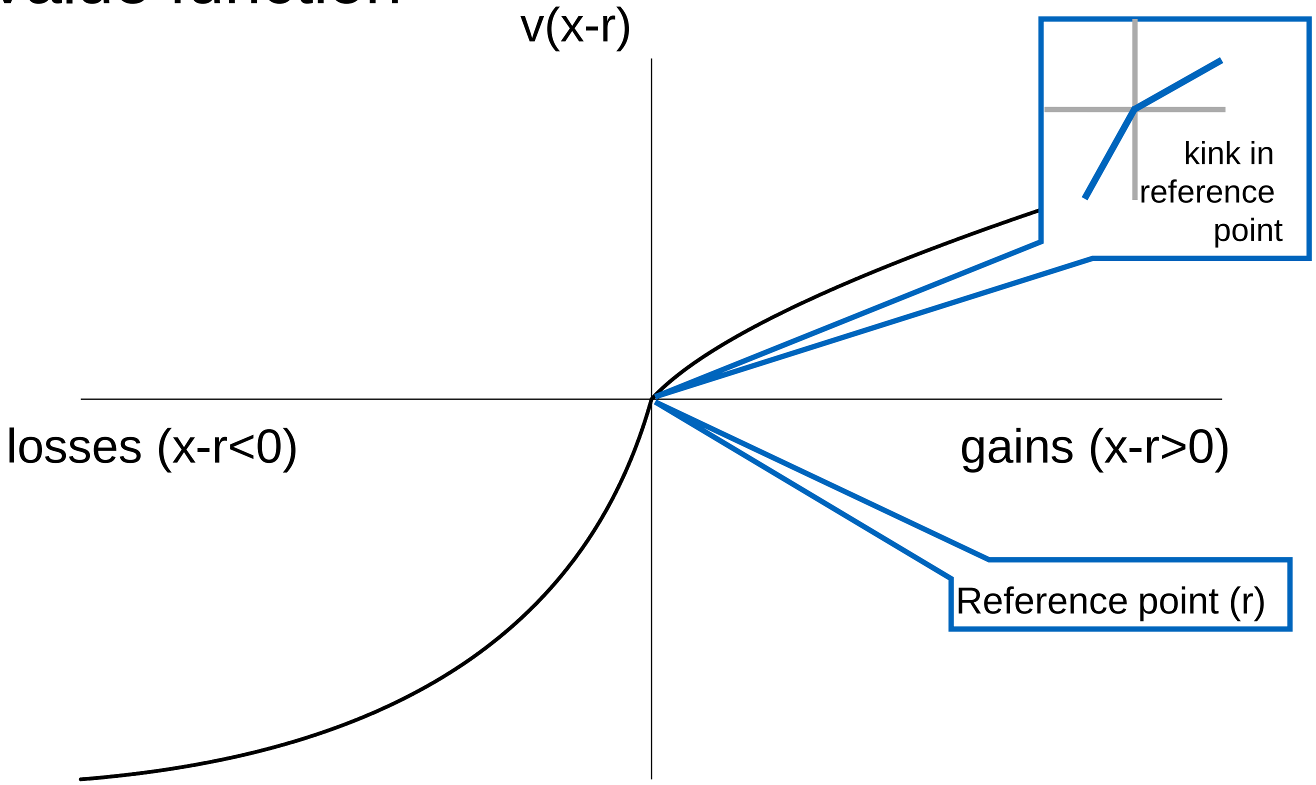

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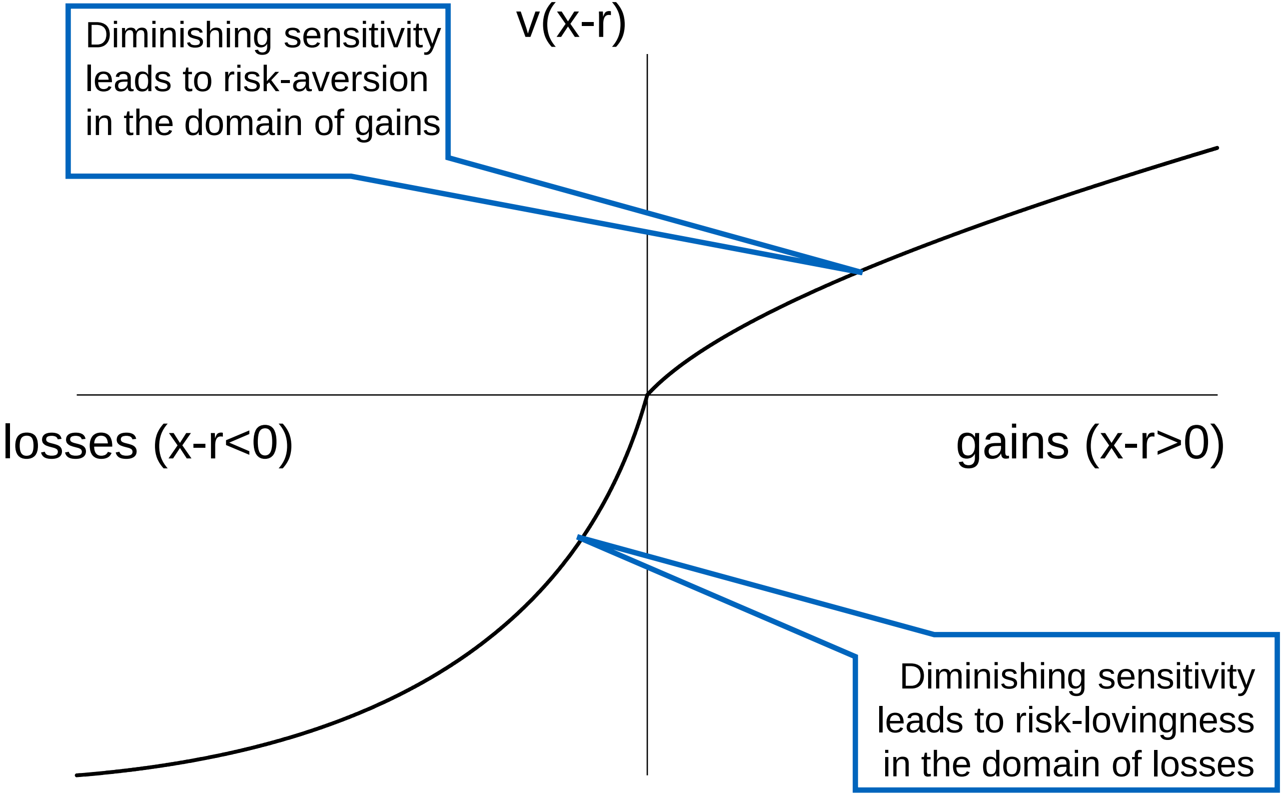

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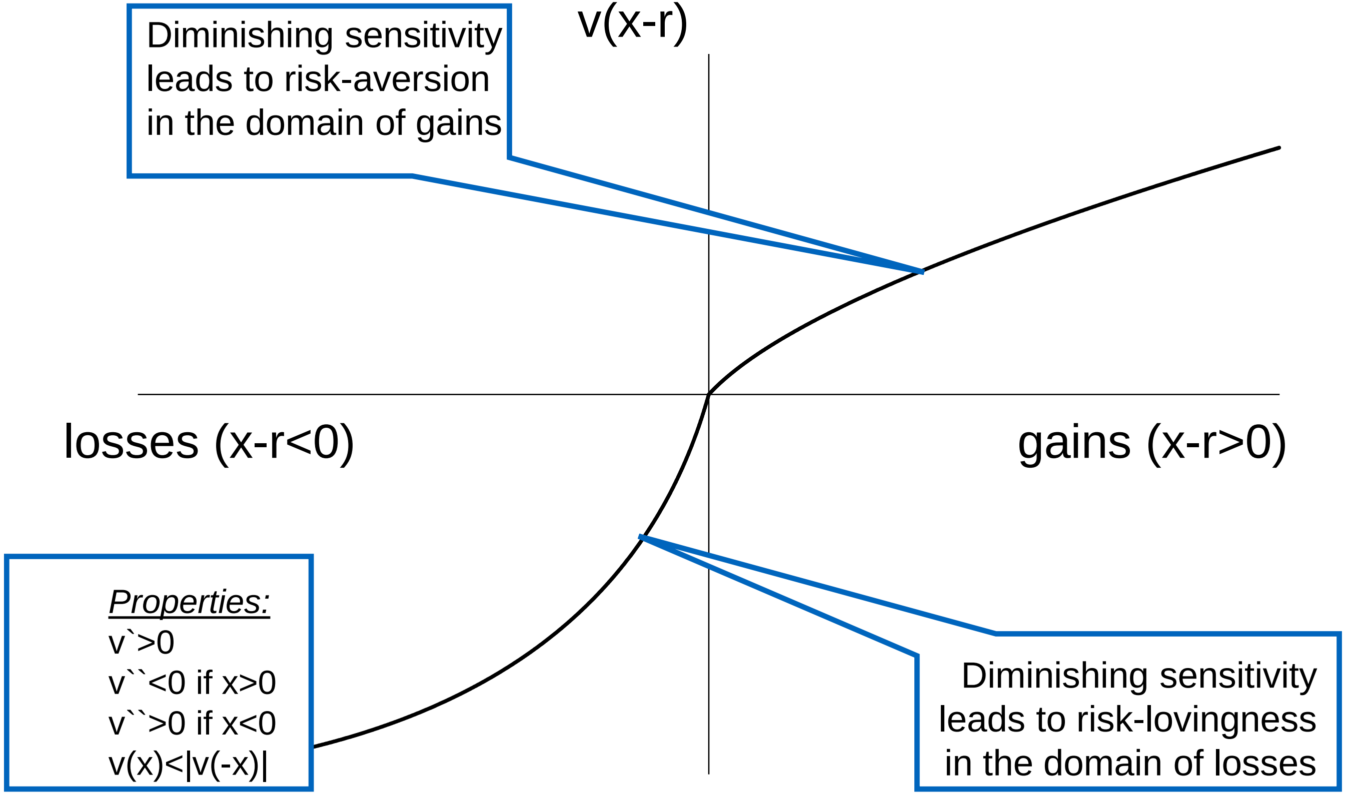


Endowment effect under reference dependence

- Suppose your utility function over mugs is given by

$$v(x) = \begin{cases} u_G = x/2, & x \geq 0 \\ u_L = -2.25(-x), & x < 0 \end{cases}$$

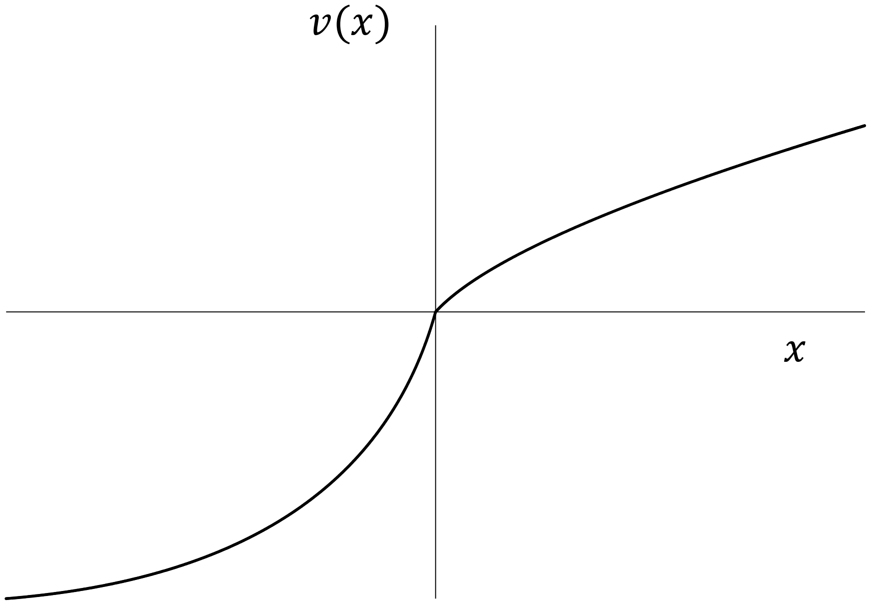
- The amount of utility of receiving one mug from 0 mugs is:

$$u_G(1) = \frac{1}{2} = 0.5$$

- The amount of utility lost from giving away that first mug is:

$$u_L(1) = -2.25 = -2.25$$

- Willingness To Accept: money corresponding to offsetting the disutility of losing one mug.
- Willingness To Pay: money corresponding to the positive utility of obtaining one mug.
- Disutility of losing one mug looms larger than the utility of obtaining one mug
- This would be in accord with empirical evidence that WTA>WTP and can explain the endowment effect



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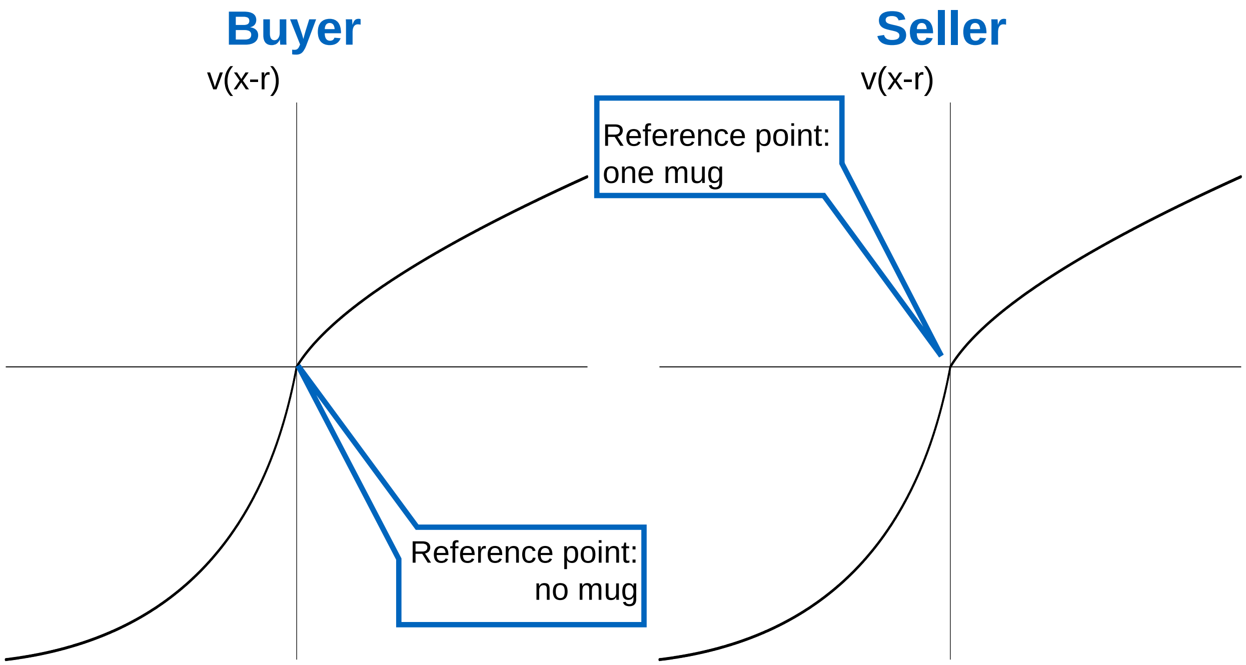

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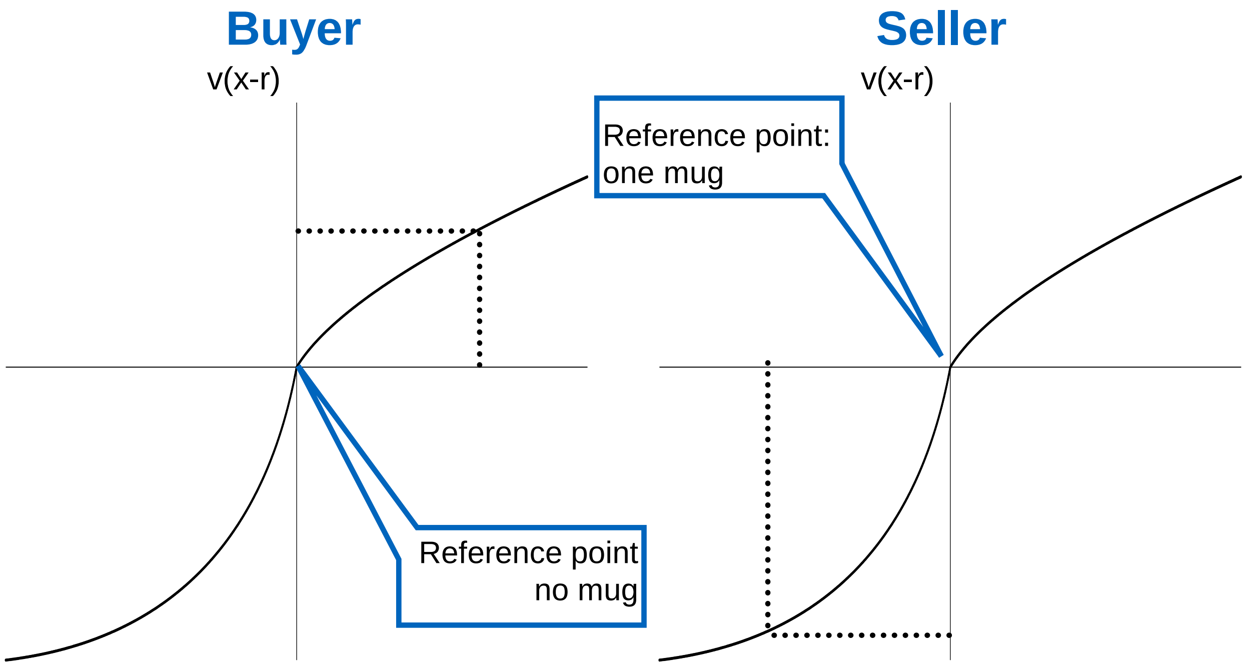

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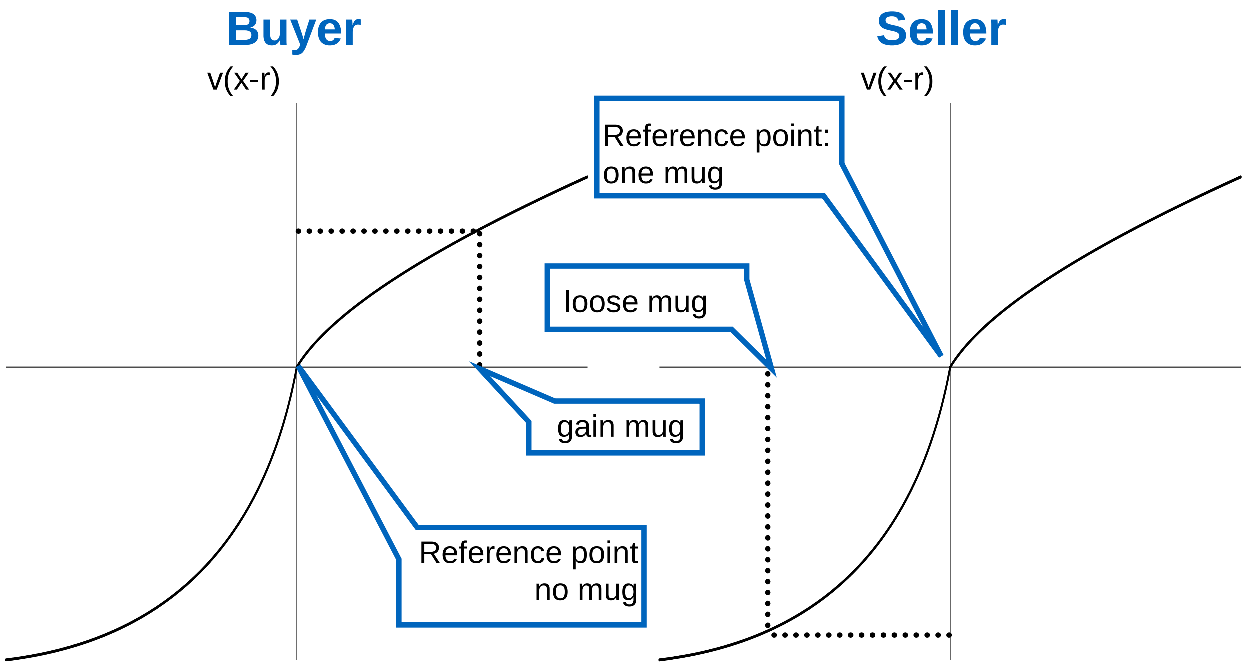

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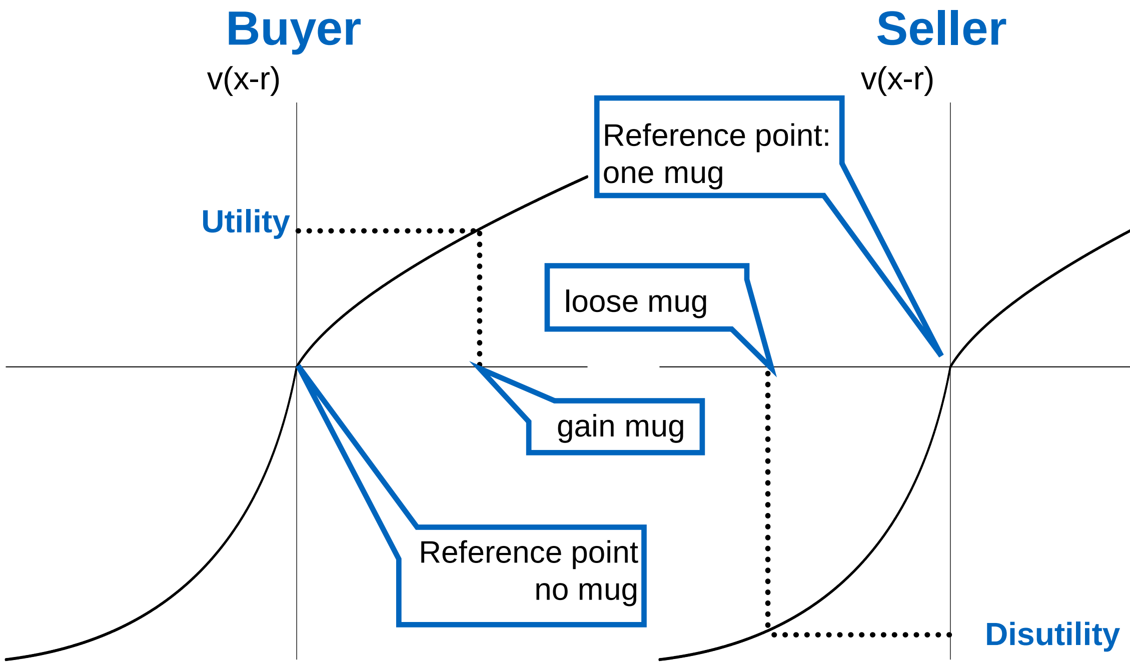


Value function overview

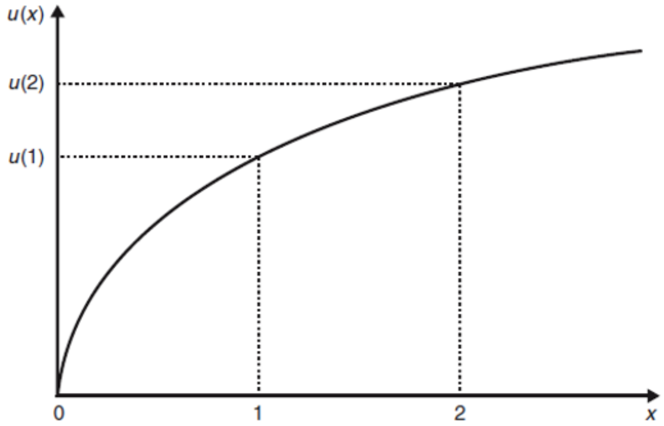
- Prospect Theory’s value function uses 3 psychological concepts:
  - **Reference dependence**: preference are defined on a reference point as well as on consequences. Unlike Expected Utility Theory, total wealth is not important – only changes to wealth given a reference point.
  - **Diminishing sensitivity**: The impact of increasing a gain or loss by some amount gets smaller with the size of that gain or loss. For example, the impact of increasing a gain from $0 to $1 is larger than the impact of increasing a gain from $1000000 to $1000001
  - **Loss aversion**: losses loom larger than gains.

- Unlike the probability weighting function, the value function is common between first generation (Prospect Theory) and second generation (Cumulative Prospect Theory)

Value function under Expected Utility

Standard model

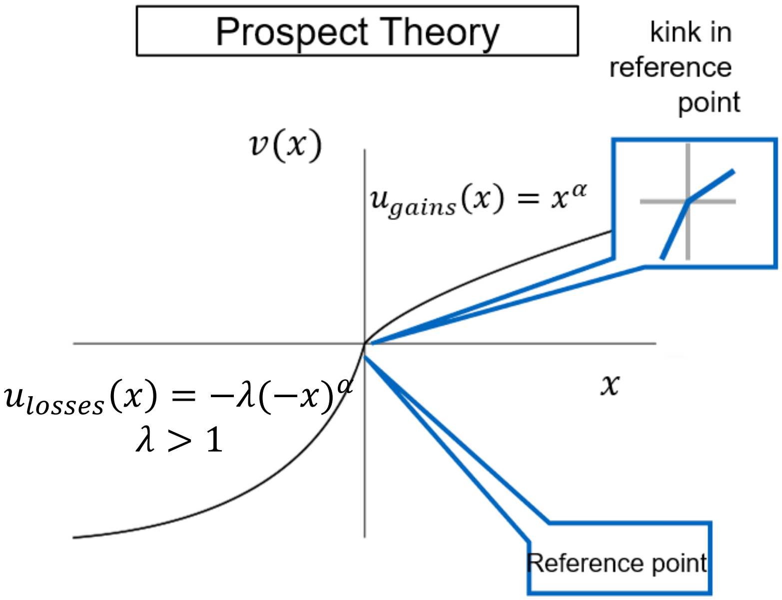
e.g. $u(x) = x^{\alpha}, 0 < \alpha < 1$



$$EU(L) = \sum_i p_i u(x_i)$$

- No reference point – all that matters is the shape (concavity) of the function.
- If u() is concave -> 0<α<1 -> risk averse (like in the picture)
- If u() is convex -> α>1 -> risk seeking
- If u() is linear -> α=1 -> risk neutral (special case of EUT)

Value function: functional form



$$\boldsymbol{PT}\text{: } V(L) = \sum_i \pi_i v(x_i)$$
$$= \Sigma_{Gains} \pi_i u_G(x_i) + \Sigma_{Losses} \pi_i u_L(x_i)$$

- $v(x_i)$ differs from $u(x_i)$ in that losses are treated differently than gains (x_i) - reference dependence. And specifically, “losses loom larger than gains” – loss aversion.
  - How much larger? λ times larger (usually $\lambda = 2.25$)

Framing and reference dependence

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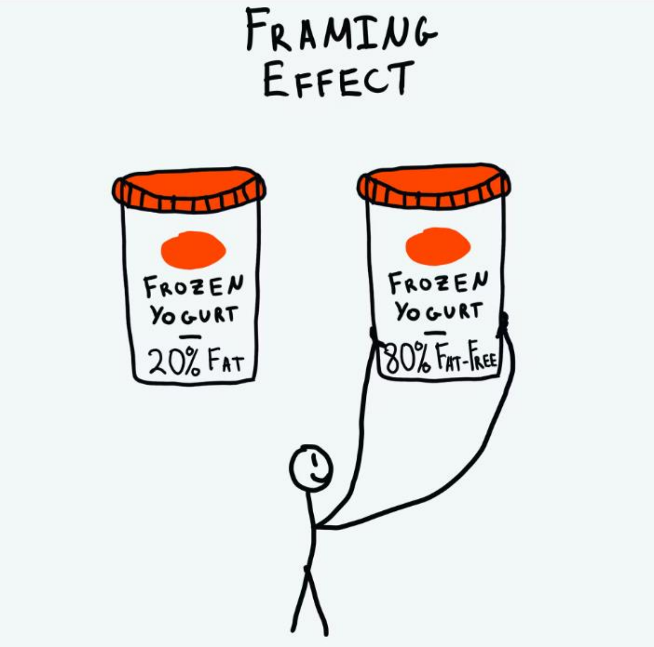


Reference dependence and framing

The endowment effect and reference point phenomena are instances of framing effects, which occur when people's preferences depend on how the options are framed. There are many kinds of framing effects.

- In 2007, the Associated Press reported that Irishman David Clarke was likely to lose his license after being caught driving 180 km/h (112 mph) in a 100 km/h (62 mph) zone. However, the judge reduced the charge, "saying the speed [in km/h] seemed 'very excessive,' but did not look 'as bad' when converted into miles per hour." The judge's assessment appears to depend on whether Clarke's speeding was described in terms of km/h or mph.
- Similarly, people traveling to countries with a different currency sometimes fall prey to what is called money illusion. Even if you know that one British pound equals about one and a half US dollars, paying two pounds for a drink might strike you as better than paying three dollars.
- Remember the calculator or stereo example: a $5 discount on the 15$ calculator is 33% saving while on the $125 stereo is only 4%. In both cases, however, one would save $5.

Context and framing effects

Framing Effects

Essentially equivalent descriptions of the same facts lead to different choices.

Reference dependence and loss aversion applied

Many companies have 30-day-no-questions-asked return policies (rarely used).
Although costly in other ways, such policies may serve to convince a customer who otherwise would not make the purchase to take the product home and try it out.

Loss aversion helps explain why politicians argue about whether cancelling tax cuts amounts to raising taxes. Voters find the foregone gain associated with a cancelled tax cut easier to stomach than they do the loss associated with a tax increase. Consequently, politicians favoring higher taxes will talk about “cancelled tax cuts” whereas politicians opposing higher taxes will talk about “tax increases.”

Reference dependence and loss aversion applied

Shift your reference point: example of checking stocks infrequently
Charity giving: What would pay for this if I didn’t have it already? WTP vs WTA. Might make it easier to donate some of your old clothes.
Create hypothetical alternatives. Should you splurge on family trip. What else could you spend the money? Additional retiring savings, a different vacation?

Can you think of real-life examples where the endowment effect played a role?
Can you think of an example where you used a reference point to simplify one of your decisions?

Evidence of reference dependence: silver medallists

- Bronze medallists appear happier than silver.
- Silver medallists: focus on what they failed to achieve? Gilovich, 1995

Evidence of reference dependence/ loss aversion: NY taxi drivers

- Classical labor supply prediction: temporary increase (decrease) in wages -> increase (decrease) in working hours
- Cab drivers earn more on rainy days. Do they work more?
- No, they work up to a threshold (their daily target) and then stop (early). And they work more when they earn less per hour
  - Not meeting daily target perceived as a loss
  - Camerer et al., (1997), Farber (2005; 2008)
  - If they had worked longer on rainy days and shorter on sunny days, they would had made more money (10% more on average), while having worked the same amount
- A lesson about productivity? Do you do the same when studying?

Diminishing sensitivity

Ernst Weber experiments, 19th century

Asked subjects to lift one object and then another, and make a guess whether one was heavier.

He found that the difference in weight needed to guess correctly was a constant proportion of the weight

For example,

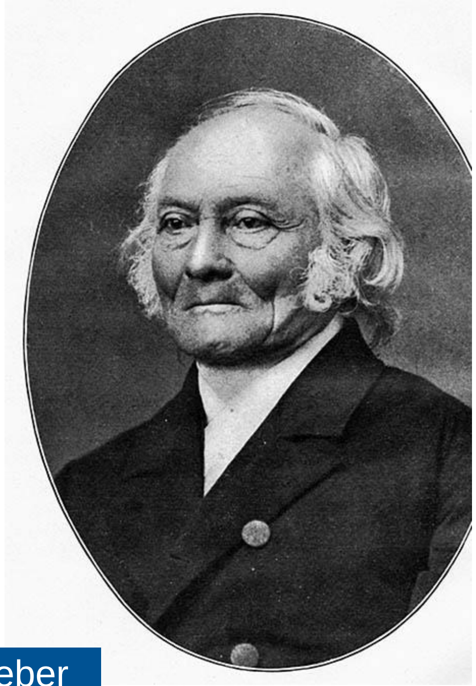
The difference needed to discriminate two stimuli, is a constant proportion of their magnitude

$\Delta R/R = k$

ΔR: amount of stimulation needed for a “just-noticeable difference”

R: amount of existing stimulation

k: constant



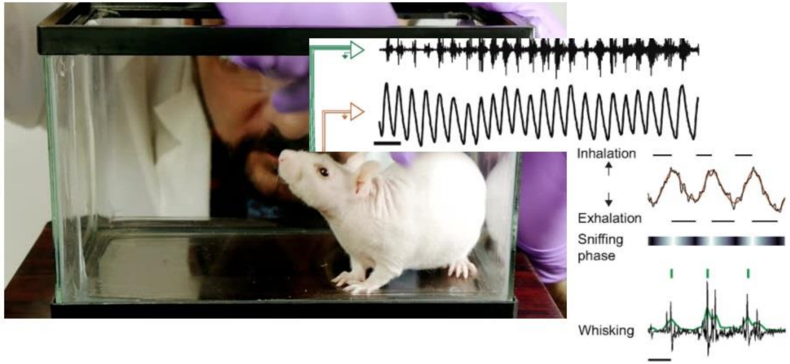
Ernst Weber

Evidence from other disciplines: Biology

- Lakshminaryanan et al, (2008): Capuchin monkeys trained to trade coins for apples or cereal cubes.
- Monkeys are indifferent between apples and cereal cubes when they both cost one token. But, if the price of apples increases, they will only buy cereal cubes.
- Endowed with apples and asked to trade: only traded 10% of the time: endowment effect in monkeys!
- It’s not that they did not know how to trade: When the cereal cubes were replaced with fruit roll ups filled with marshmallows (which they love), monkeys traded 90% of the time.

Evidence from other disciplines: Neuroscience

- Dopamine neurons correspond to the “pleasure chemical” in the brain.
- Neuroscientific experiments with animals show evidence of a “reward prediction error”.
    - Schultz et al., 1997
- Dopamine neurons do not respond to rewards themselves but to the difference between expectation and reality. Expectation acting as a “reference point” in this case.



Today

VI. Decisions Under Risk and Uncertainty (II)

- Prospect Theory and Cumulative Prospect Theory
  - Overview
  - Value function and reference dependence
  - Simple probability weighting
  - Cumulative decision weights
  - Overview and applications
  - Challenges and limitations
  - Beyond Prospect Theory: e.g. Regret Theory

Probability: why is it so hard?!

- The notion of a “probability” was always counter intuitive for humans
  - Remember the “conjunction fallacy”, “blinking lights” but see also “gambler’s fallacy”, “Ellsberg’s paradox”, etc.
- Maybe people struggle to make peace with the fact that uncertainty is fundamental. After all, something either happens or it does not.
  - Science for a long time: there are no fundamentally uncertain states – only lack of knowledge

Probability: why is it so hard?!

- A formal mathematical theory did not exist until 1654
- Antoine Gombaud: *how do you decide who won if a game gets abruptly interrupted?*

Anotine Gombaud

Probability: why is it so hard?!

- A formal mathematical theory did not exist until 1654
- Antoine Gombaud: *how do you decide who won if a game gets abruptly interrupted?*
- The problem got the attention of famous mathematicians: Blaise Pascal and Pierre de Fermat

Blaise Pascal

Pierre de Fermat

What is probability?

- What is the probability that heads will turn after flipping a fair coin?
- The answer most people will give is 50%.
- What does this mean?
- Frequentist approach (perhaps the most common):
  - Think of it as a series of repeated experiments.
  - If I were to flip a coin a lot of times, then on average, I would get head approximately half of the time.
  - Notice the use of the Law of Large numbers…

What is probability

- The frequentist approach is not the only approach to the concept of probability.
- There is another way of interpreting (and modelling) probabilities. According to Bayesian approach probability is a belief. Despite the “subjective” nature of this second approach, this belief cannot be arbitrary – it must follow the notions of probability theory.
  - Optional. See here for an interesting philosophical discussion regarding the frequentist and the Bayesian approach: https://www.youtube.com/watch?v=GEFxFVESQXc&ab_channel=CassieKozyrkov

Probability theory 101

- **Experiment**: any process or procedure for which more than one outcome is possible
- **Sample space**: a set consisting of all the possible outcomes: $O_1, O_2, \dots O_n$
- **Probabilities**: $p_1, p_2 \dots , p_n$
- We say that the probability of **outcome** O_i is p_i and we write: $P(O_i) = p_i$
- Example: “Roll a 4 in a normal dice game” (the experiment is the roll of the dice).
  - Sample Space: {1,2,3,4,5,6}. Outcome: 4. $P(roll\ a\ 4) = \frac{1}{6}$
- In order for a probability measure to be valid it has to satisfy:

$$0 \leq p_i \leq 1, for\ every\ i$$

and

$$\Sigma p_i = p_1 + p_2 + \cdots + p_n = 1$$

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…

Allais' paradox through EUT

- Choice scenario 1: A=(2500, 0.33; 2400, 0.66; 0, 0.01) or **B=(2400,1)**
- Choice scenario 2: **C=(2500, 0.33; 0)** or D=(2400, 0.34; 0)

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

$$u(2400) > 0.33u(2500) + 0.66u(2400) + 0.01u(0) \Rightarrow$$

$$0.34u(2400) > 0.33u(2500) \qquad (I)$$

- Preferring Prospect C over Prospect D implies that $EU(C) > EU(D) \Rightarrow$

$$0.33u(2500) > 0.34u(2400) \qquad (II)$$

Clearly, I and II cannot be true at the same time.

Allais' paradox through Prospect Theory

Preferring Prospect B=(2,400, p=1) over Prospect A=(2,400,p=0.66; 2,500,p=0.33;0,p=0.01) implies that:

$$v(2400) > \pi(0.66)v(2400) + \pi(0.33)v(2500) + 0 \Rightarrow$$

$$[1 - \pi(0.66)]v(2400) > \pi(0.33)v(2500) \qquad I$$

Preferring Prospect C=(2,500, p=0.33; 0, p=0.67) over Prospect D=(2,400,p=0.34; 0,p=0.66) implies that:

$$\pi(0.33)v(2500) > \pi(0.34)v(2400) \qquad II$$

Taking I and II together we get that:

$$1 - \pi(0.66) > \pi(0.34) \Rightarrow \pi(0.66) + \pi(0.34) < 1$$

Allais paradox through Prospect Theory

$$\pi(p) + \pi(1 - p) < 1$$

- Unlike probabilities, probability weights do not (necessarily) add up to 1.
- The fact that probability weights of complementary events add up to less than one, is referred to as ***sub-certainty***.
- Subcertainty captures an essential element of people's attitudes to uncertain events, namely that the sum of the weights associated with complementary events is typically less than the weight associated with the certain event.

Preference for lotteries and insurance

Choice scenario III: **E=(5000,0.001;0)** or F=(5,1)
Choice scenario IV: G=(-5000, 0.001;0) or **H(-5,1)**

From *(I)*=> $\pi(0.001)v(5000) > v(5) \Rightarrow \pi(0.001) > \frac{v(5)}{v(5000)}$ assuming that v is concave (for gains) this implies that $\pi(0.001) > 0.001$ so $\pi(p) > p$, for small p.

$$e.g. u_G = x^{0.5} \Rightarrow \pi(0.001) > \frac{2.235}{70.710} = 0.031 > 0.001$$

The readiness to pay for insurance in *(IV)* implies the same conclusion, assuming the value function for losses is convex. Specifically: $v(-5) > \pi(0.001)v(-5000)$

$e.g. u_L = -\lambda(-x)^{0.5} \Rightarrow -\lambda 5^{0.5} > \pi(0.001)(-\lambda)5000^{0.5} \Rightarrow ..\text{dividing both sides with "-λ"}\ changes\ the\ inequality \Rightarrow$

$$\pi(0.001) > \frac{5^{0.5}}{5000^{0.5}} = \frac{2.235}{70.710} = 0.031 > 0.001$$

Taken together

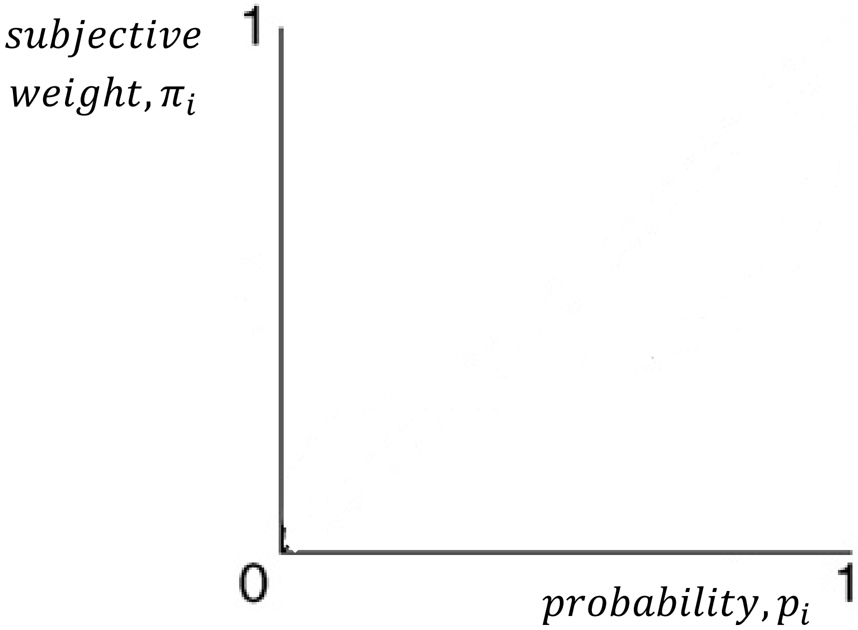
- Subcertainty: $\pi(p) + \pi(1-p) < 1$
- Overweighting small probabilities: $\pi(p) > p,$ for p close to 0 (e.g. p<0.25).
- Combining the two implies that $\pi(p) < p,$ for p close to 1: underweighting large probabilities (e.g. p>0.75)
  - Why? Consider the alternative, for which $\pi(p) > p$, for p close to 1 too. Then

$$\pi(p) + \pi(1-p) > p + 1 - p = 1$$

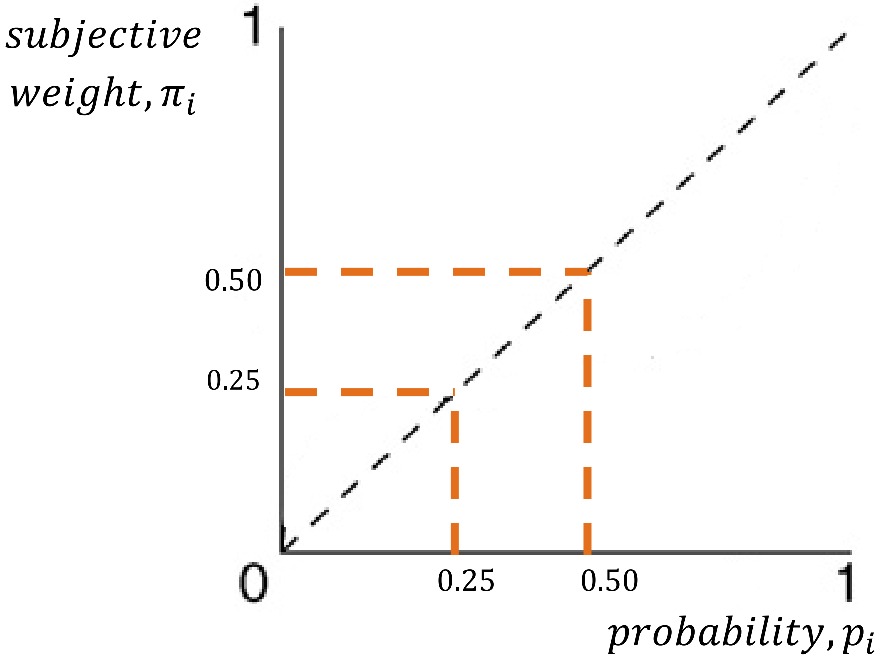
Taken together

- Subcertainty: $\pi(p) + \pi(1-p) < 1$
- Overweighting small probabilities: $\pi(p) > p,$ for p close to 0 (e.g. p<0.25).
- Combining the two implies that $\pi(p) < p,$ for p close to 1: underweighting large probabilities (e.g. p>0.75)
- Note: overweighting small probabilities and underweighting large probabilities implies limited sensitivity to mid-range probabilities (e.g. $0.25 \leq p \leq 0.75$).

How do people treat probabilities in their decisions?

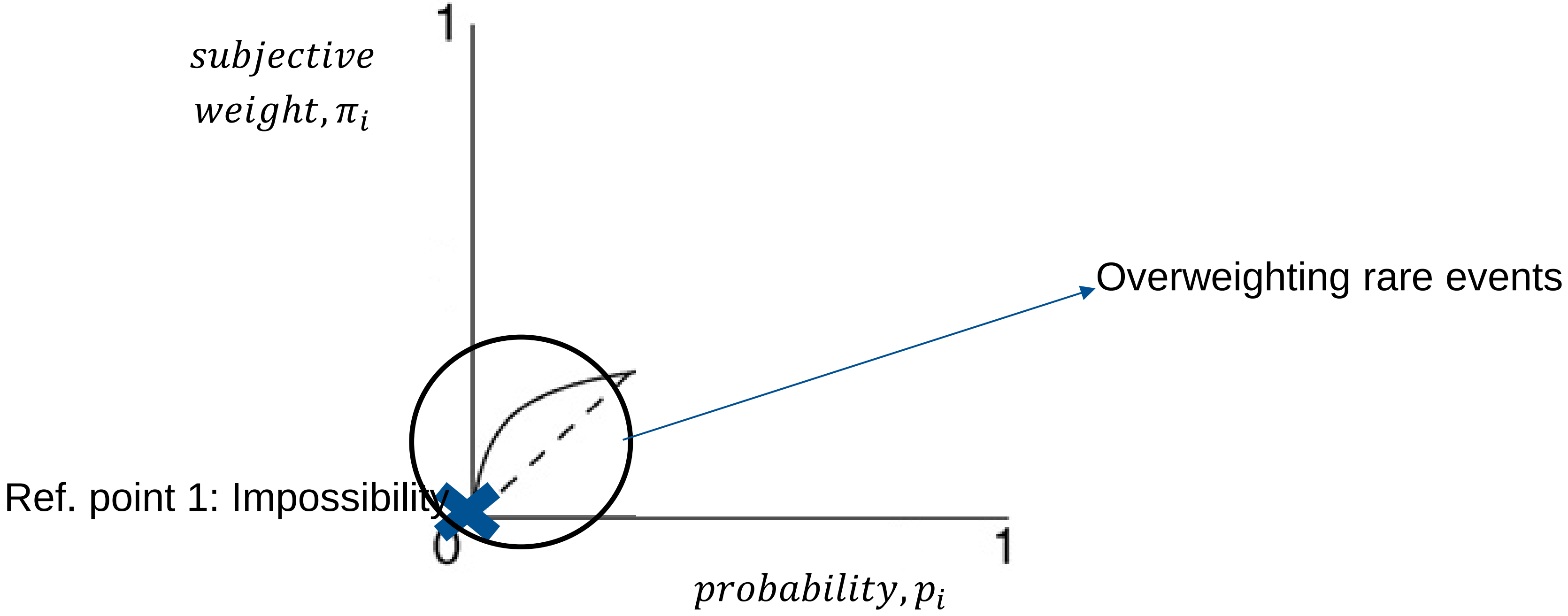


Standard model

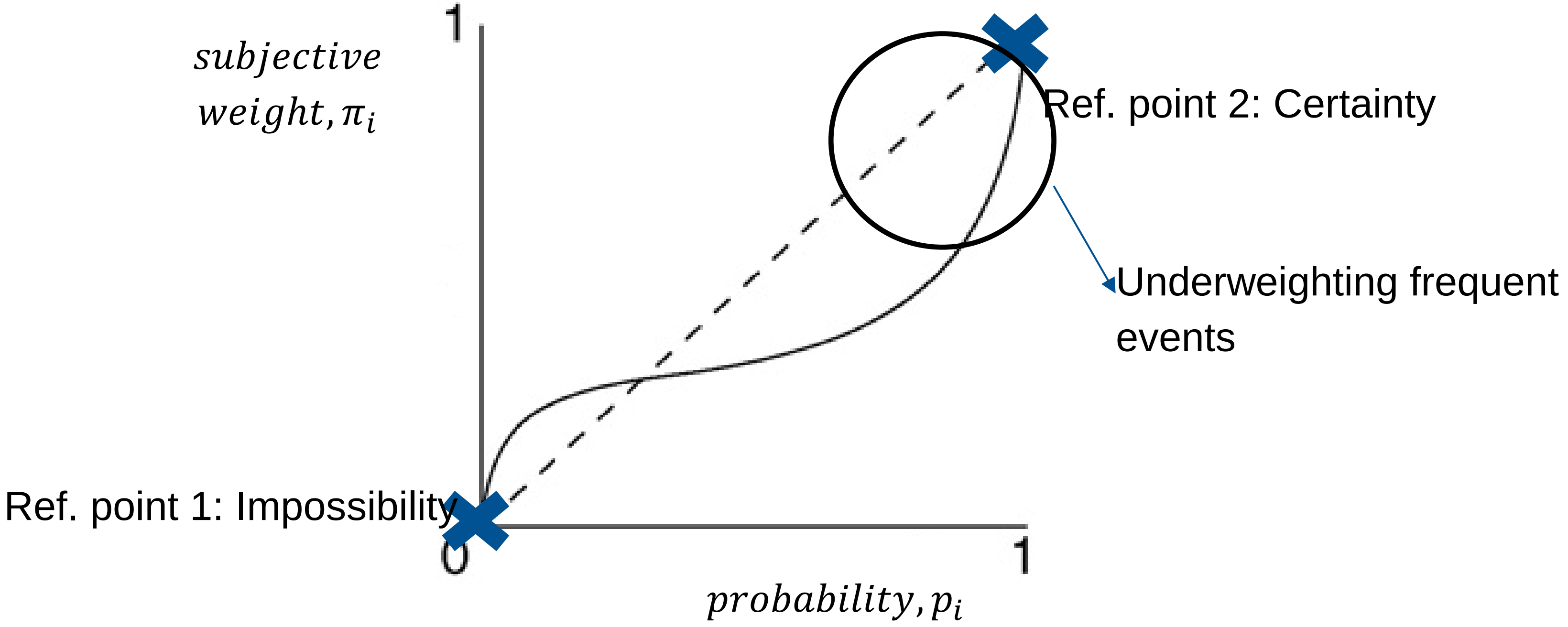


$$\Sigma\pi_i = 1$$
$$p_i = \pi_i, \forall\ i$$
$$\pi(0.50) = 2 * \pi(0.25)$$

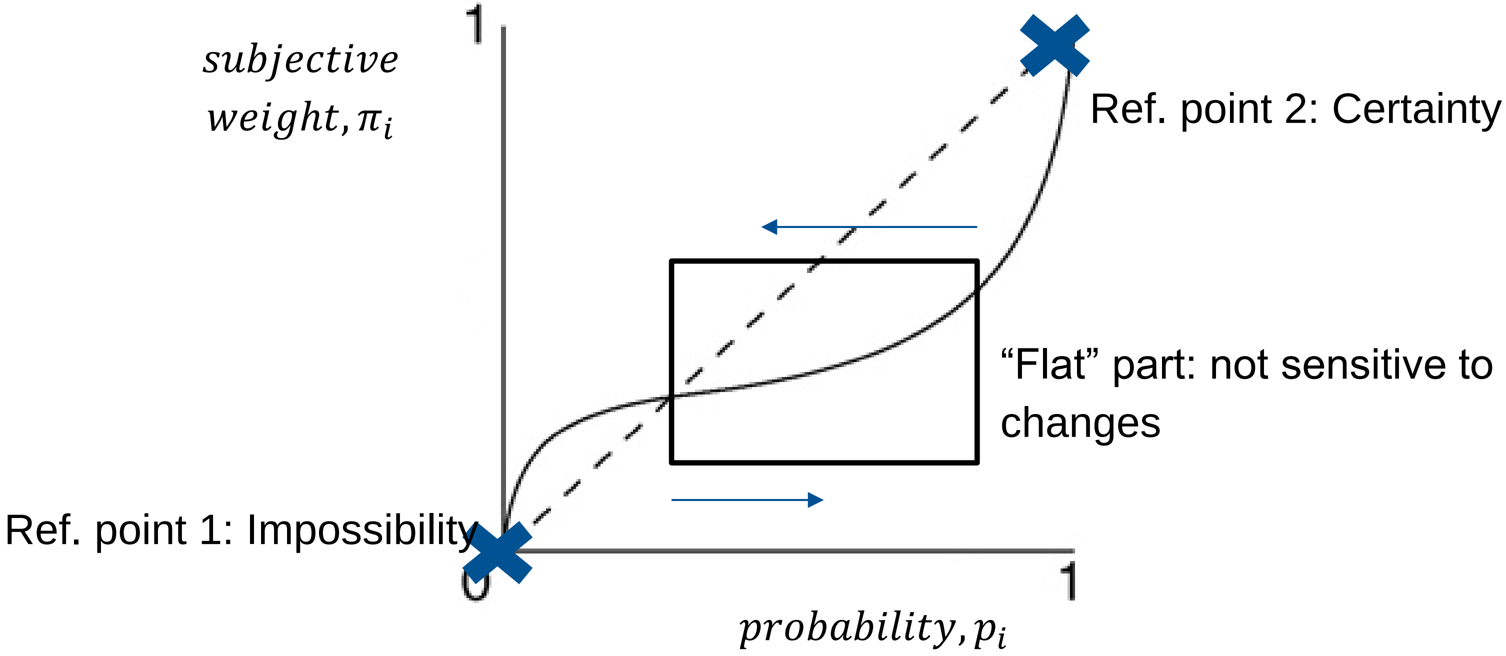
Probability weighting: reference points + dim. sensitivity



Probability weighting: reference points + dim. sensitivity



Probability weighting: reference points + dim. sensitivity



A drawback of simple probability weighting

- Consider a choice between: $A: (\$20, 0.5; \$10, 0.5)$ or $B: (\$10, 0.99; \$0, 0.01)$
- Notice that A (first order stochastically) dominates B. That is, for every outcome x, A gives at least as high a probability of receiving at least x as does B, and for some x, A gives a higher probability of receiving at least x.
- Let:
  - u(20) = 2; u(10) = 1; u(0) = 0
  - $\pi(0.5)$ = 0.25 and $\pi(0.99)$= 0.95.
- Then, if $\mathrm{V}(L) = \sum_i \pi(p_i)\, u(x_i)$, we have $\mathrm{V(A)} = 0.75 < 0.95 = \mathrm{V(B)}$
- So: Simple probability-weighting of this form permits choice of a dominated gamble.
- To avoid this, 1st generation prospect theory postulated an editing phase.
- As the editing phase restricts mathematical tractability, a second generation of PT was developed

Today

Beyond the standard model: Prospect Theory

- Overview
- Value function and reference dependence
- Simple probability weighting
- Cumulative decision weights
- Overview and applications
- Challenges and limitations
- Beyond Prospect Theory: e.g. Regret Theory

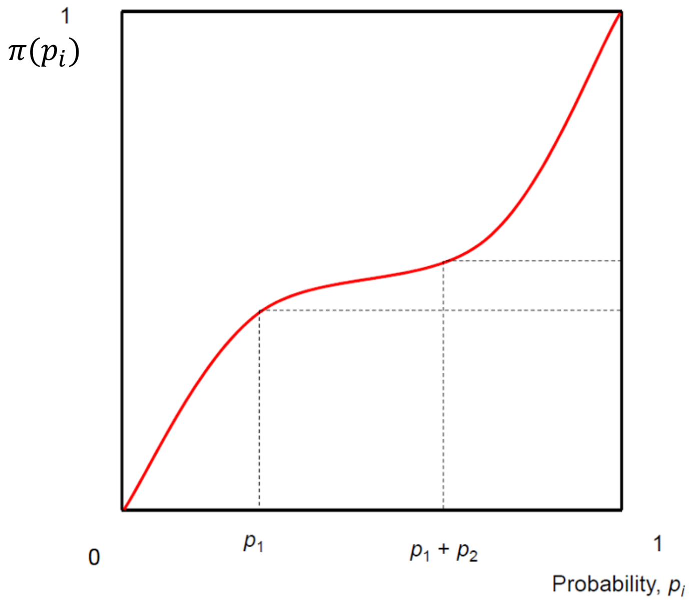
Cumulative Prospect Theory

- Second generation of Prospect Theory: Cumulative Prospect Theory (1992; Tversky & Kahneman)
- Borrows an idea from Rank Dependent Utility theories (see Quiggin, 1982).

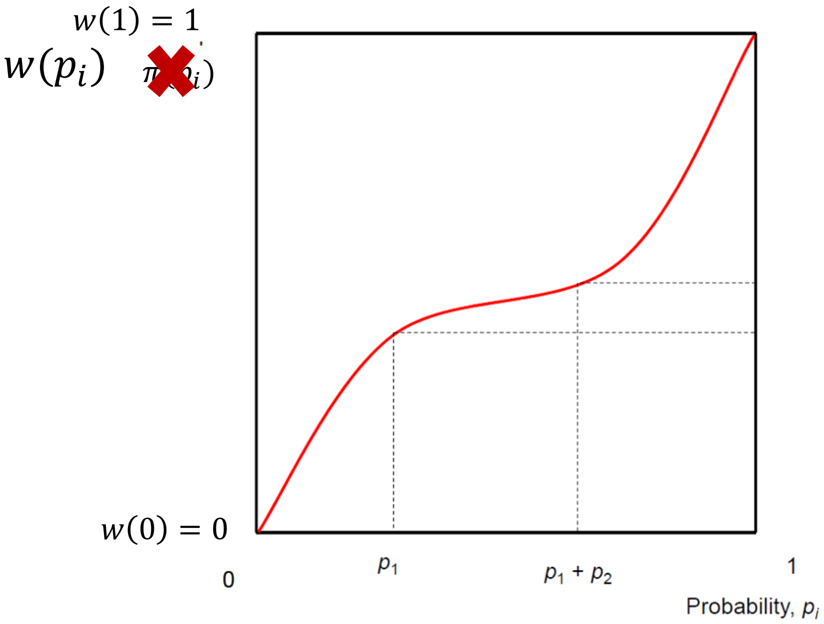
$$V(L) = \sum_i \pi_i v(x_i)$$

- The function form resembles that of original PT but π_i are now modified:
- π_i: are decision weights. They are no longer a simple transformation of p. Instead, they depend on the **position** of x_i in the ordering of outcomes as well as on probabilities.
- $w(p)$: probability weighting function. It replaces the role of $\pi(.)$ in first generation PT.

From probability weights ($w(p_i)$) to decision weights π_i



From probability weights ($w(p_i)$) to decision weights π_i



Probability transformation takes place in two steps now.

1. First through a probability weighting function and then
2. through a cumulative decision weight rule.

Under Cumulative Prospect Theory: probability weights and decision weights are two different things.

From probability weights $w(p_i)$ to decision weights π_i

- Let's consider $L = (x_1, p_1; x_2, p_2; x_3, p_3)$
- Let $\pi_i = w(pr. outcome\ is\ at\ least\ as\ good\ as\ x_i) - w(pr. outcome\ is\ strictly\ better\ than\ x_i)$
- Example: $X = \{x_1, x_2, x_3\}, with\ x_1 \succ x_2 \succ x_3$. Then the decision weights are:

$$\pi_1 = w(p_1) - w(0) = w(p_1)$$

$$\pi_2 = w(p_1 + p_2) - w(p_1)$$

$$\pi_3 = w(p_1 + p_2 + p3) - w(p_1 + p_2) = w(1) - w(p_1 + p_2) = 1 - w(p_1 + p_2)$$

- Note: $\pi_1 + \pi_2 + \pi_3 = 1$

- Decision weights add to 1 (but probability weights not necessarily)

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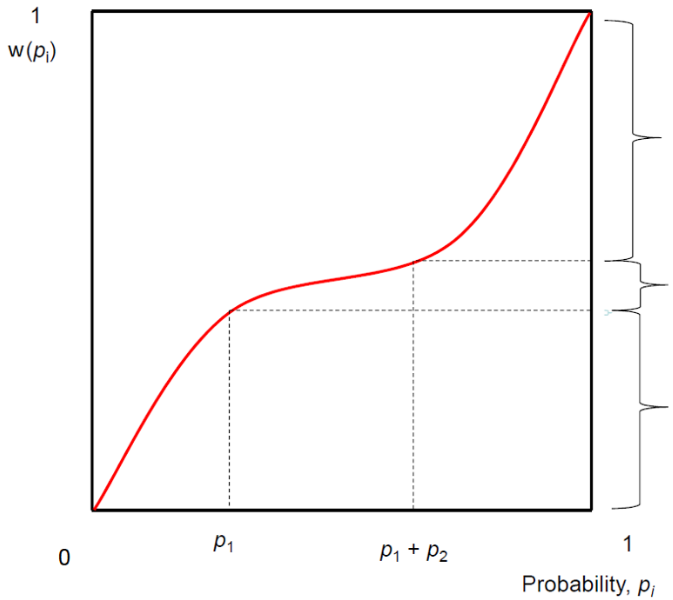
From probability weights ($w(p_i)$) to decision weights π_i



$\pi_3 = 1 - w(p_1 + p_2)$

$\pi_2 = w(p_1 + p_2) - w(p_1)$

$\pi_1 = w(p_1)$

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Intuition

- $V(L) = w(p_1)v(x_1) + \big(w(p_1 + p2) - w(p_1)\big)v(x_2) + (1 - w(p_1 + p_2)v(x_3) \Rightarrow$
  $\Rightarrow v(x_3) + \big(v(x_2) - v(x_3)\big)w(p_1 + p_2) + \big(v(x_1) - v(x_2)\big)w(p_1)$
- Interpretation: $V(L)$ has three components:
  - Utility of getting at least x_3 is guaranteed
  - Extra utility of getting from x_3 to x_2 has “weight” given by the probability of the outcomes at least as good as x_2
  - Extra utility of getting from x_2 to x_1 has “weight” given by the probability of the outcome at least as good as x_1
- On this interpretation, cumulative (rank-dependent) weighting of utility levels is like simple probability weighting, but applied to utility increments instead of levels.

Dominance no longer violated

- Consider a choice between: $A: (\$20{,}0.5; \$10{,}0.5)\ or\ B: (\$10{,}0.99; \$0{,}0.01)$
- Lottery A first order stochastically dominates B.
- Under PT, we showed that it is possible that B is preferred to A.
- Under CPT, this is no longer possible
- Suppose as before that
  - u(20) = 2; u(10) = 1; u(0) = 0
  - $w(0.5)$ = 0.25 and $\mathrm{w}(0.99)$= 0.95
    - Notice that we now use “w” for probability weights and π for decision weights. Under Prospect Theory w and π were the same. Under Cumulative Prospect Theory, they are different
- $V(A) = \pi(0.5)u(20) + \pi(0.5)u(10) = w(0.5)u(20) + [1 - w(0.5)] * u(10) = 1.25$
- $V(B) = \pi(0.99)u(10) + \pi(0.01)u(0) = w(0.99)u(10) + [1 - w(0.99)u(0) = 0.95$
- V(A)>V(B), thus under Cumulative Prospect Theory the dominated option is ***not*** chosen

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Expected Utility Theory vs. Prospect Theory

Expected Utility Theory

- Linear weighting of probabilities
- Risk preferences depend only on the shape of utility over wealth
- People are either always risk averse, always risk seeking or always risk neutral

(Cumulative) Prospect Theory

- Non-linear probability weighting
- Risk preferences depend on utility over wealth AND probability weighting AND reference points AND loss aversion coefficient
- 4-fold pattern:
    - risk seeking for small probability gains
    - risk averse for high probability gains
    - risk averse for small probability losses
    - risk seeking for high probability losses

Overview of probability weighting and applications

- Probability weighting uses psychological principles of: i) reference dependence (certainty and impossibility) and ii) diminishing sensitivity (away from these reference points).
- Prospect Theory: probabilities are not treated linearly (as in EUT).
- Rare events are overweighted – Frequent events are underweighted – Changes in medium probability events are not perceived as much.
- The theory can explain systematic violations of EUT such as the Allais paradox & the simultaneous preference for risky lotteries and risk averse insurance.
- Simple non-linear weighting cannot exclude violations of first order stochastic dominance
- Cumulative decision weights solve this problem

Overview of probability weighting and applications

- It can explain why people buy insurance AND play the lottery
  - Buying insurance is considered to be a risk averse move
  - Playing the lottery is considered risk seeking
  - Standard model: a person is either risk averse or risk seeking, but not both (stable and consistent preferences).
  - Overweighting small probabilities can explain this.

- Probability-weighting also explains why people purchase extended warranties on equipment such as computers, in spite of the fact that they tend not to be a very good deal

Overview of probability weighting and applications

- Overweighting of rare events can account why people fear airplane crashes, terrorist attacks, and many other such extreme but rare events.
  - *Availability bias*: when thinking about the likelihood of an event, people tend to think different scenarios about what might happen. Extreme events (which are typically rare) stimulate more vivid representations and thus seem more likely than they are.

- In many cases, resources are devoted more to very rare and vivid social problems compared to more common problems.

Overview of probability weighting and applications

- Underweighting of high probabilities: people become more conservative than they should when the odds are in their favor.
  - Law: plaintiffs might settle for a lesser amount even though they have a very strong case
  - Medical decision making: people often seek out unnecessary treatments to deal with a medical challenge that has a good prognosis.

Overcoming probability weighting

- Translate abstract probabilities into natural frequencies.
  - Slovic et al., 2000
  - If a certain drug helps avoid serious illness in 20% of the patients, think that 2 out of 10 people avoid serious illness.

- Availability bias: Dampen your internal narrator – think that you are advising a friend.

Loss aversion and framing effects

- Framing effects: Essentially equivalent descriptions of the same facts lead to different choices.

- Loss aversion helps explain why politicians argue about whether cancelling tax cuts amounts to raising taxes. Voters find the foregone gain associated with a cancelled tax cut easier to stomach (gains domain) than they do the loss associated with a tax increase (loss domain).
- Consequently, politicians favoring higher taxes will talk about “cancelled tax cuts” whereas politicians opposing higher taxes will talk about “tax increases.”

Loss aversion and the equity premium puzzle

- Equity premium puzzle: the investor returns on equities (stock) have been on average so much higher than returns on bonds, that it is hard to explain why investors buy bonds, even after allowing for a reasonable amount of risk aversion.
- To quantify the level of risk aversion implied if these figures represented the *expected* outperformance of equities over bonds, investors would prefer a certain payoff of $51,300 to a 50/50 bet paying either $50,000 or $100,000 (Mankiw et al. 1991)

Loss aversion and the equity premium puzzle

	Period 1	Period 2	Period 3	…	Overall
Bond	+0.01	0.02	0	…	+0.1
Stock	+1	-2	+1.8	…	+2

- Myopic loss aversion: Investors are "**loss averse**" and evaluate their portfolios frequently.
  - Benartzi and Thaler, 1995

Loss aversion and status quo bias

- Harvard University Clinic offered in the 80s a new optional health insurance for its employees. Already employed personal had to choose between the new or the old insurance plan. Newly employed personal also had to chose between the two insurance plans. New employees were significantly more likely to pick the new plan, while the other employees remained mostly in the old plan

- Similar effects have been observed for retirement and investment plans

- If current situation (status quo) is perceived as a reference point, then loss aversion would not favor giving it away for something else

- Remember also the experiments with mugs and chocolates from Lecture 4

Overcoming reference dependence

- Shift your reference point: example of checking stock-portfolio infrequently
- Charity giving: What would pay for this if I didn’t have it already? WTP vs WTA. Might make it easier to donate some of your old clothes.
- Create hypothetical alternatives. Should you splurge on family trip. What else could you spend the money? Additional retiring savings, a different vacation?

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Challenge to PT: Description – Experience gap

Decisions from **Description**:

- Numerical statistics about probability and outcomes
- E.g. weather forecast, performance of an asset in the stock market

Decisions from **Experience**:

- Sequential sampling of events – uncertainty regarding
- E.g. should I park my bike in this neighbourhood?

A simple experiment: Description vs. Experience

Description:

Choice 1: A=(20, 0.1; 0) or B=(2, 1)

Would you prefer lottery A that offers 20 euros with probability 10% and 0 otherwise or lottery B that offers 2 euros for sure?

Experience:

A

B

A simple experiment: Description vs. Experience

Description:

Choice 1: A=(20, 0.1; 0) or B=(2, 1)

Would you prefer lottery A that offers 20 euros with probability 10% and 0 otherwise or lottery B that offers 2 euros for sure?

Experience:

Option A

Option B

A simple experiment: Description vs. Experience

Description:

Choice 1: A=(20, 0.1; 0) or B=(2, 1)

Would you prefer lottery A that offers 20 euros with probability 10% and 0 otherwise or lottery B that offers 2 euros for sure?

Experience:

Option A	Option B
0	

A simple experiment: Description vs. Experience

Description:

Choice 1: A=(20, 0.1; 0) or B=(2, 1)

Would you prefer lottery A that offers 20 euros with probability 10% and 0 otherwise or lottery B that offers 2 euros for sure?

Experience:

Option A

Option B

2

A simple experiment: Description vs. Experience

Description:

Choice 1: A=(20, 0.1; 0) or B=(2, 1)

Would you prefer lottery A that offers 20 euros with probability 10% and 0 otherwise or lottery B that offers 2 euros for sure?

Experience:

Option A	Option B
0	

A simple experiment: Description vs. Experience

Description:

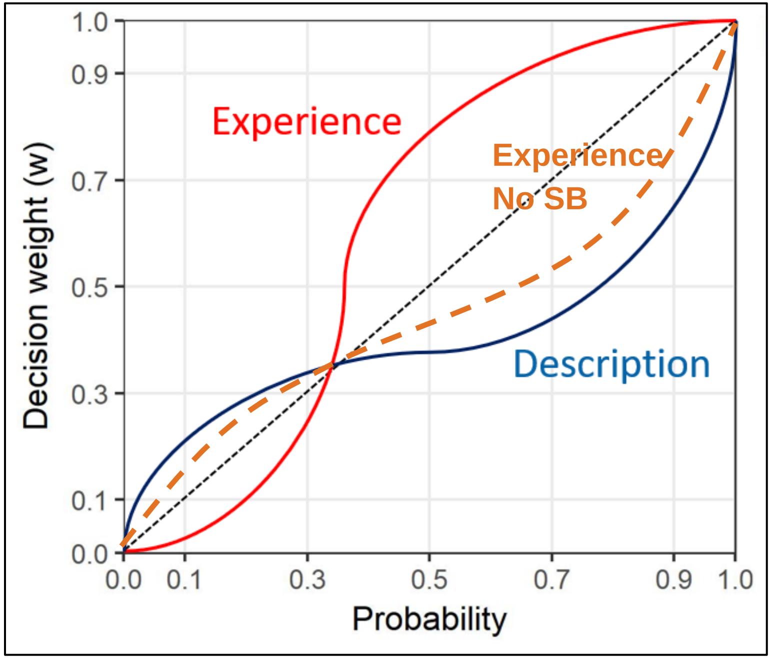
Choice 1: A=(20, 0.1; 0) or B=(2, 1)

Would you prefer lottery A that offers 20 euros with probability 10% and 0 otherwise or lottery B that offers 2 euros for sure?

Experience:

Option A	**Option B**
	2

Challenge to PT: Description – Experience gap



- Description: inverse S-shaped weighting function - > overweighting rare events
- Experience: S-shaped weighting function -> underweighting rare events
  - See Hertwig et al., (2004);
- Experience – Without Sampling Bias: less overweighting
  - See Kopsacheilis (2018); Cubitt, Kopsacheilis & Starmer (2020)
- Problem: the way information is obtained – even when it is mathematical equivalent – influences behaviour.
- Easy (but not ideal) fix: Decision makers have multiple weighting functions. Their shape depend on the context in which the decision takes place.

More problems: preference reversals

Scenario 1:

$-bet: low probability of high outcome. E.g.
How much do you value a bet with a 0.08 chance of winning $100?

CE($-bet)

Scenario 2:

P-bet: High probability of smaller outcome. E.g.
How much do you value a bet with a 0.8 chance of winning $10?

CE(P-bet)

Scenario 3:

Choose: would you prefer a bet with
a 0.08 chance of winning $100 ($-bet)
or one with
a 0.8 chance of winning $10? (P-bet) ?

Preference reversals

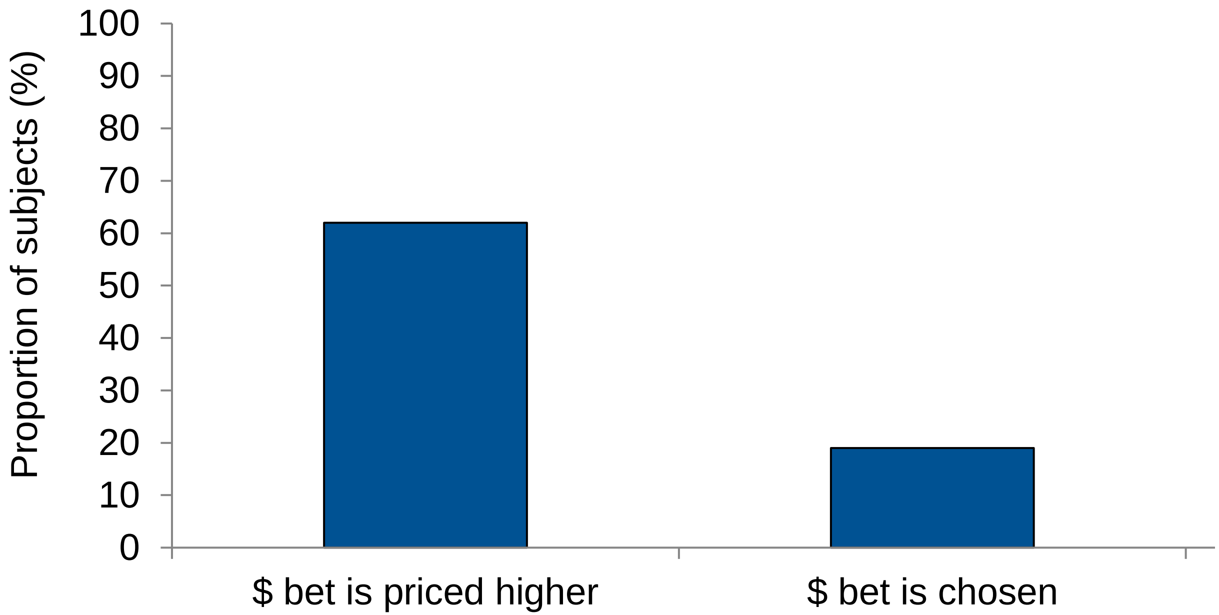
- People typically valuate the $-bet higher than the P-bet: CE($-bet)>CE(P-bet)

but

- Choose the P-bet over the $-bet when asked to choose between the two!
- These type of preferences violate transitivity.
- Assume that CE($-bet)=$8, CE(P-bet)=$6.
- Now, consider choices between a $-bet, a P-bet and a certain amount: C=$7.
- People often state the following cycle:
- Choice 1: $-bet $\succ$C
- Choice 2: C$\succ$P-bet
- Choice 3: P-bet $\succ$$-bet
- How often do people exhibit such preferences?

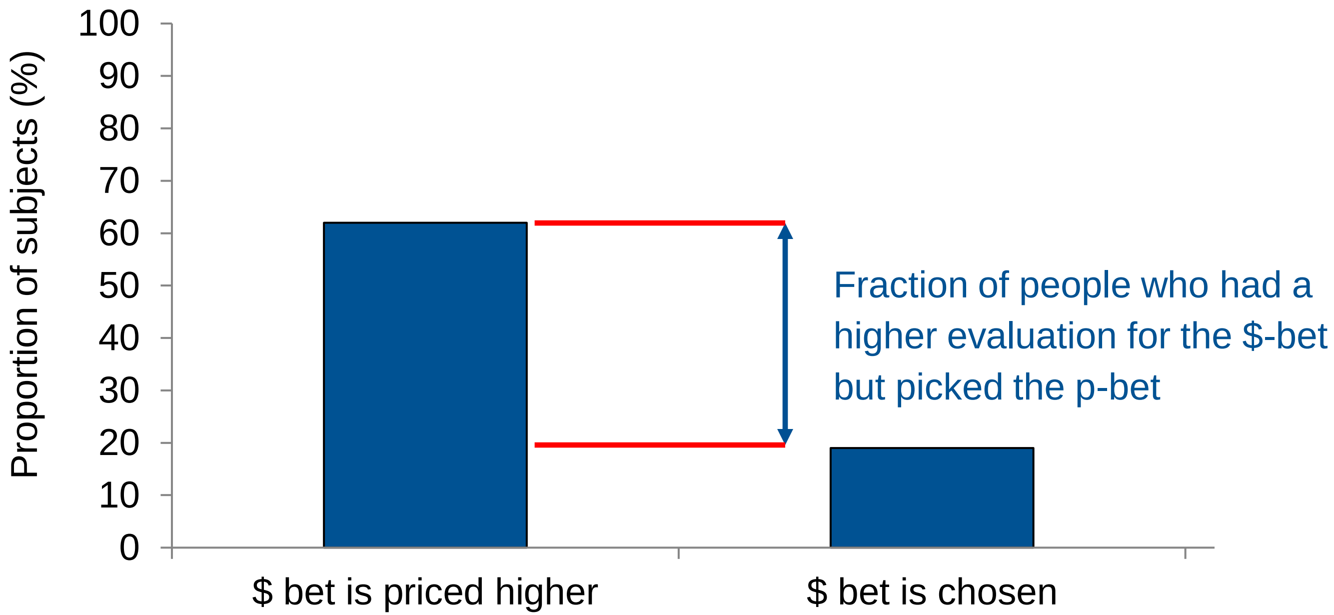
Preference reversals

Tversky, Slovic and Kahneman (1990)



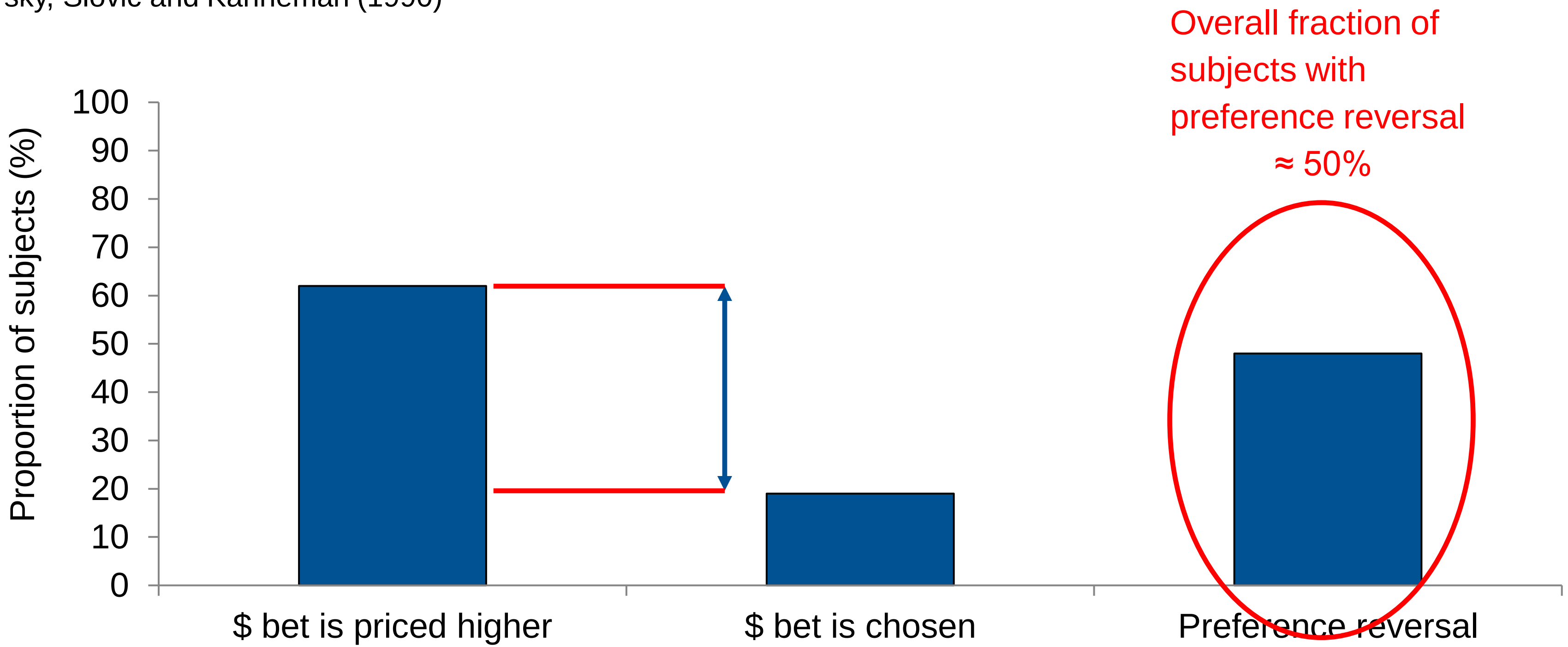
Preference reversals

Tversky, Slovic and Kahneman (1990)



Preference reversals

Tversky, Slovic and Kahneman (1990)



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Regret Theory

- Neither EUT nor Prospect Theory (or Cumulative Prospect Theory) can explain violations of transitivity.
- We need a different type of model.
- Regret Theory (Loomes and Sugden, 1982; Fishburn, 1982; Bell, 1982):

"For example, compare the sensation of losing $100 as the result of an increase in income tax rates, which you could have done nothing to prevent, with the sensation of losing $100 on a bet on a horse race. Our guess is that most people would find the latter experience more painful, because it would inspire regret."

-Loomes and Sugden, 1982

Most other models

	s_1	s_2	s_3	EV	EUT	CPT
	1-30	31-60	61-100			
$-bet	$18	$0	$0	$\Sigma_i p_i x_i$	$\Sigma_i p_i u(x_i)$	$\Sigma_i \pi_i v(x_i)$
P-bet	$8	$8	$0	$\Sigma_i p_i y_i$	$\Sigma_i p_i u(y_i)$	$\Sigma_i \pi_i y_i)$
C	$4	$4	$4	$\Sigma_i p_i z_i$	$\Sigma_i p_i u(z_i)$	$\Sigma_i \pi_i v(z_i)$

- Models we have seen thus far (EV, EUT, CPT): calculate a “value” for each lottery and compare this value across lotteries to determine which one is preferred.
- The state in which the outcome occurs does not matter

Regret Theory

	s_1	s_2	s_3
	1-30	31-60	61-100
$-bet	$18	$0	$0
P-bet	$8	$8	$0
C	$4	$4	$4

$$L_1 \succcurlyeq L_2 \ iff \ \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

u: is the utility of wealth. Similarly to EUT, let's assume it to be concave (e.g. $u(x) = x^{0.8}$). Moreover, $u(-x) = -u(x)$
Q: is the regret/ rejoice component. It is assumed to be convex $(e.g. Q(x) = x^{1.5})$. Moreover, $Q(-x) = -Q(x)$

Let's compare the choice between $-bet and P-bet first:

Regret Theory

	s_1	s_2	s_3
	1-30	31-60	61-100
$-bet	$18	$0	$0
P-bet	$8	$8	$0

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

Let's compare the choice between $-bet and P-bet first:
We start by considering what would happen if state 1 is realised.
Notice that Regret Theory, unlike all models we have seen so far, operates with within state comparisons, across lotteries.
Previous models, were calculating a weighted average across columns for each row and then comparing that value across rows.
To better understand the principle of Regret Theory, it's important to display lotteries in their "matrix contingent form"

Regret Theory

	s_1
	1-30
$-bet	$18
P-bet	$8

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

Let's compare the choice between $-bet and P-bet first: We start by considering what would happen if state 1 is realised.

$$s_1\!: \; 0.3Q\big(u(18) - u(8)\big) = 0.3(18^{0.8} - 8^{0.8})^{1.5} = 3.174 + \cdots$$

Regret Theory

	s_2
	31-60
$-bet	$0
P-bet	$8

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

Let's compare the choice between $-bet and P-bet first:
What if State 2 occurs?

$$s_1: \; 0.3Q\big(u(18) - u(8)\big) = 0.3(18^{0.8} - 8^{0.8})^{1.5} = 3.174 + \cdots$$

$$s_2: 0.3Q\big(u(0) - u(8)\big) = 0.3(0^{0.8} - 8^{0.8})^{1.5} = -3.638 + \cdots$$

Regret Theory

	s_3
	61-100
$-bet	$0
P-bet	$0

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

Let's compare the choice between $-bet and P-bet first:
What if State 3 occurs? No difference there.

$$s_1{:}\; 0.3Q\big(u(18) - u(8)\big) = 0.3(18^{0.8} - 8^{0.8})^{1.5} = 3.174 + \cdots$$

$$s_2{:}\, 0.3Q\big(u(0) - u(8)\big) = 0.3(0^{0.8} - 8^{0.8})^{1.5} = -3.638 + \cdots$$

$$s_3{:}\, 0.4 * 0 = 0$$

Regret Theory

	s_1	s_2	s_3
	1-30	31-60	61-100
$-bet	$18	$0	$0
P-bet	$8	$8	$0

$$L_1 \succcurlyeq L_2 \; iff \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

Let's compare the choice between $-bet and P-bet first:
What if State 3 occurs? No difference there.

$$s_1:\; 0.3Q\big(u(18) - u(8)\big) = 0.3(18^{0.8} - 8^{0.8})^{1.5} = 3.174 + \cdots$$

$$s_2: 0.3Q\big(u(0) - u(8)\big) = 0.3(0^{0.8} - 8^{0.8})^{1.5} = -3.638 + \cdots$$

$$s_3: 0.4 * 0 = 0$$

So, overall: $3.174 - 3.638 < 0$, therefore, P-bet≻$-bet
The intuition is that if the $-bet is selected, then the "regret" of ending up with $0 in s_2 is bigger than the "rejoice" of winning $18 instead of $8 in s_1

Regret Theory

	s_1	s_2	s_3
	1-30	31-60	61-100
P-bet	\$8	\$8	\$0
C	\$4	\$4	\$4

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[A_1(s_j)] - u[A_1(s_j)]\} \geq 0$$

The principle is similar (skipping the calculations here) for the comparison between the P-bet and the certain amount.
The regret of not receiving anything at s_3 if the P-bet is selected, is overshadowing the rejoice of \$8 instead of \$4 in the other two states. Therefore, the C is selected over the P-bet.

Regret Theory

	s_1	s_2	s_3
	1-30	31-60	61-100
$-bet	$18	$0	$0
C	$4	$4	$4

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

But… the rejoice of $18 instead of $4, compensates for the regret of not receiving $4 in states 2 and 3, if the $-bet is selected over the certain amount.

Therefore, $-bet $\succ$ C

This completes the cycle that violates transtivity:

$$Pbet \succ Sbet \succ C \succ Pbet$$

Applications of regret aversion

- **The Dutch postcode lottery**:
  - The postcode of one's home is the ticket.
  - Even if someone does not pay to participate, one may still find out that one would have won had one played
  - Regret aversion urges people to buy a ticket

- **Fear of Missing out (FOMO)**:
  - Ever felt like relaxing home on a Saturday night until the phone rung with your friend inviting you to a party?
  - Sure, you feel tired and would prefer to stay home..
  - But what if it's a great party? You don't want to regret missing out…