

Making decisions (part 2)

Computational Cognitive Science 2014

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The “disease problem”

A dangerous new disease is about to strike. It is currently projected to kill 600 people. Two response plans are being considered:

Plan A:

200 people will be **saved**

Plan B:

1 in 3 chance to **save** 600 people

2 in 3 chance to **save** 0 people

The “disease problem”

A dangerous new disease is about to strike. It is currently projected to kill 600 people. Two response plans are being considered:

Plan C:
400 people will **die**

Plan D:
1 in 3 chance that no-one will **die**
2 in 3 chance that 600 people will **die**

Framing effects

- Framing effects (Tversky & Kahneman 1981)
 - The two scenarios are numerically identical
 - The difference is the framing: i.e., how it's described
- Gain frame:
 - People were **risk averse**
 - 72% chose A (200 saved) over B (33% chance of 600 saved)
- Loss frame
 - People were **risk seeking**
 - 22% chose C (400 deaths) over D (33% chance of 0 deaths)

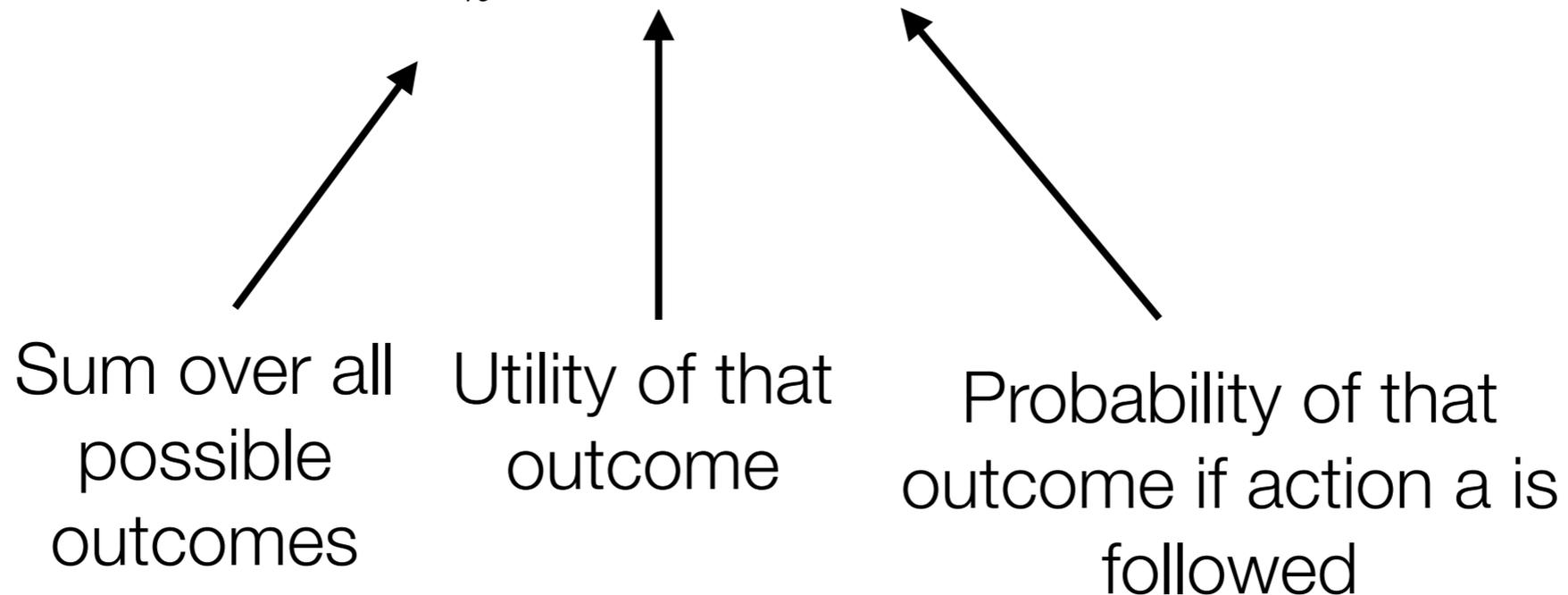
Reference-dependent utilities.
a.k.a. “prospect theory”

Prospect theory

- Kahneman & Tversky (1979)
- Key idea:
 - There are no “absolute” utility functions
- The decision maker picks a “reference point”
 - Outcomes better than the reference points are “gains”
 - Outcomes below the reference points are “losses”
- “Value function” is:
 - Monotonic increasing
 - Convex for gains, concave for losses
 - Steeper for losses than gains.

Here's expected utility theory

$$EU(a) = \sum_z u(z)P(z|a)$$



Prospect theory uses the same idea

$$EU(a) = \sum_z u(z)P(z|a)$$

Expected
utility theory

$$PT(a, r) = \sum_z v(z, r)P(z|a)$$

Prospect
theory*



Same idea as expected utility, but instead we use the reference-dependent **value function** $v(z, r)$ rather than a utility function $u(z)$

Prospect theory uses the same idea

$$EU(a) = \sum_z u(z)P(z|a)$$

Expected
utility theory

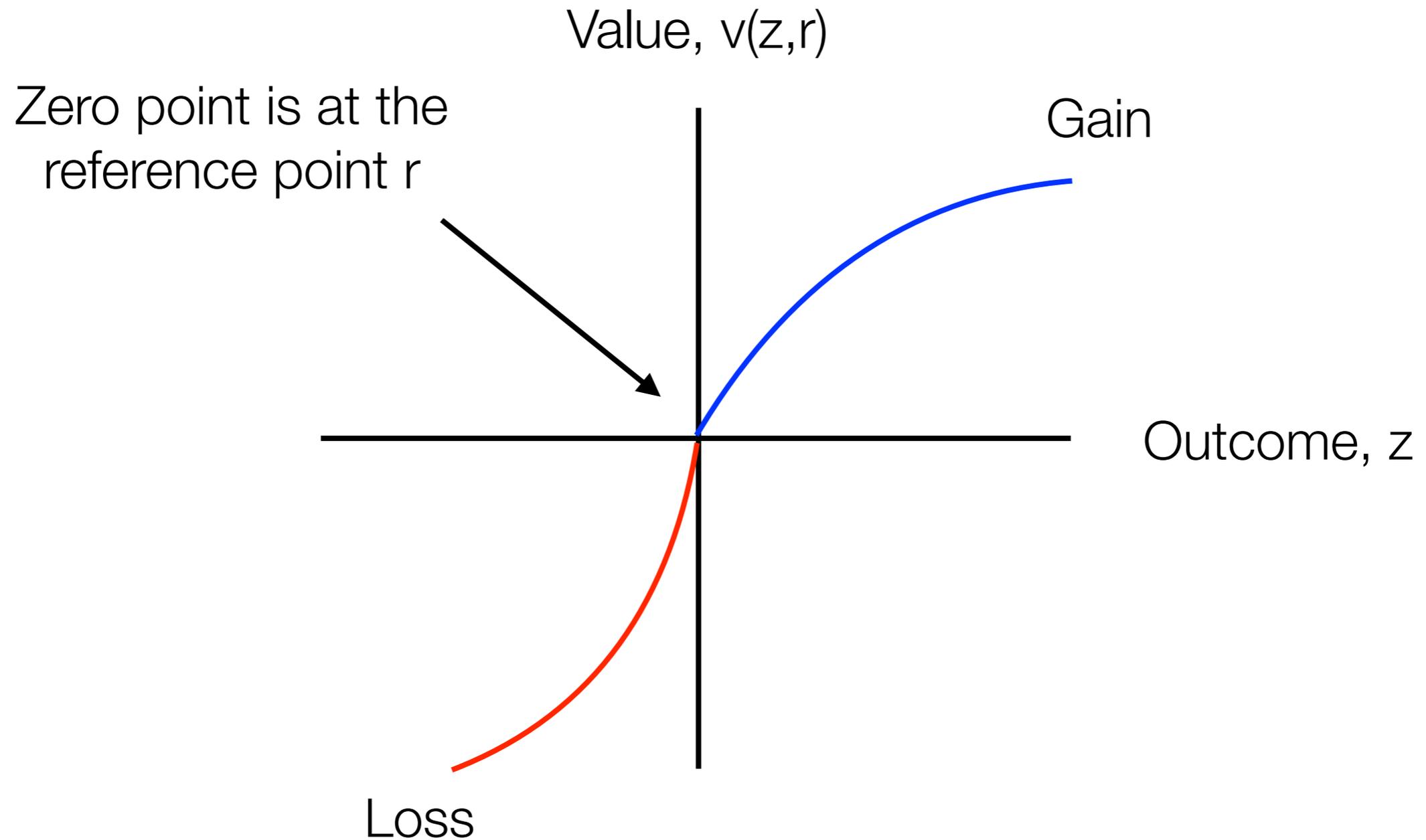
$$PT(a, r) = \sum_z v(z, r)w(z|a)$$

Prospect
theory

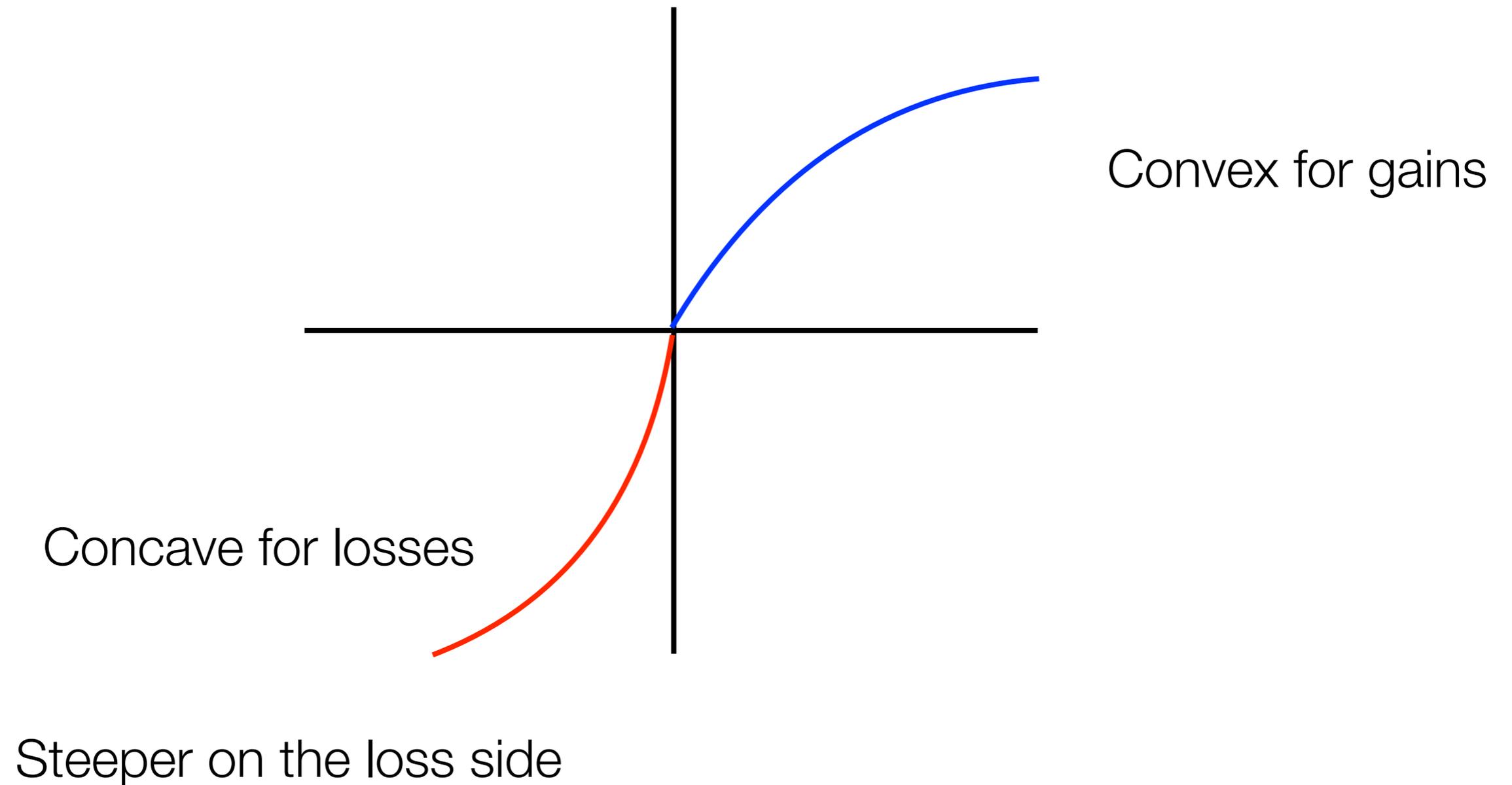


Actually, the full version uses “decision weights” which aren’t the same things as probabilities, but I’m going to ignore that

What does a value function look like?

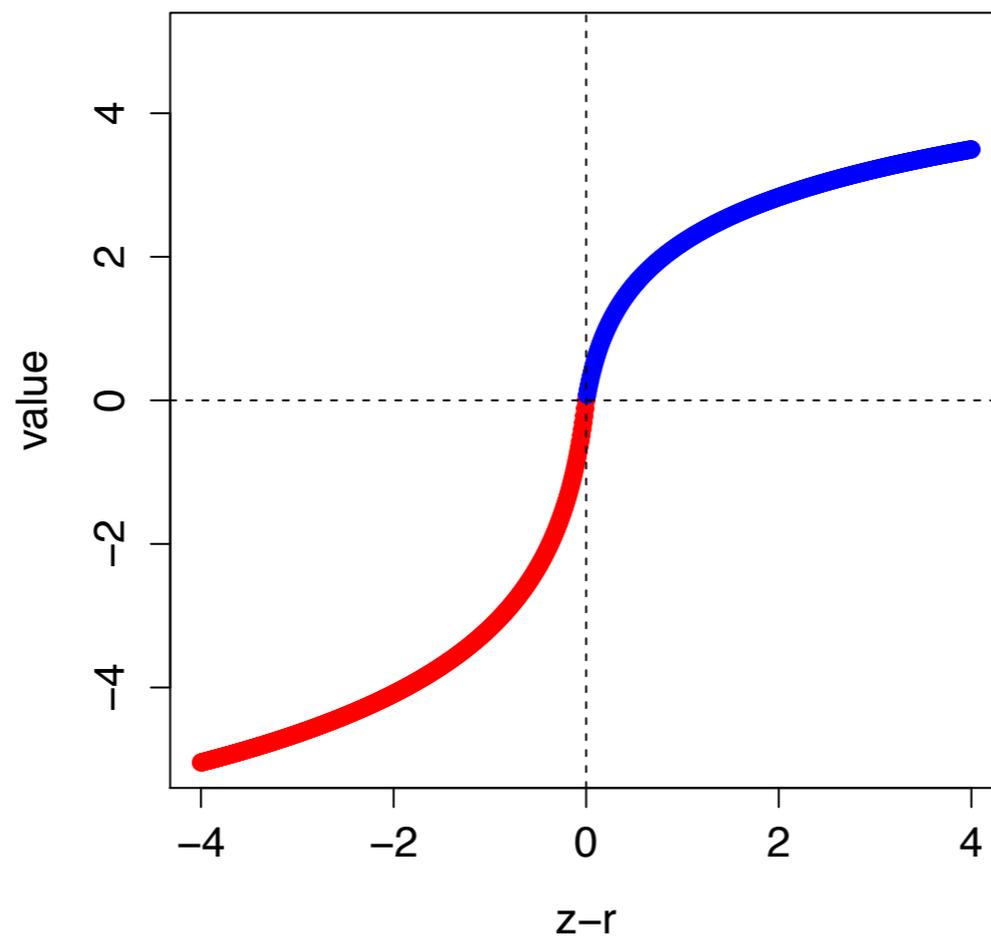


What does a value function look like?



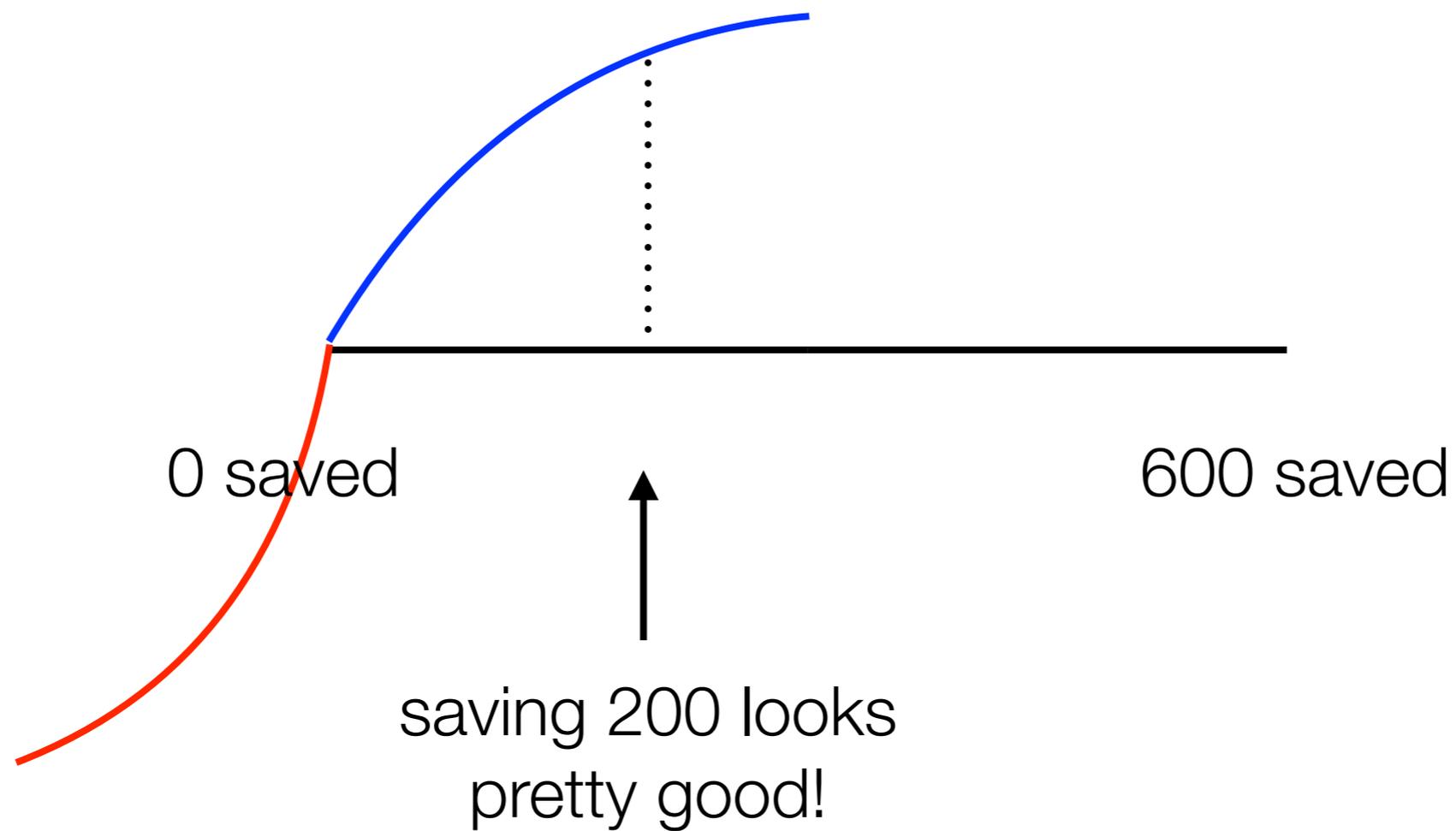
Example of a possible value function

$$v(z, r) = \begin{cases} \ln(1 + 8(z - r)) & \text{if } z \geq r \\ -\log_2(1 + 8(r - z)) & \text{if } z < r \end{cases}$$

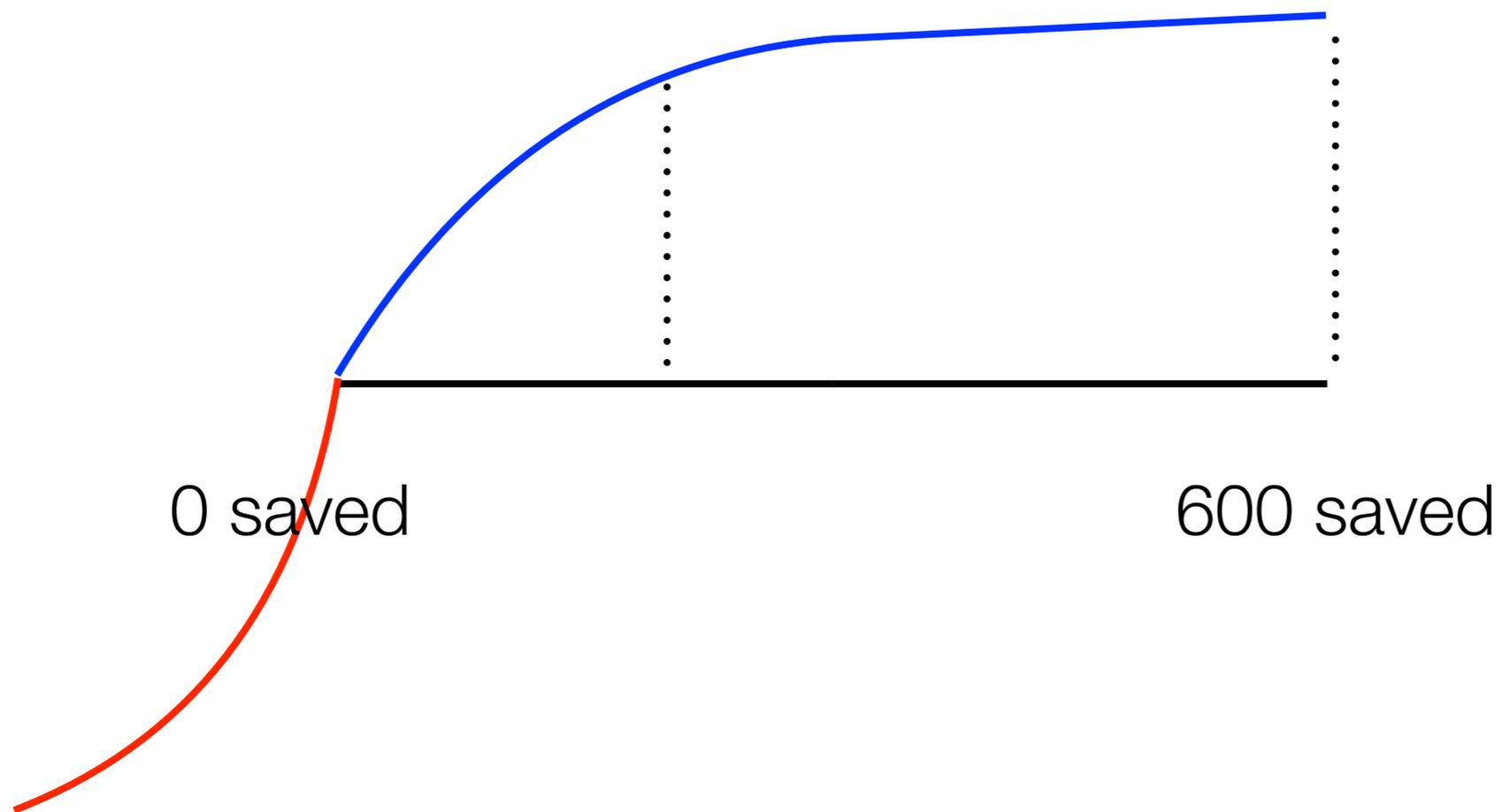


Reference points matter!

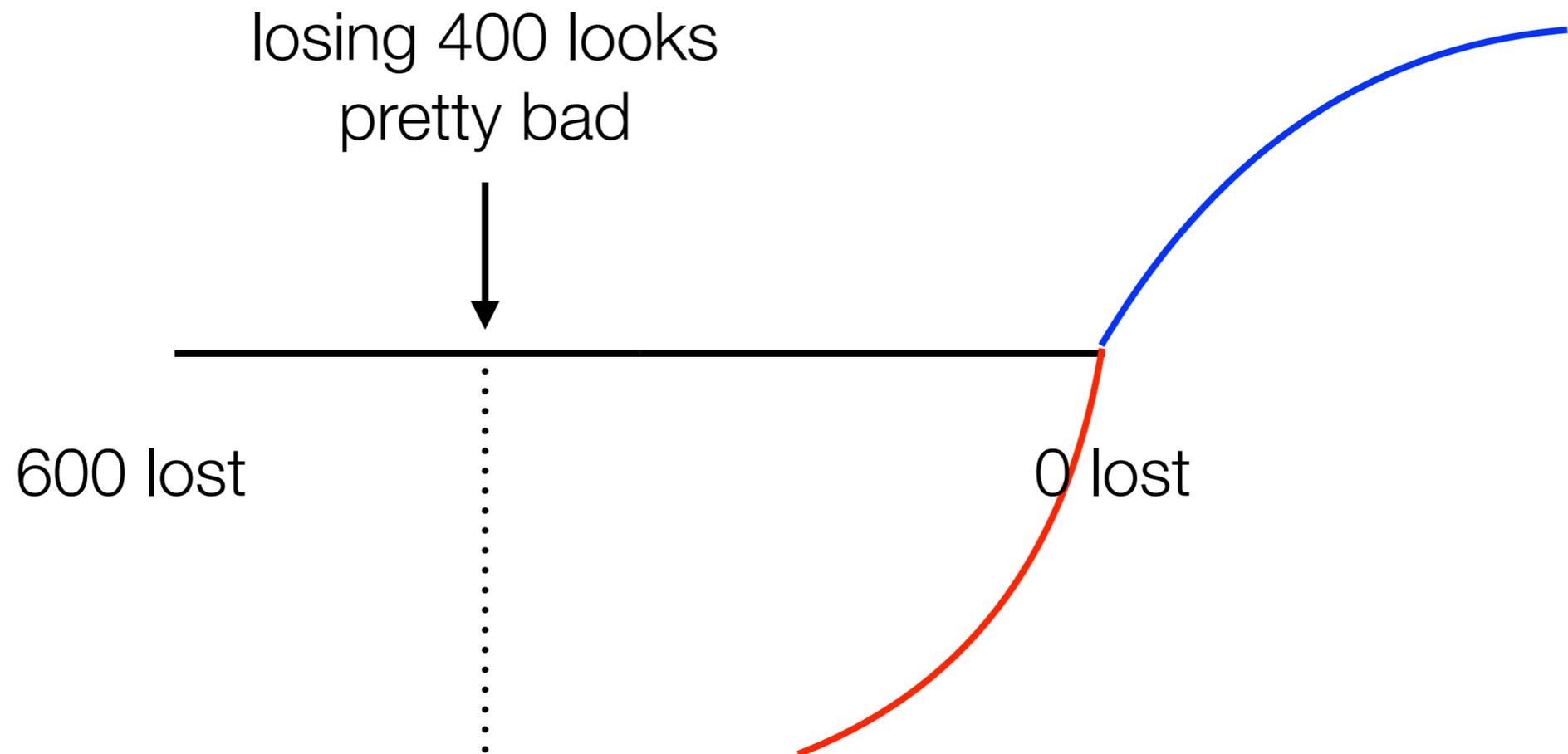
In the “lives saved” framing the reference point tends to be 0 saved



Saving 600 is better than saving 200, but it's not three times better

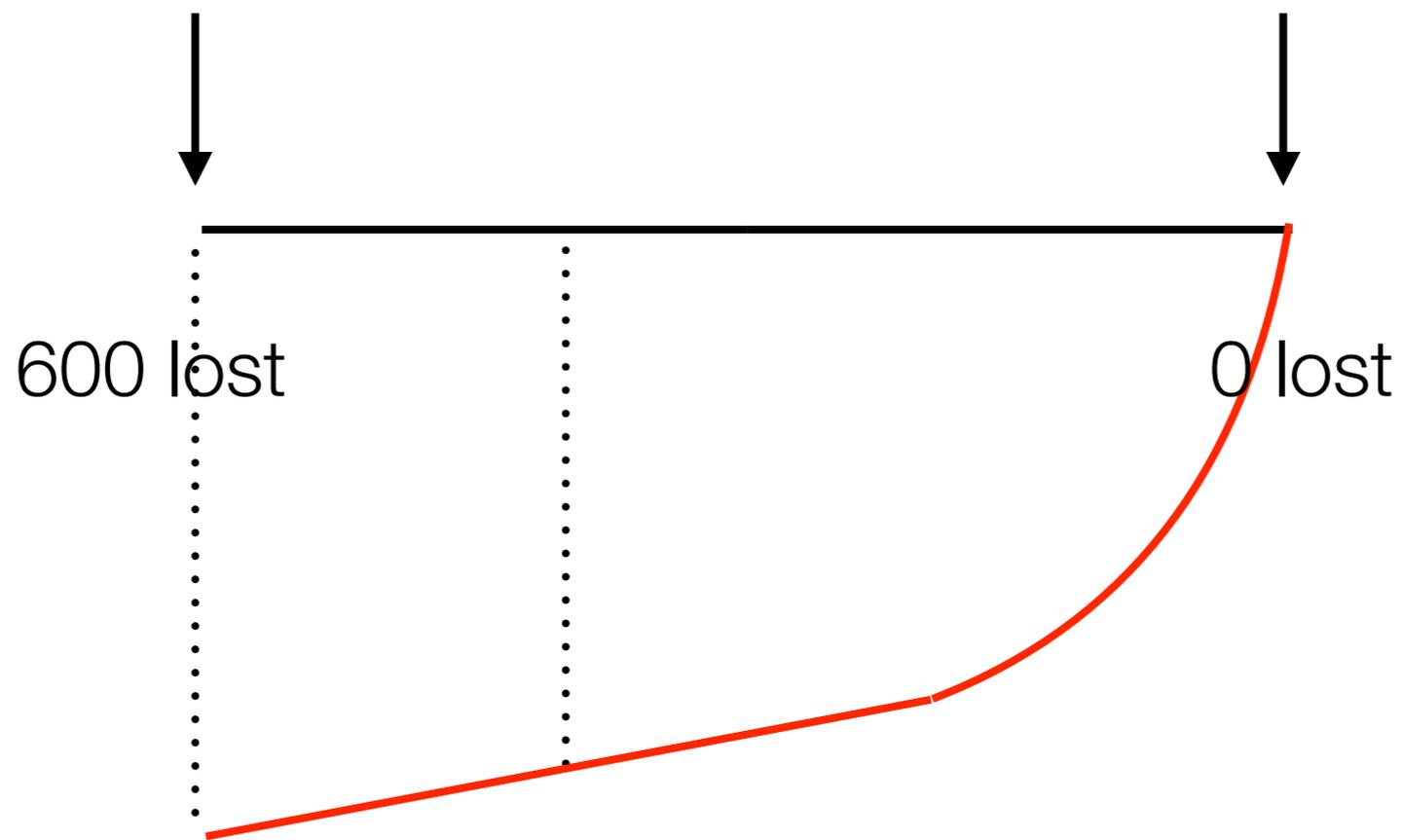


In the “lives lost” framing the reference point tends to be 0 lost



losing 600 is worse than losing 400, but not by much

gambling on that 33% chance of saving everyone now looks really enticing



Triage from a prospect theory perspective



Suppose the triage nurse believes this

8 possible outcomes
(i.e., survivor lists)

	abc	ab	ac	bc	a	b	c	-
abc								
acb								
bac								
bca								
cab								
cba								

6 possible
actions (i.e.,
treatment
orders)

Suppose the triage nurse believes this

	abc	ab	ac	bc	a	b	c	-
abc				1				
acb				.5		.5		
bac	.125							
bca	.5							.5
cab						1		
cba								1

probabilities of the different outcomes if
different actions are taken

EU theory: maximise the expected number of survivors

expected utility of each action

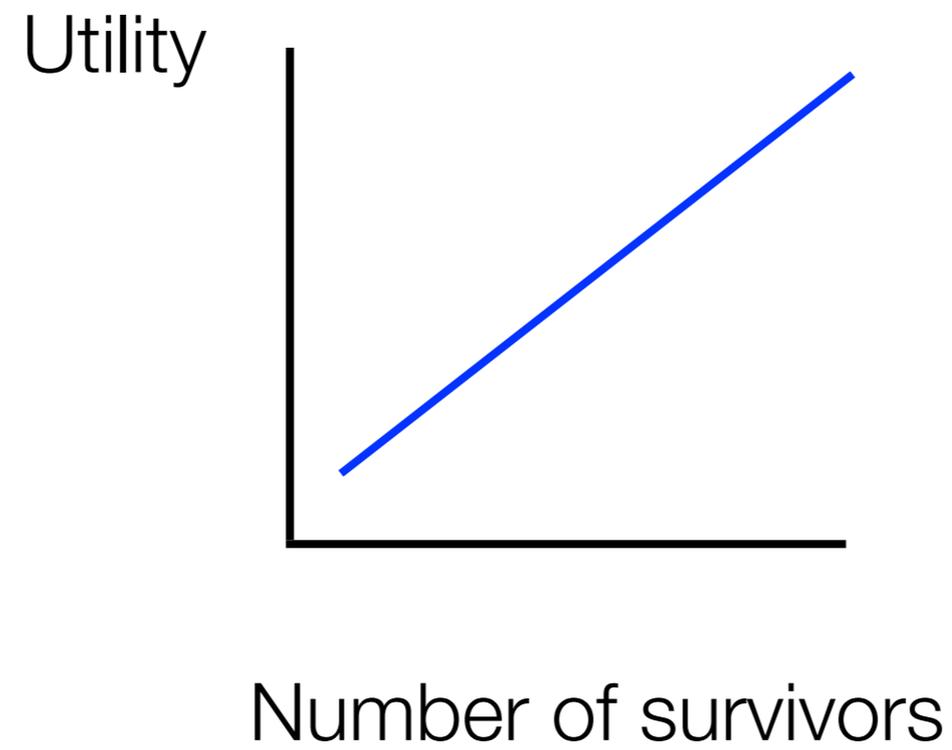
	abc	ab	ac	bc	a	b	c	-
abc				1				
acb				.5		.5		
bac	.125	.125	.125	.125	.125	.125	.125	.125
bca	.5							.5
cab						1		
cba								1

2
1.5
1.5
1.5
1
0

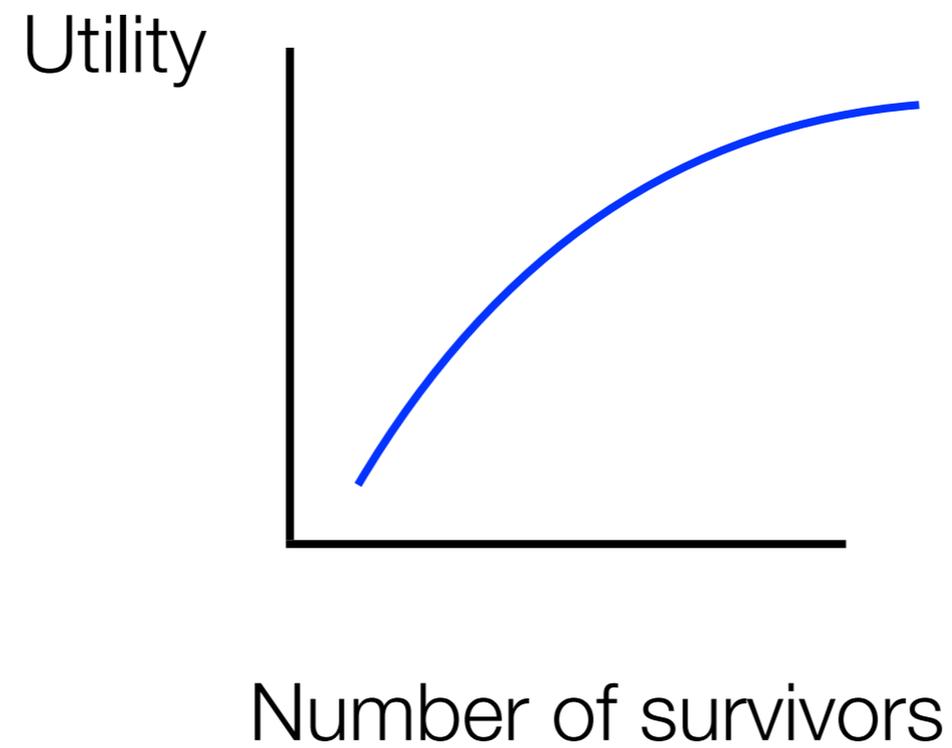
3	2	2	2	1	1	1	0
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utility of each outcome

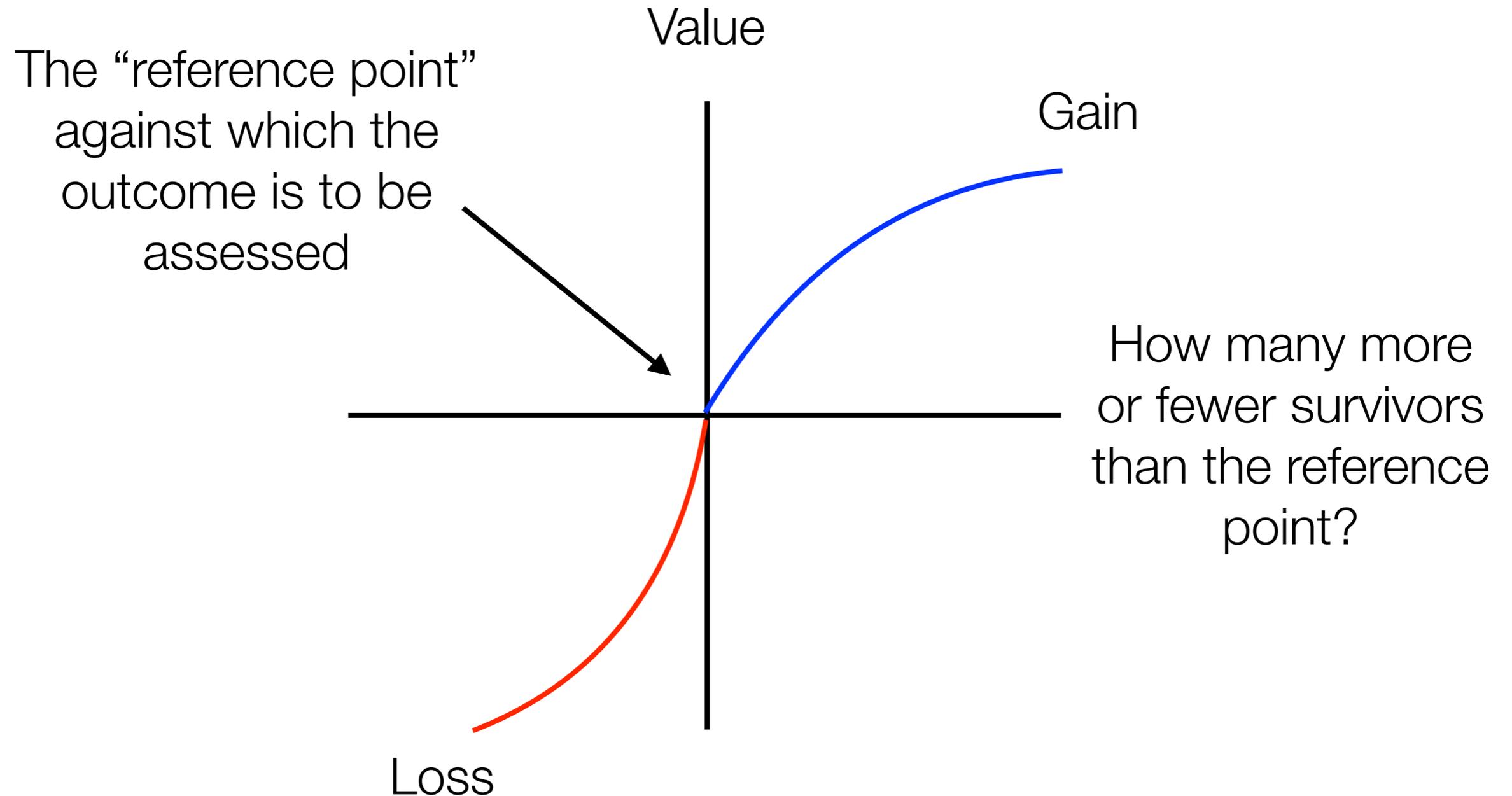
What we're assuming here:



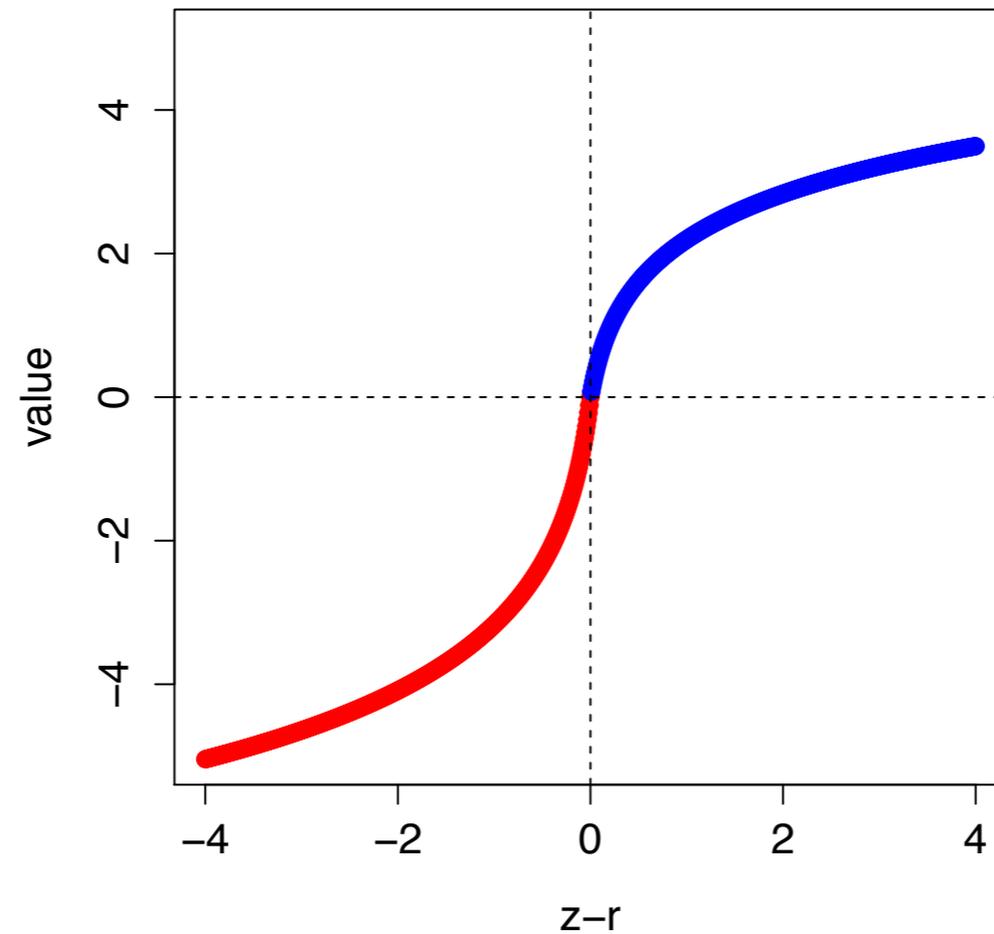
We could use logarithmic utility...



But we'll go further and use prospect theory



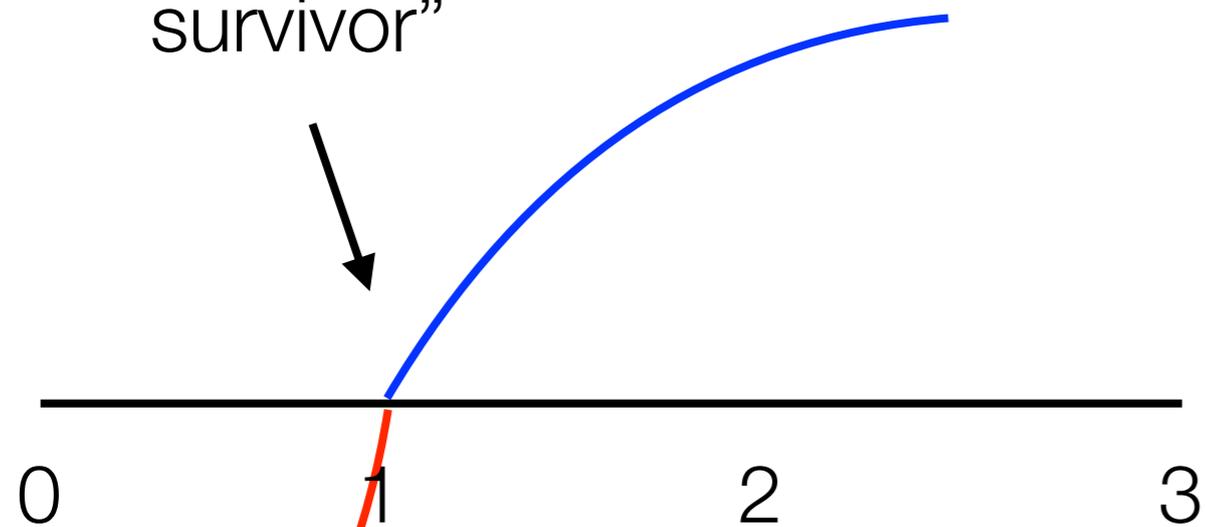
But we'll go further and use prospect theory



$$v(z, r) = \begin{cases} \ln(1 + 8(z - r)) & \text{if } z \geq r \\ -\log_2(1 + 8(r - z)) & \text{if } z < r \end{cases}$$

But we'll go further and use prospect theory

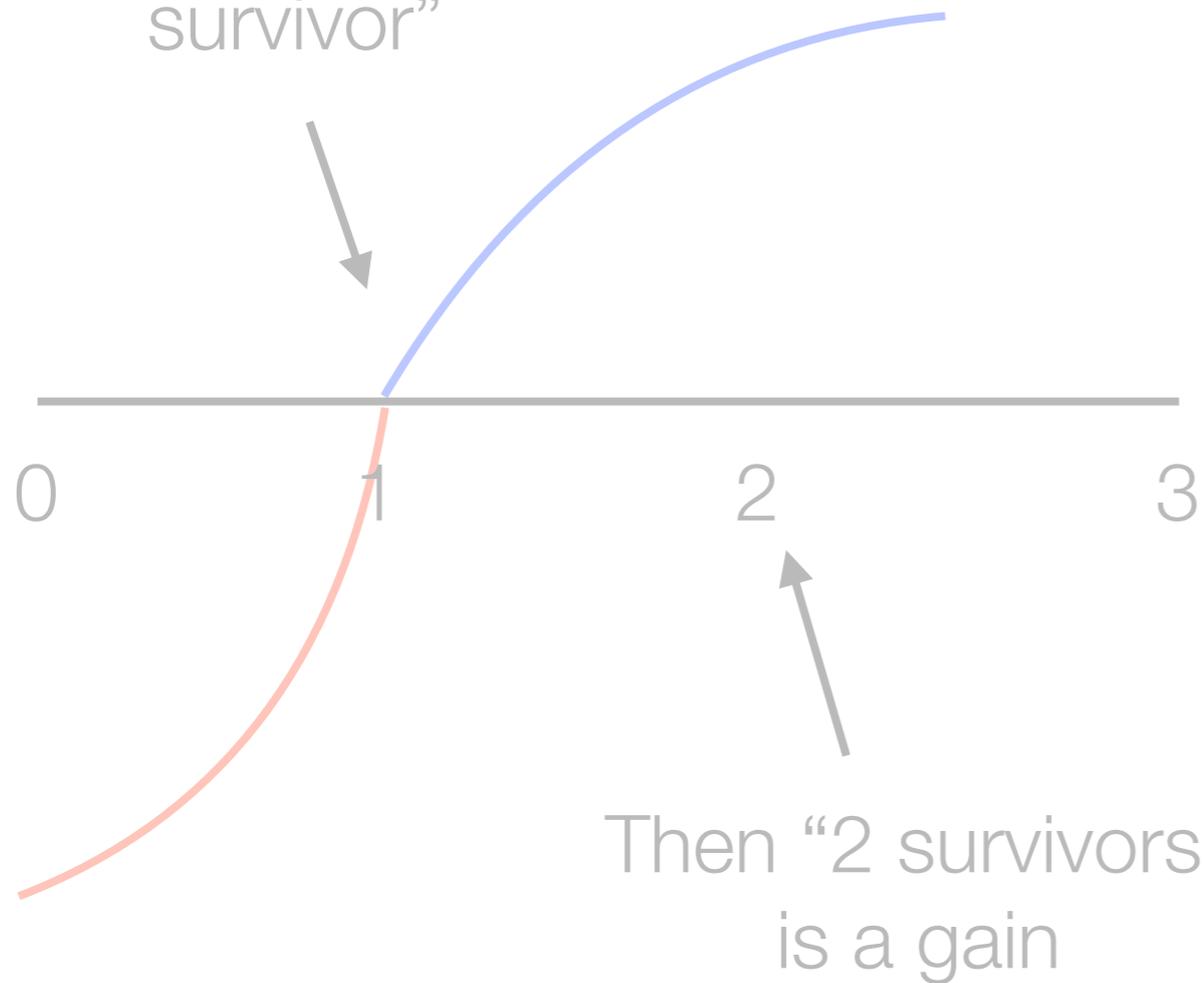
If the reference point is "1 survivor"



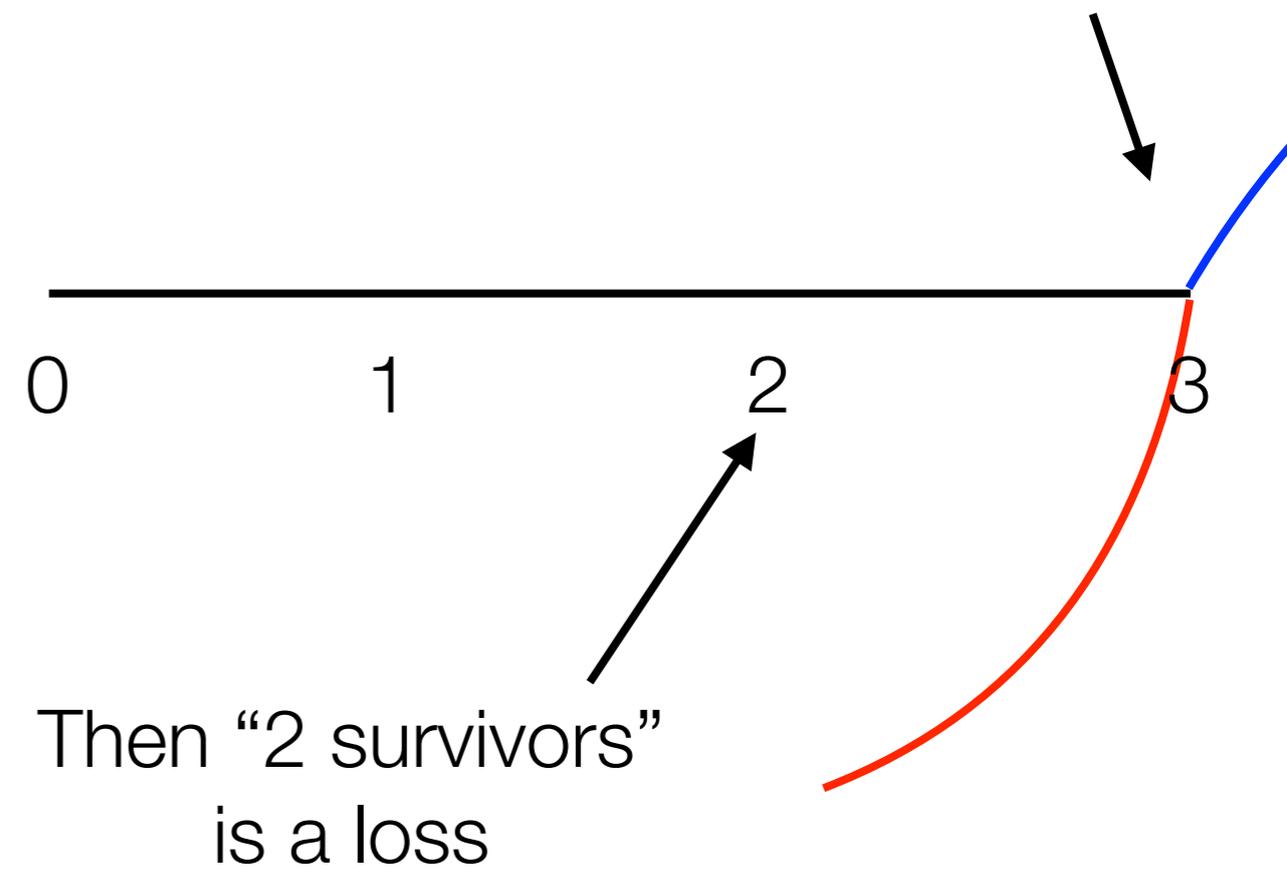
Then "2 survivors"
is a gain

But we'll go further and use prospect theory

If the reference point is "1 survivor"



If the reference point is "3 survivors"



Demonstration code: [trriage2.R](#)

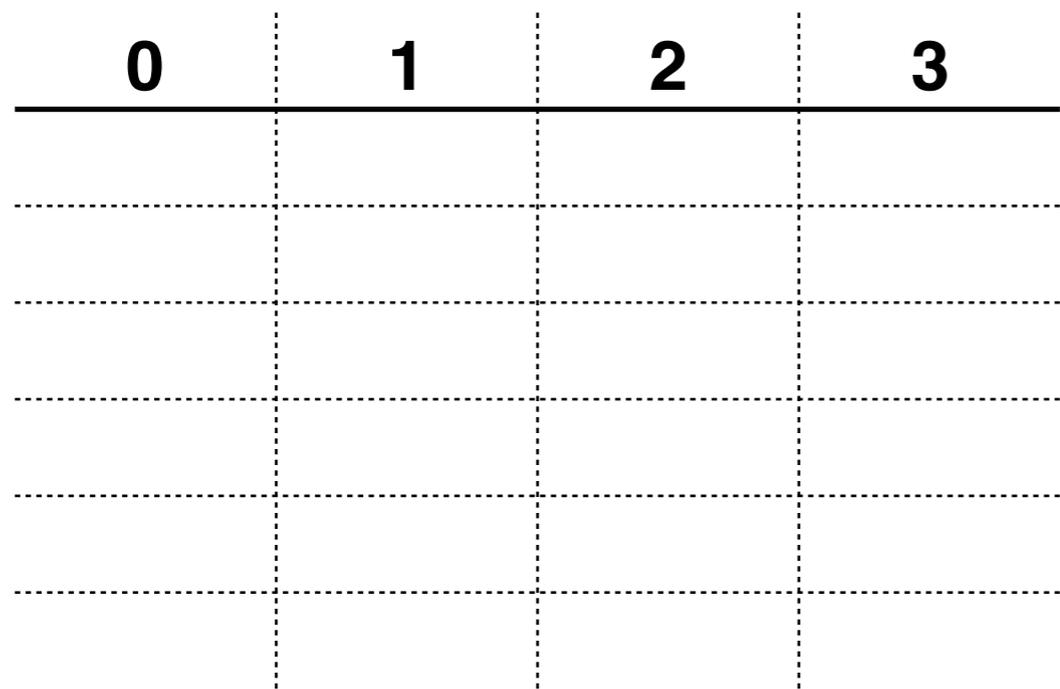
The options vary in riskiness

	abc	ab	ac	bc	a	b	c	-	
abc				1					← safe choice
acb				.5		.5			
bac	.125								
bca	.5							.5	← risky choice
cab						1			
cba								1	

↑
↑
 everybody lives!!!
 everybody dies!!!

	abc	ab	ac	bc	a	b	c	-
abc				1				
acb				.5		.5		
bac	.125	.125	.125	.125	.125	.125	.125	.125
bca	.5							.5
cab						1		
cba								1

reference point



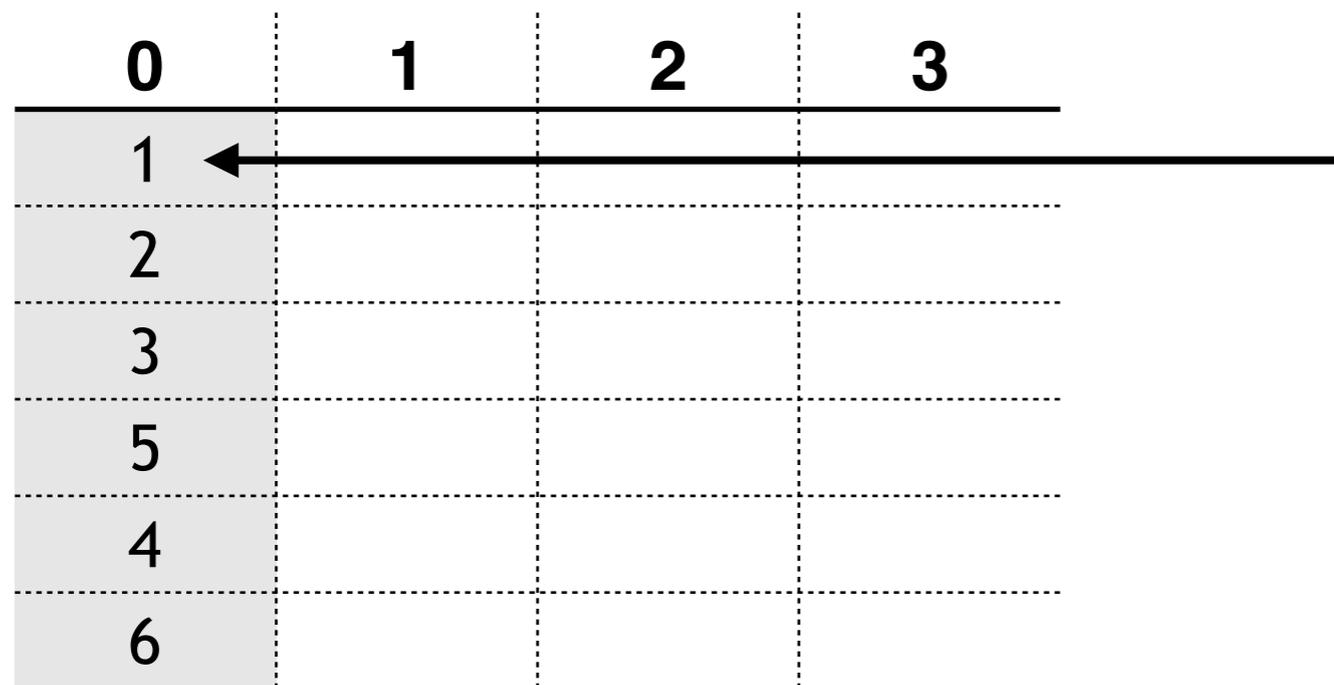
ranking of the
6 options

	abc	ab	ac	bc	a	b	c	-
abc				1				
acb				.5		.5		
bac	.125	.125	.125	.125	.125	.125	.125	.125
bca	.5							.5
cab						1		
cba								1



safe option

reference point



when the reference point is “0 saved”, a guaranteed gain of 2 survivors looks good

	abc	ab	ac	bc	a	b	c	-
abc				1				
acb				.5		.5		
bac	.125	.125	.125	.125	.125	.125	.125	.125
bca	.5							.5
cab						1		
cba								1

← safe option

reference point

	0	1	2	3
1				
2				
3				
5				
4				
6				

←

but when the reference point is “3 saved”, a guaranteed gain of 2 survivors just looks like **“I lost someone”**

	abc	ab	ac	bc	a	b	c	-
abc				1				
acb				.5		.5		
bac	.125	.125	.125	.125	.125	.125	.125	.125
bca	.5							.5
cab						1		
cba								1

← risky option

reference point

0	1	2	3
1			2
2			4
3			3
5			1
4			5
6			6

←

and the triage nurse is now willing to take a risky option in order to avoid losing anyone

Prospect theory applied to the
newspaper...

“In Sydney’s west you can be on a quarter of a million dollars family income a year and you’re still struggling.”

- Joel Fitzgibbon in 2013 (former chief whip for the ALP)

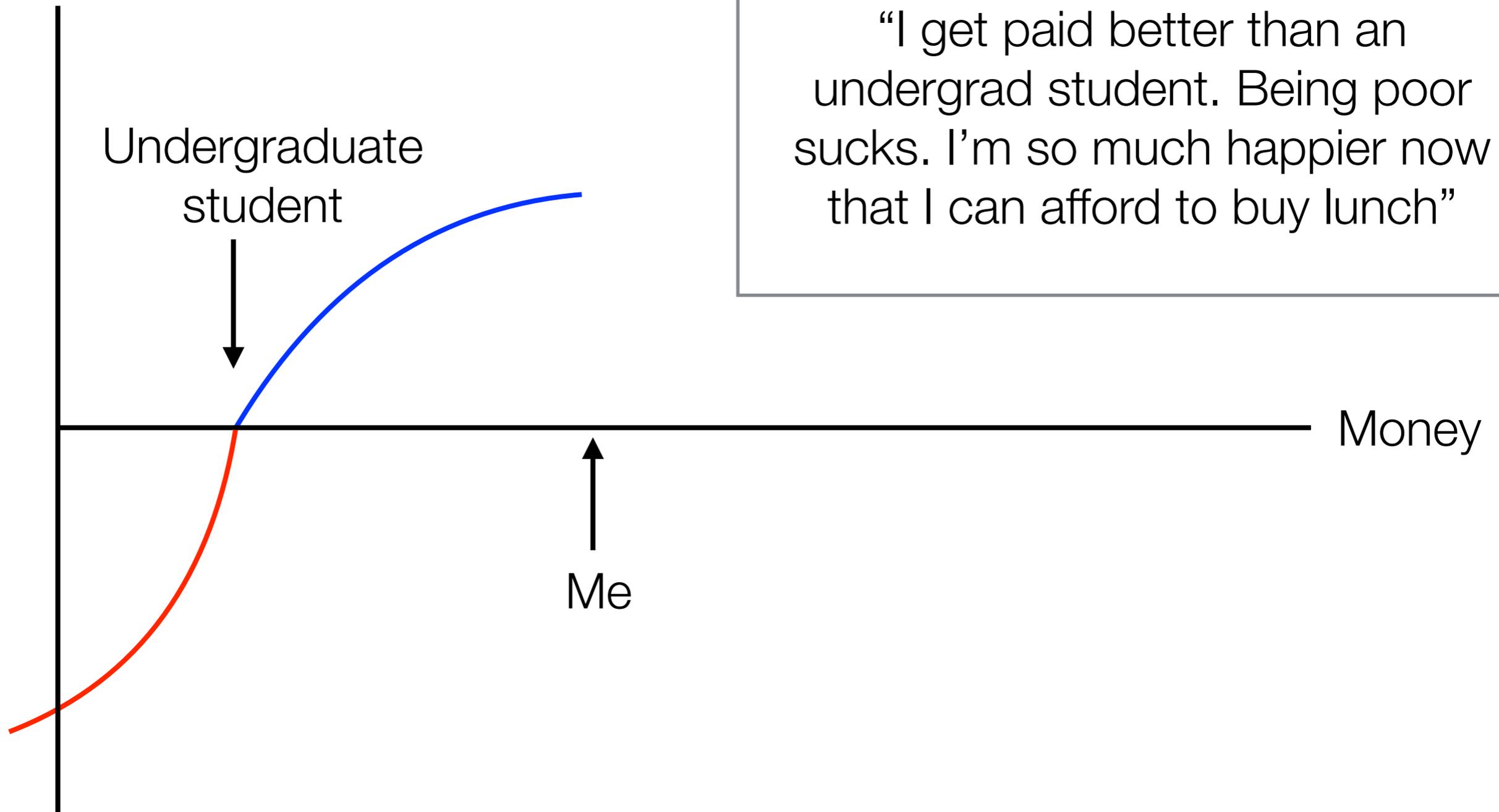
“I feel stuck [on \$350,000]. The New York that I wanted to have is still just beyond my reach.”

- Andrew Schiff in 2012 (director of marketing for some financial company or something)

etc. etc. This happens a lot

Does money buy happiness?

Happiness



Does money buy happiness?

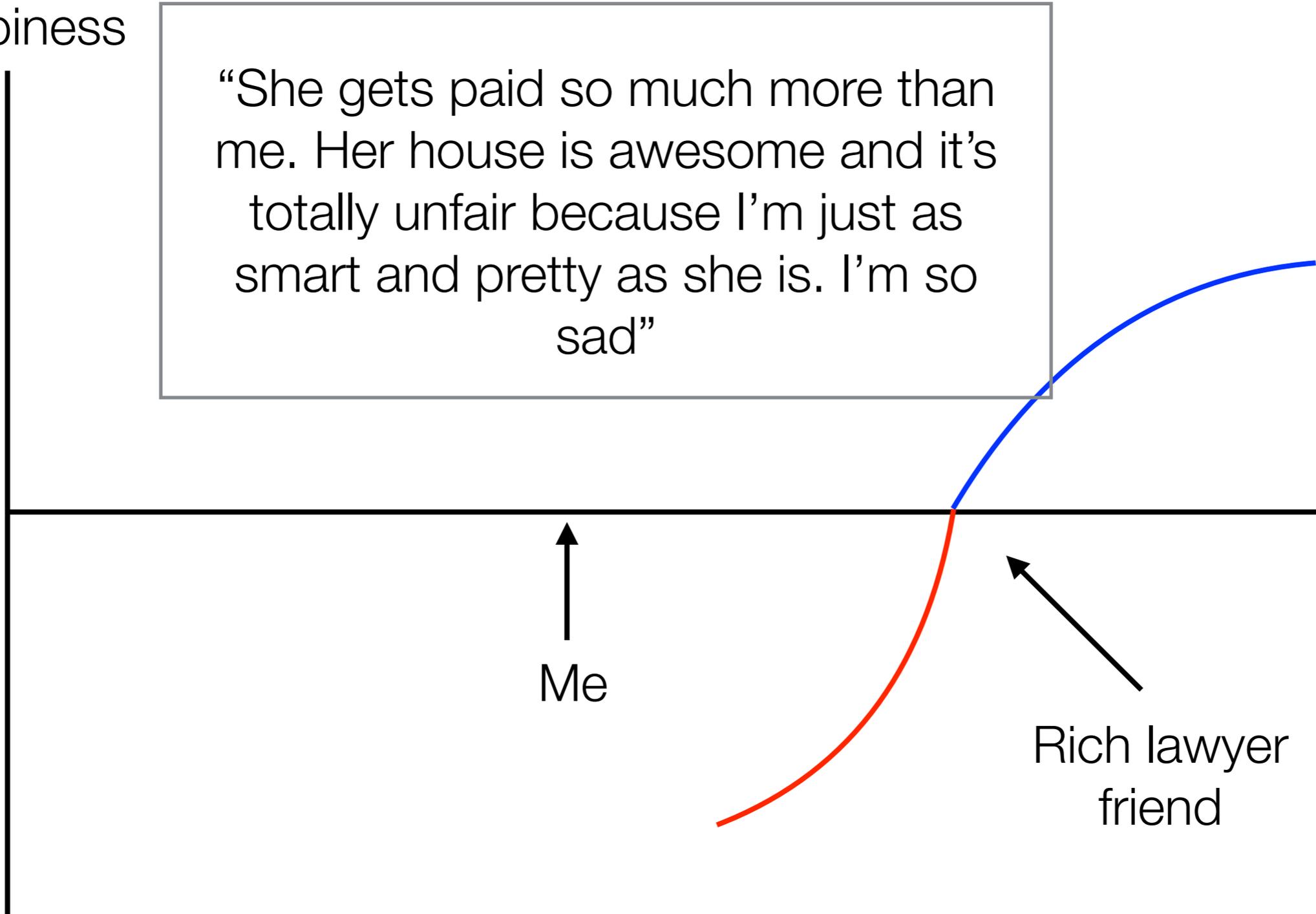
Happiness

“She gets paid so much more than me. Her house is awesome and it’s totally unfair because I’m just as smart and pretty as she is. I’m so sad”

Money

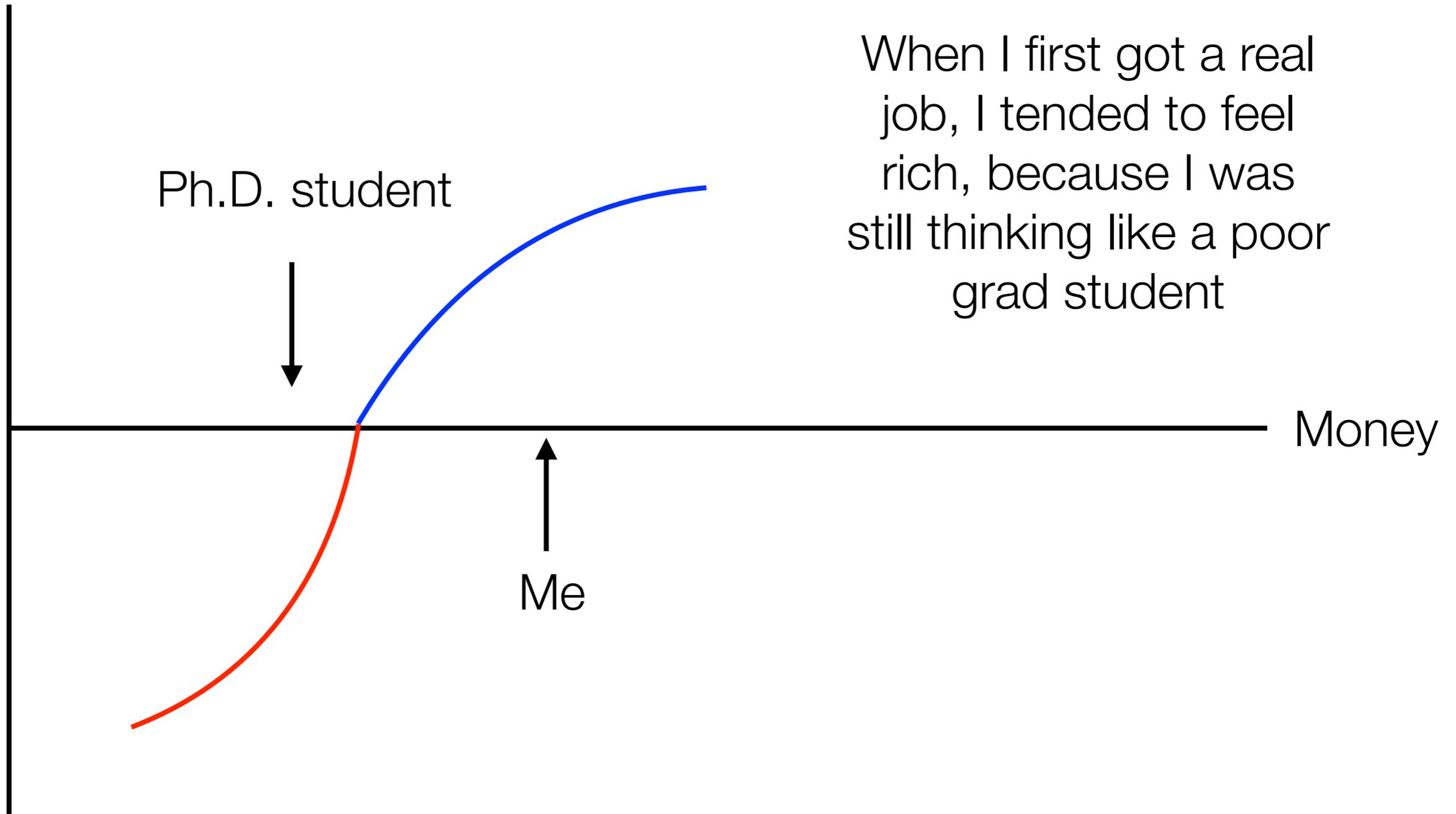
↑
Me

↖
Rich lawyer
friend



Your reference points move

Happiness



Ph.D. student



Me



When I first got a real job, I tended to feel rich, because I was still thinking like a poor grad student

Money

Your reference points move

Happiness

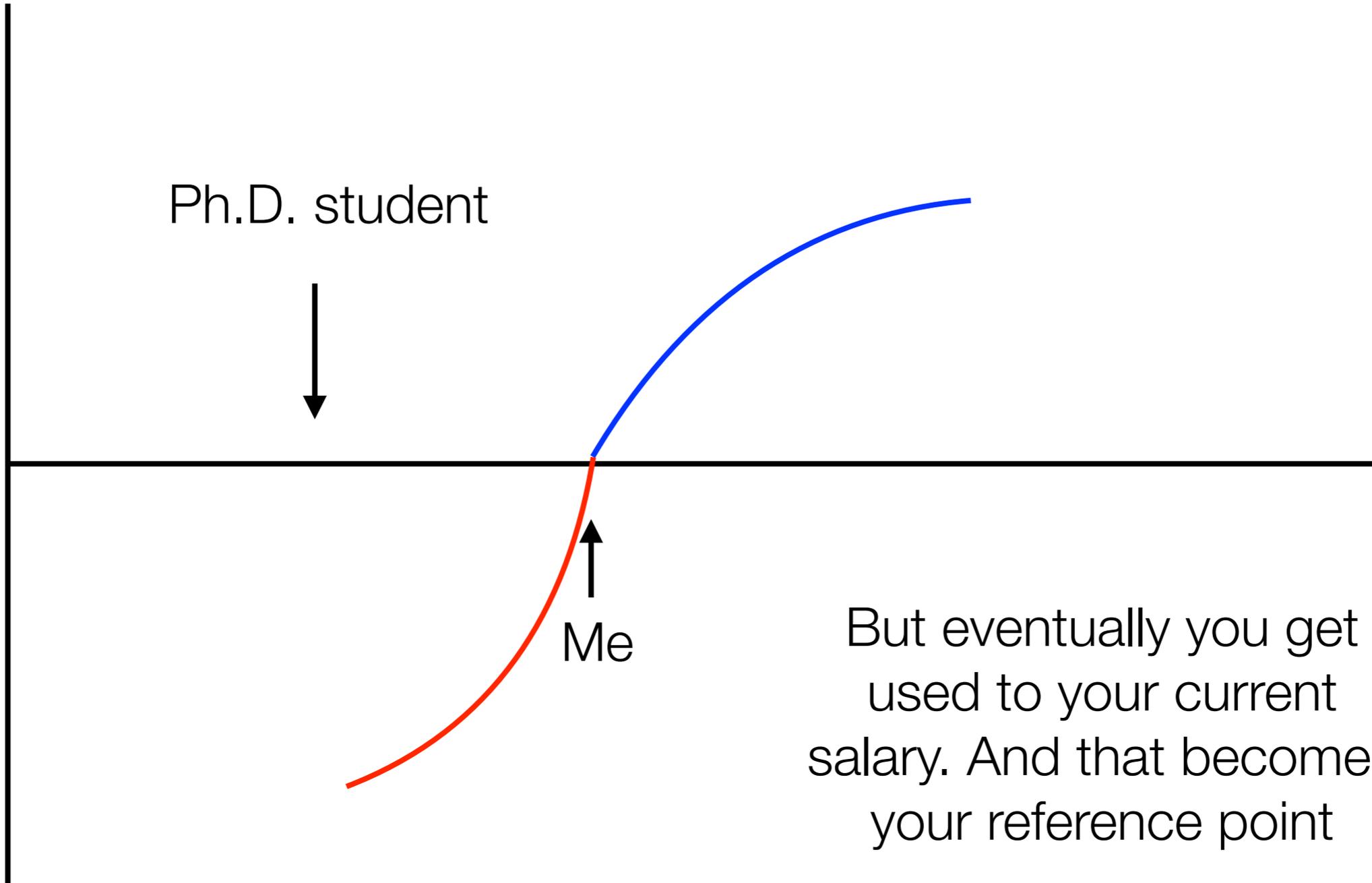
Ph.D. student



Money

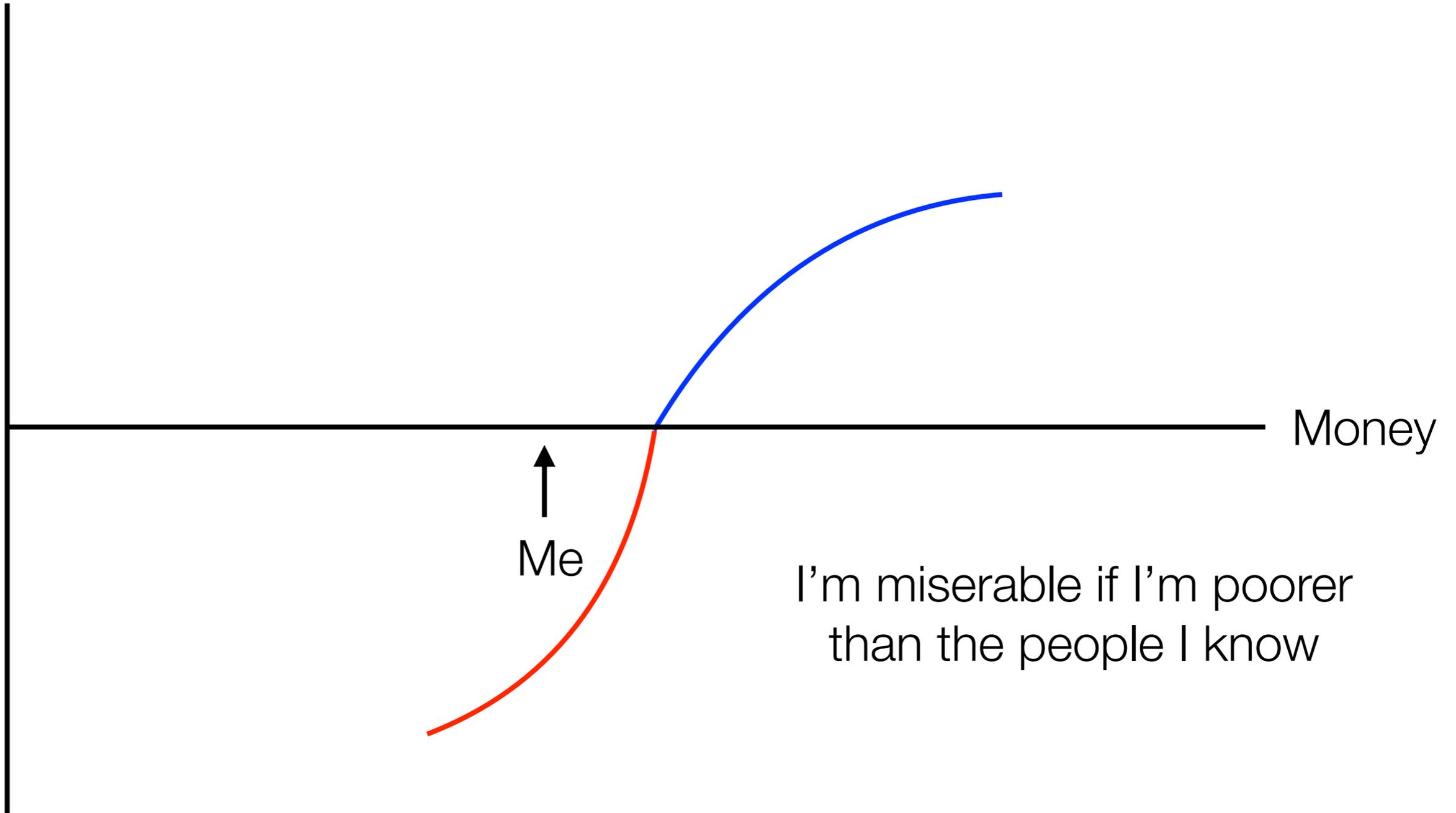
Me

But eventually you get used to your current salary. And that becomes your reference point



Or, more likely...

Happiness



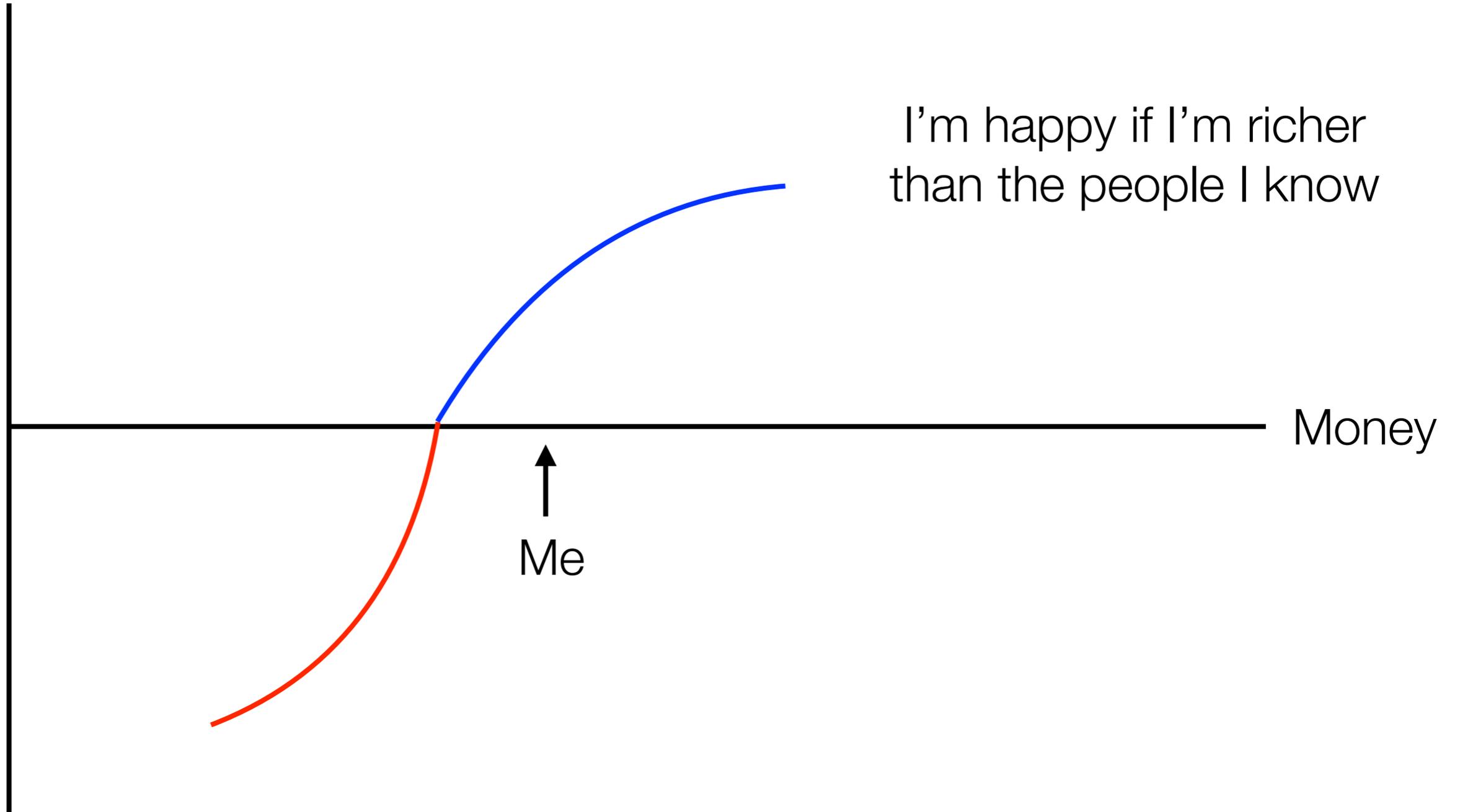
Money

Me

I'm miserable if I'm poorer
than the people I know

Or, more likely...

Happiness



I'm happy if I'm richer than the people I know

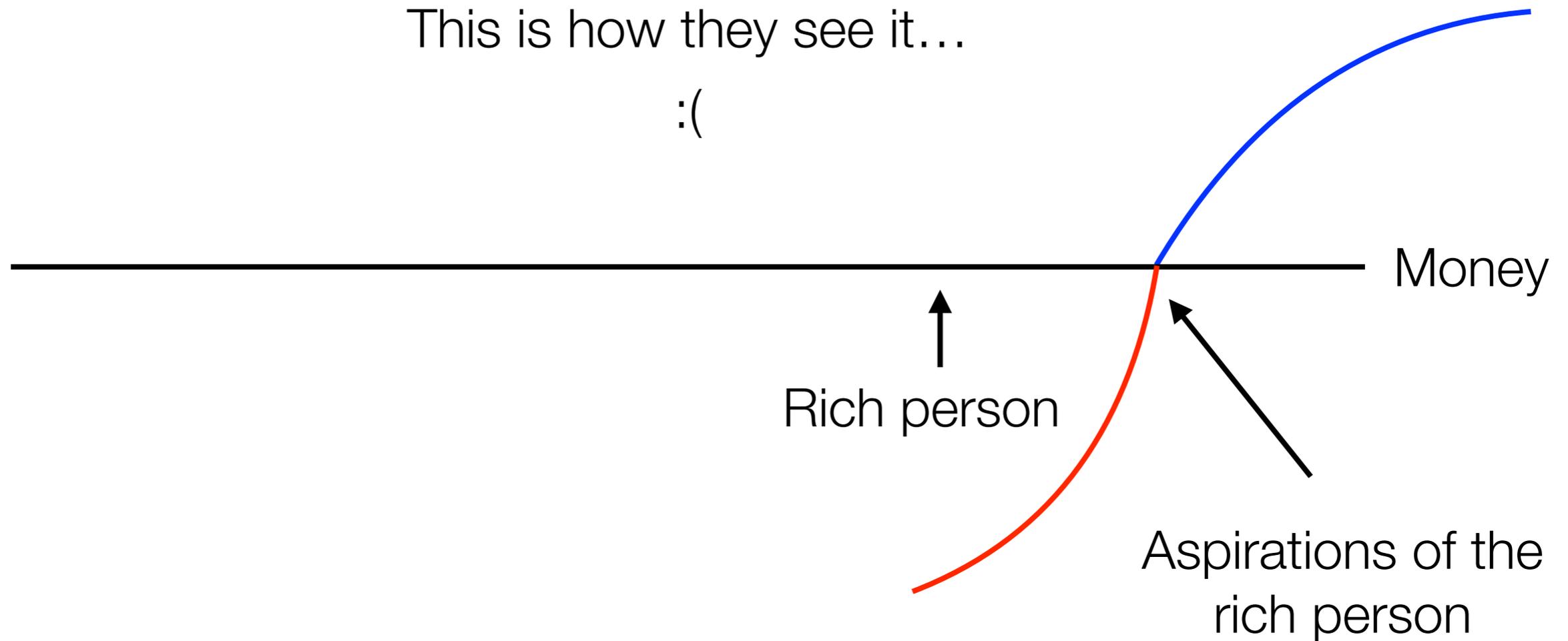
Money

↑
Me

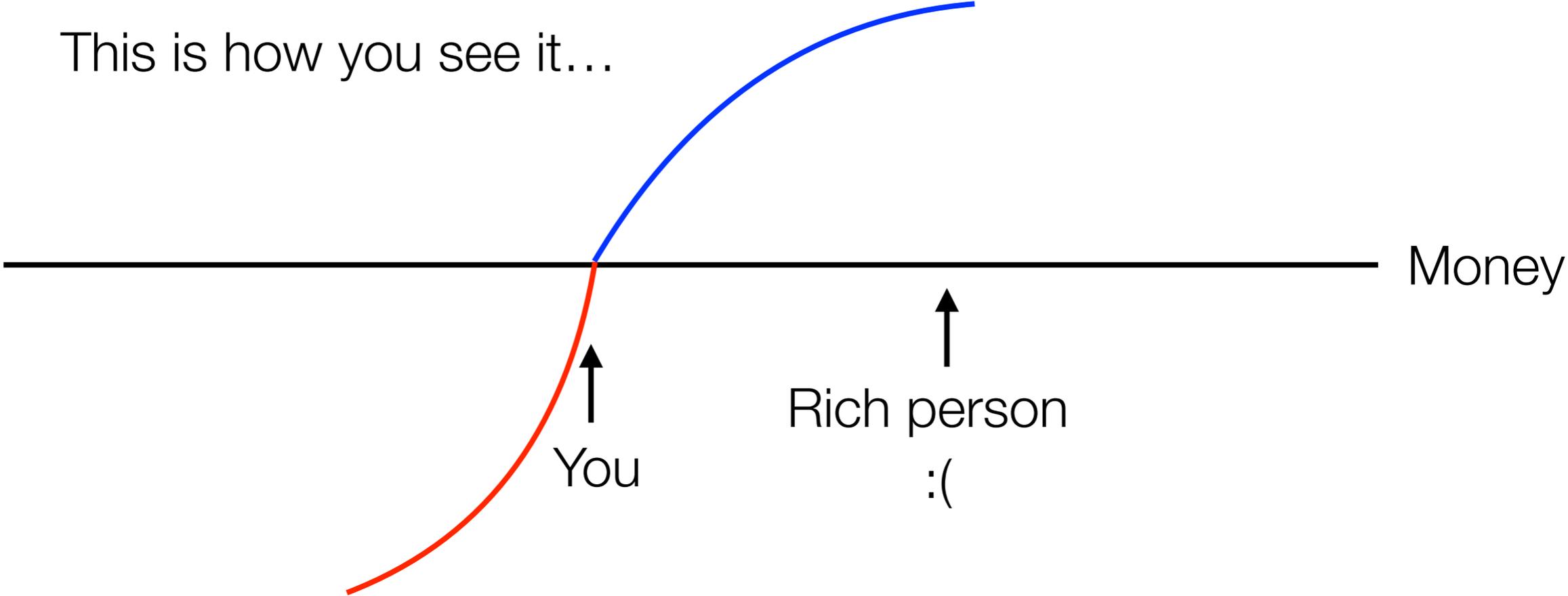
This is why you hear rich people crying
poor all the freaking time

This is how they see it...

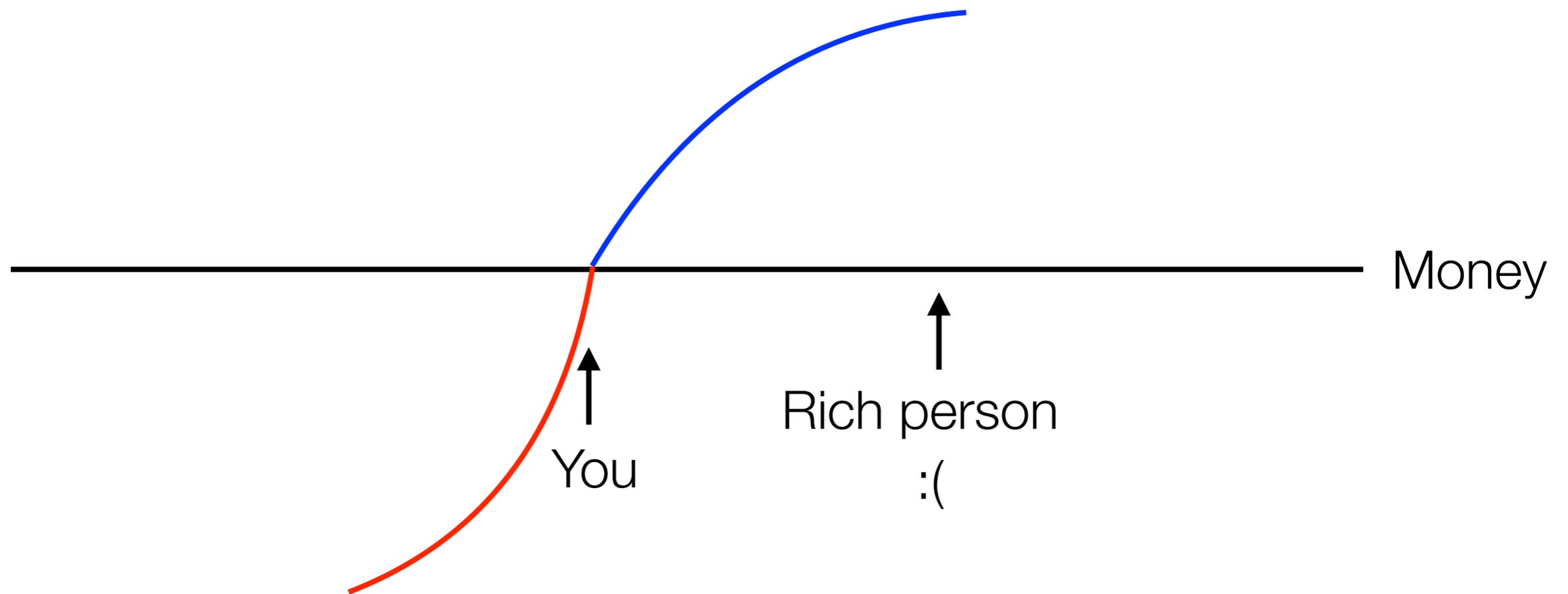
:(



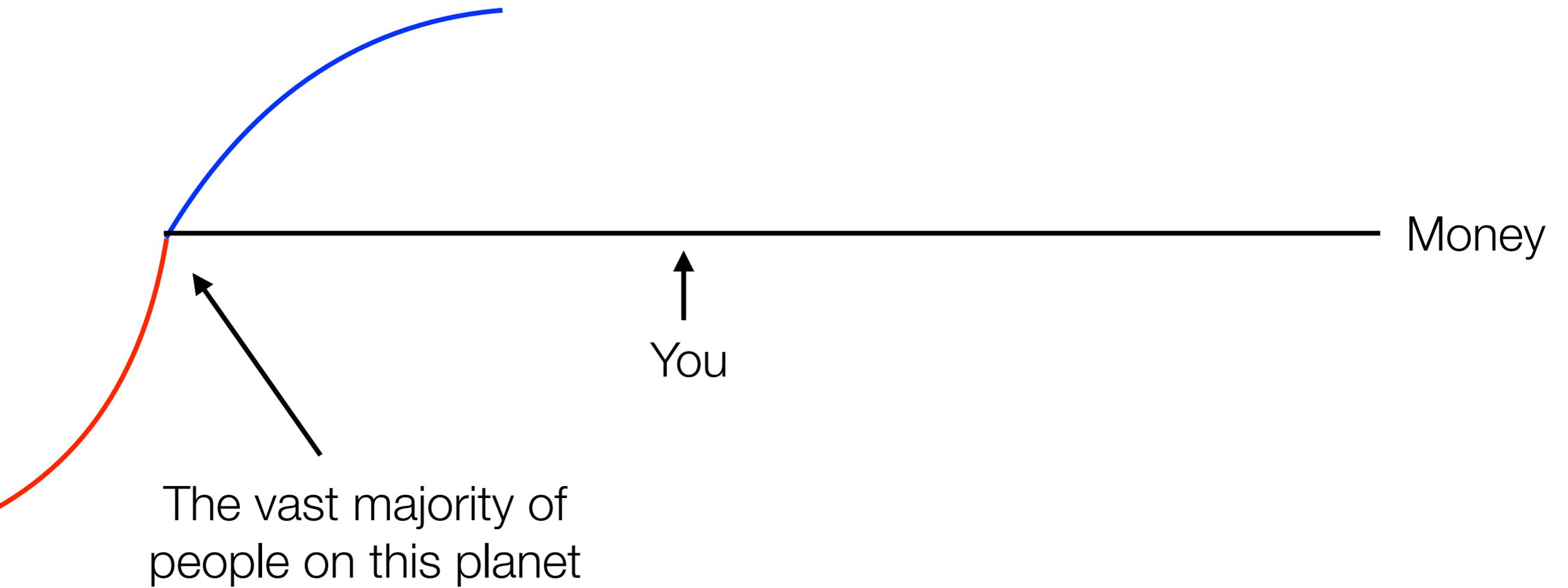
This is how you see it...



The truth is, of course, that the rich person is totally out of touch with reality. But there's nothing weird about them. This happens to us all



Life is worse for almost everyone else.
It's very very easy to forget that.



Back to the cognitive science...
Where are these “value” functions?
In the mind, or in the world?

Decision by sampling

- Prospect theory is committed to psychological “value functions”
 - We got rid of “absolute utilities in the head” ...
 - ... only to replace them with “value functions in the head”

Decision by sampling

- Prospect theory is committed to psychological “value functions”
 - We got rid of “absolute utilities in the head” ...
 - ... only to replace them with “value functions in the head”
- Maybe this is all rubbish. Maybe none of them exist?
- Stewart, Chater & Brown (2006) propose that...
 - We have memories of different events, which we can retrieve (sample)
 - But all we can do is assess “better than” or “worse than”
 - There are no value curves, no utilities etc.

How good was last night's dinner?

I have lots of memories of eating dinner.



How good was last night's dinner?

I can make "better vs worse" judgments about them (to some extent)

meh.



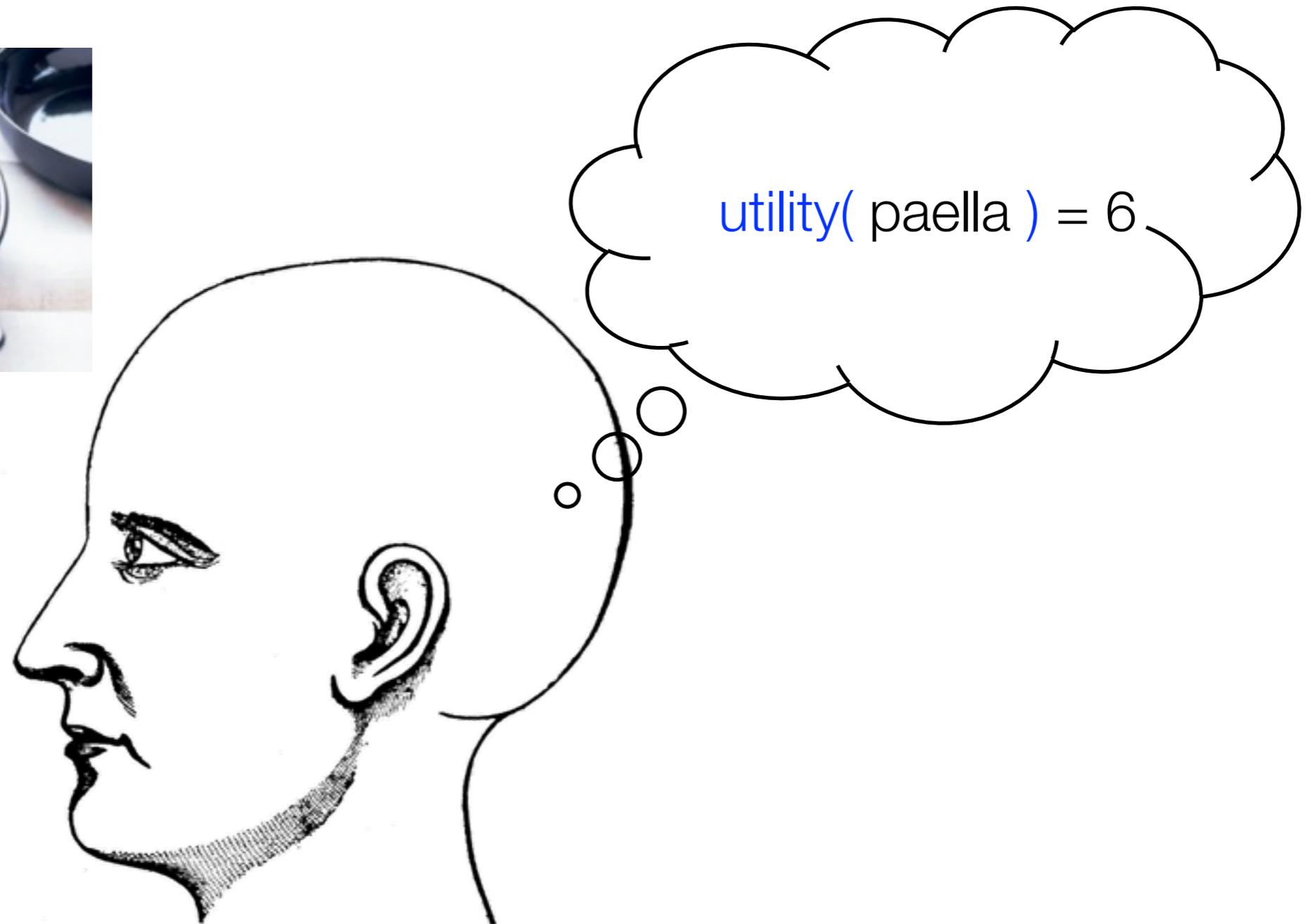
good.



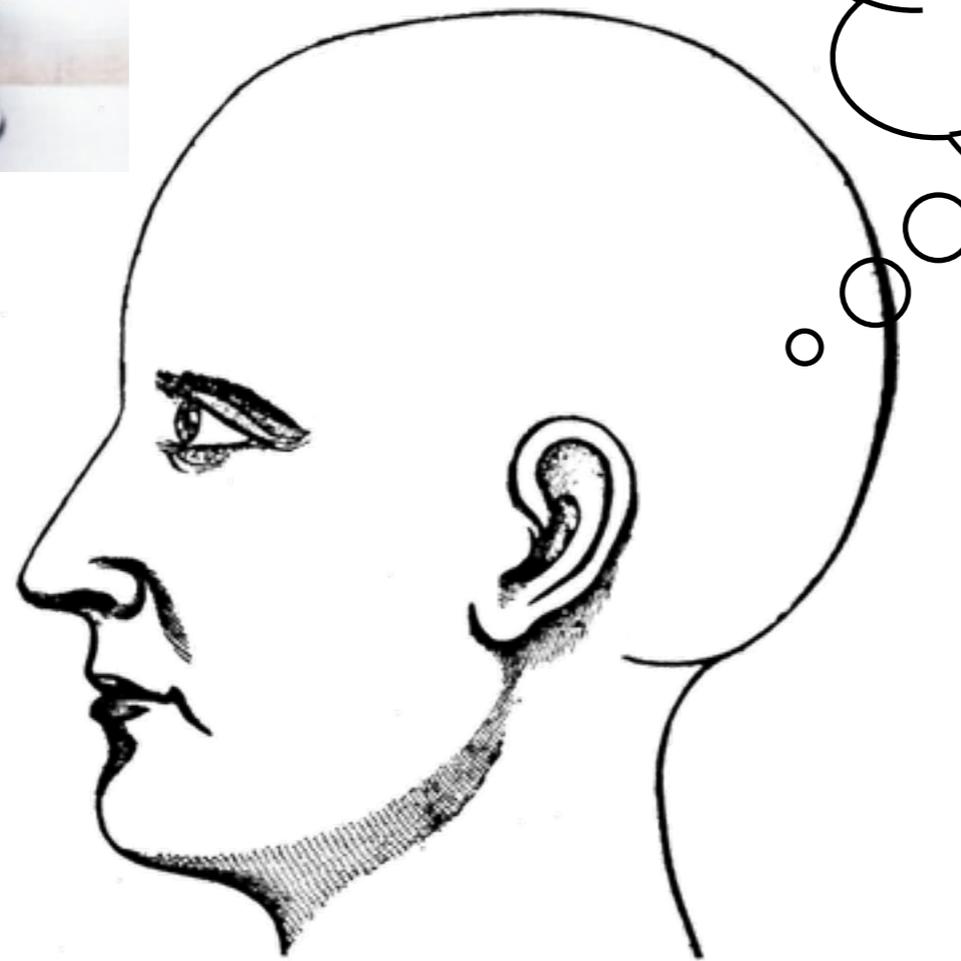
better.



We don't do this...

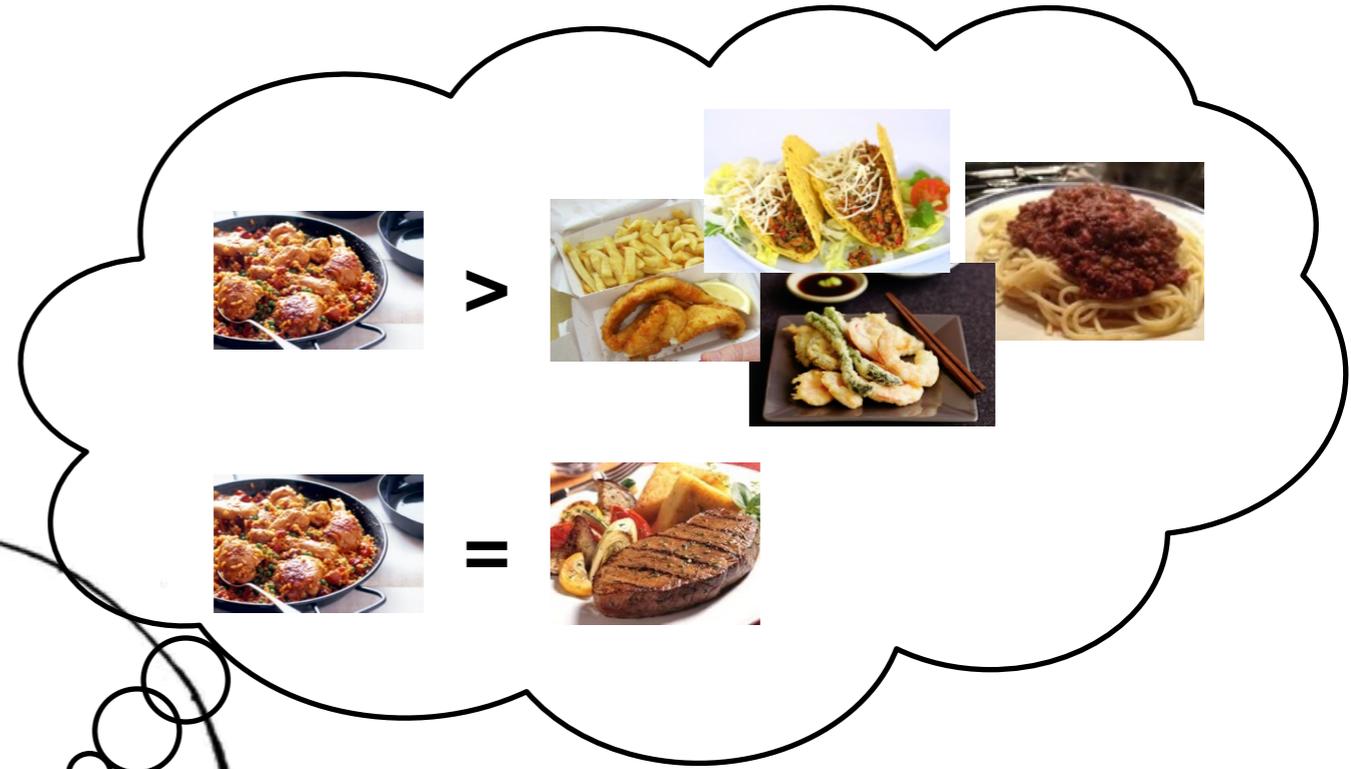
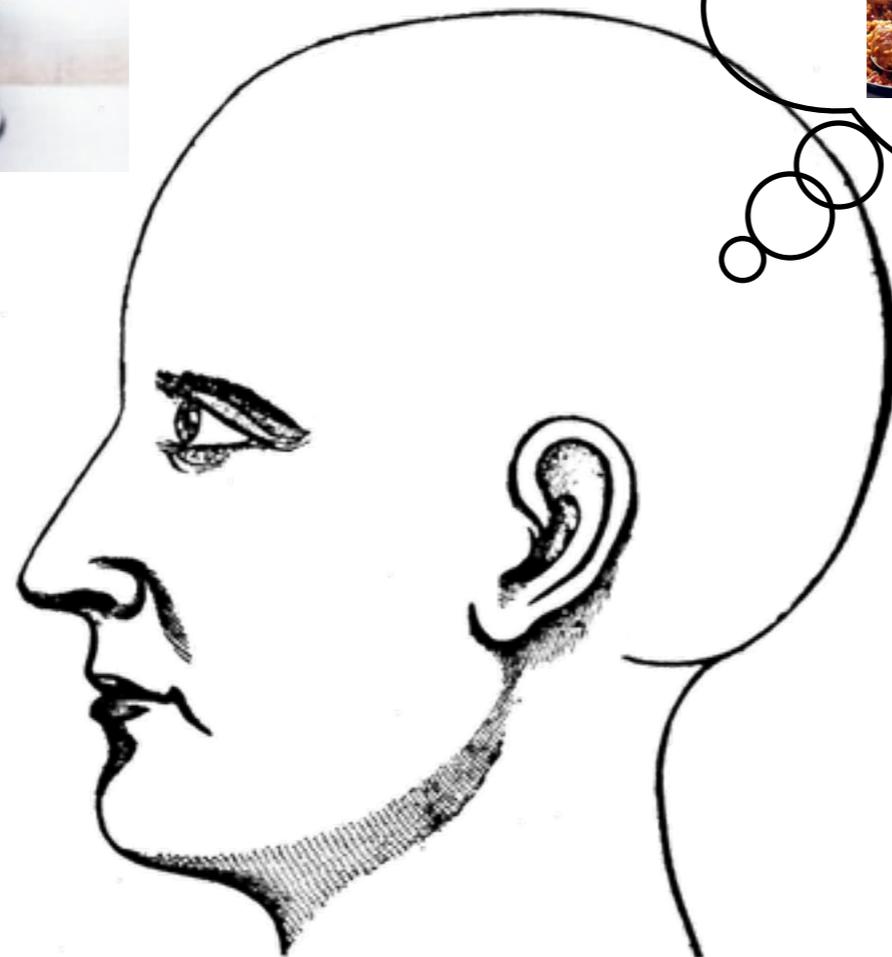


And we don't do this...



value(paella, spag. bol)
= +10

What we do is this...



Retrieve some memories of past meals and (implicitly) count how many of those memories are better than the current one.

Memories for monetary **gains**?

+\$**50** from grandma

+\$**2000** from pay check

+\$**2000** from pay check

+\$**2000** from pay check

+\$**100** from royalties

+\$**10** from winning a bet

+\$**2000** from pay check

Memories for monetary **losses**?

-\$**3** for coffee

-\$**3** for coffee

-\$**10** for lunch

-\$**3** for coffee

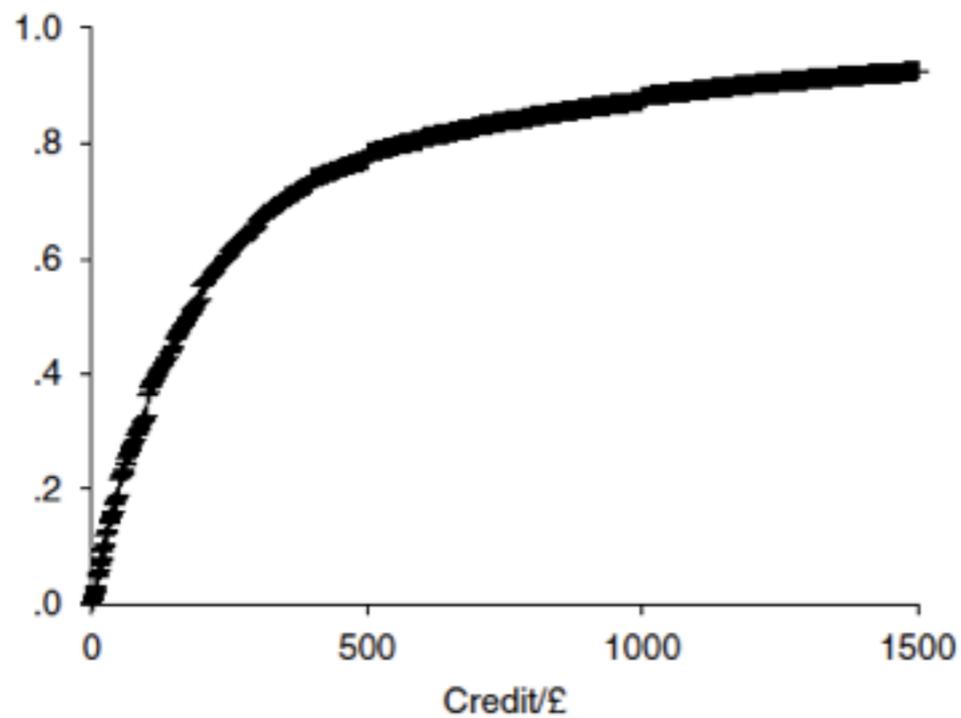
-\$**150** for shoes

-\$**30** for dinner

-\$**25000** for retaining walls

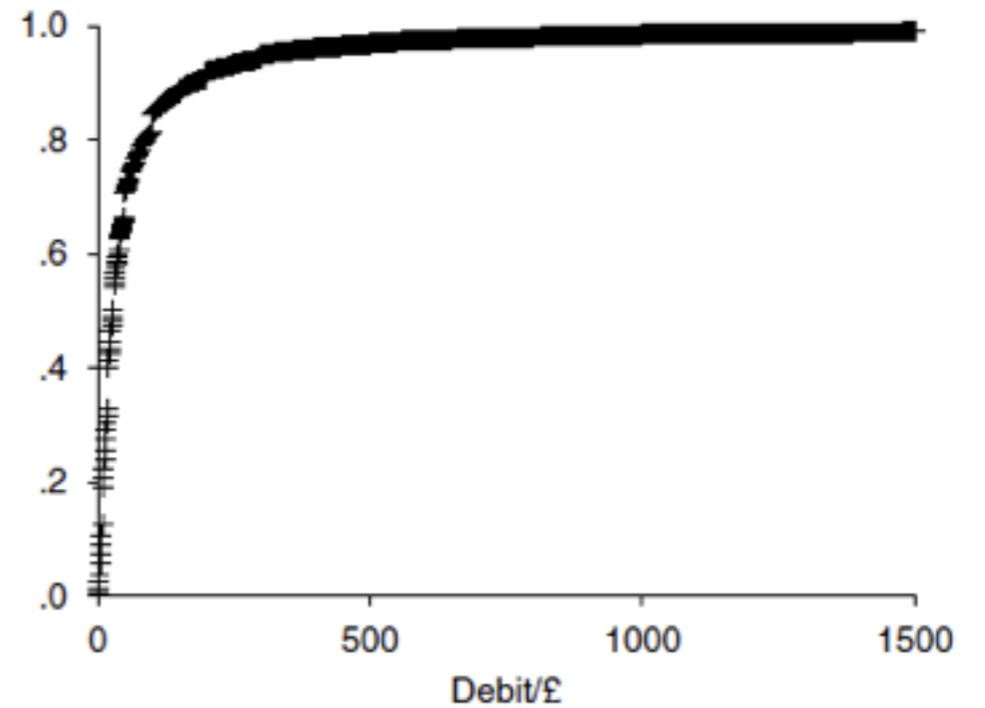
Use bank records as a proxy...

Deposits



Amount of money, X

Withdrawals

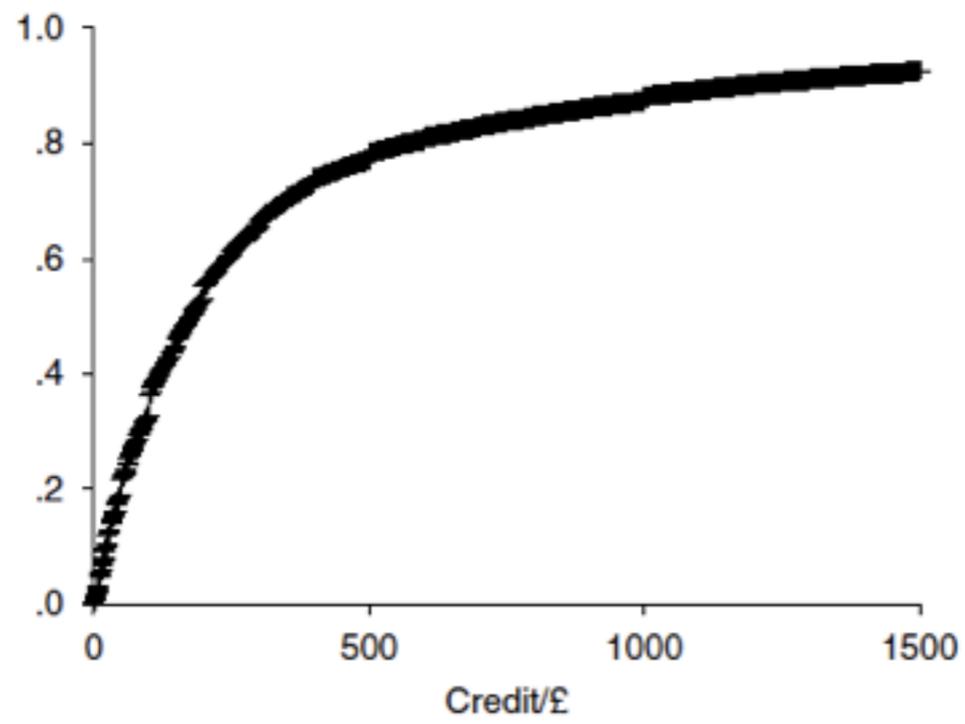


Amount of money, X

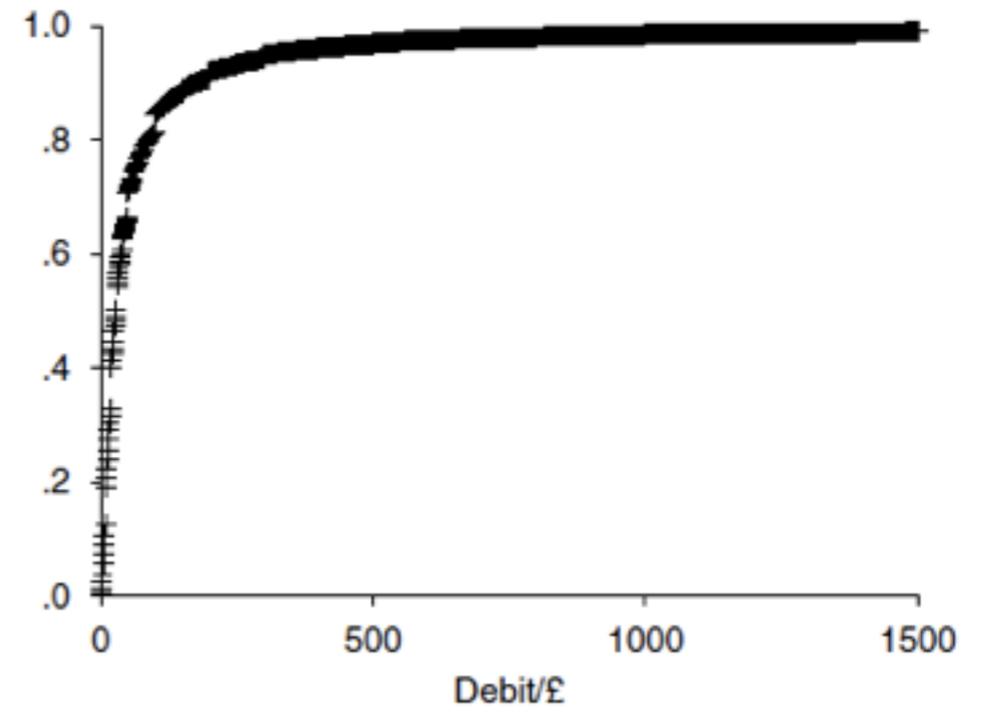
Proportion of transactions that are less than X

Hm...

Gains

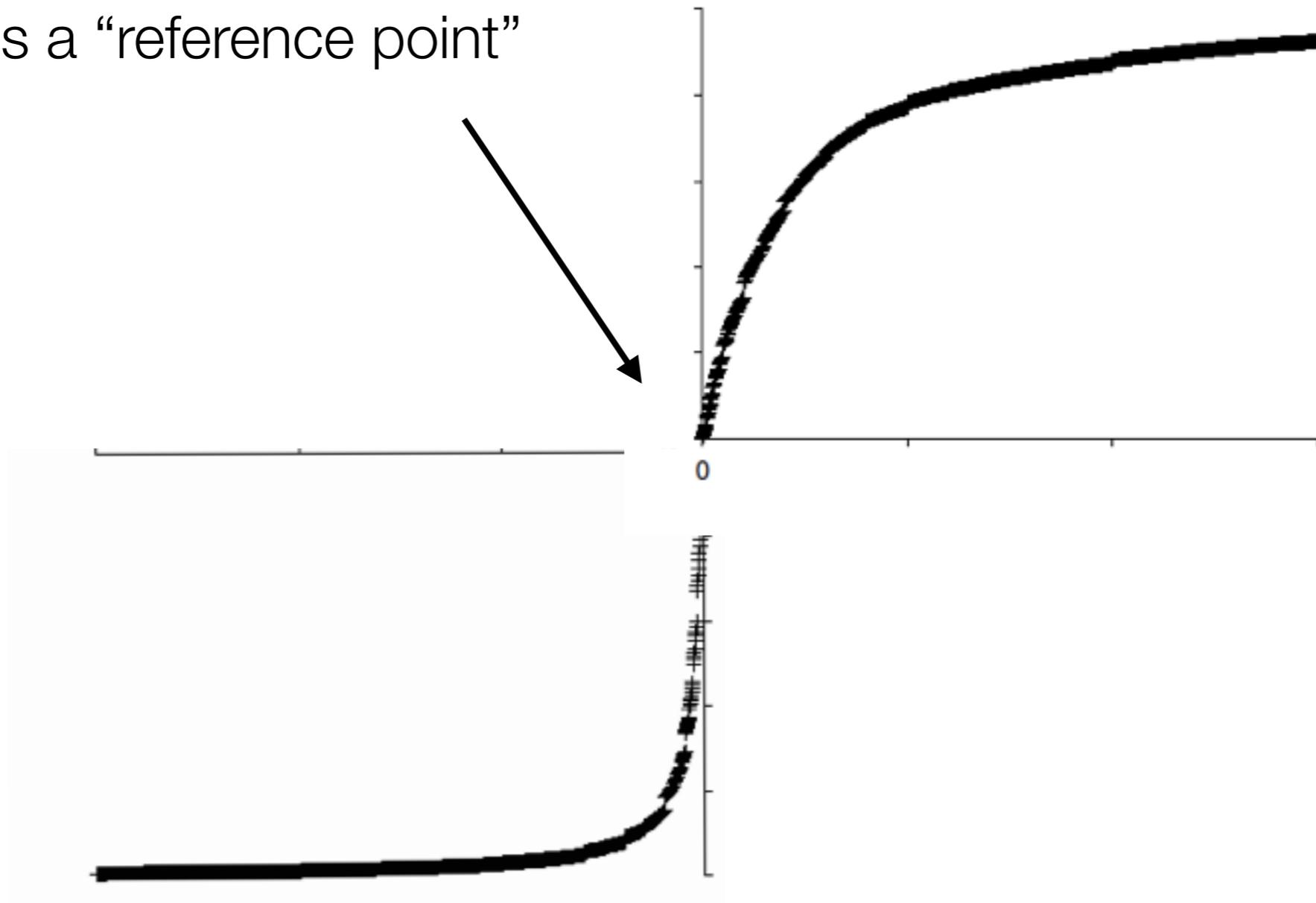


Losses



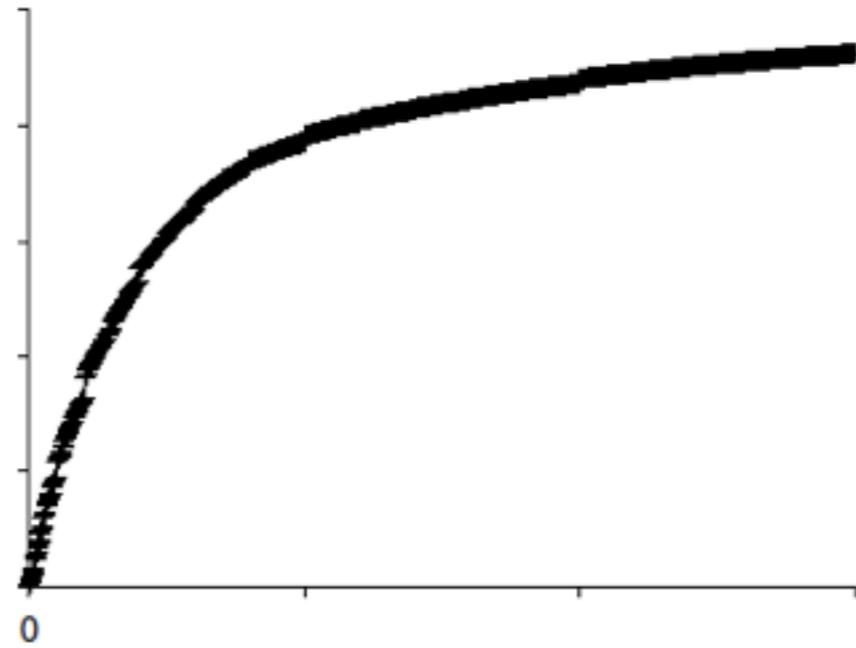
A “gains” curve that emerges because of the structure of my past experience

current bank balance is a “reference point”



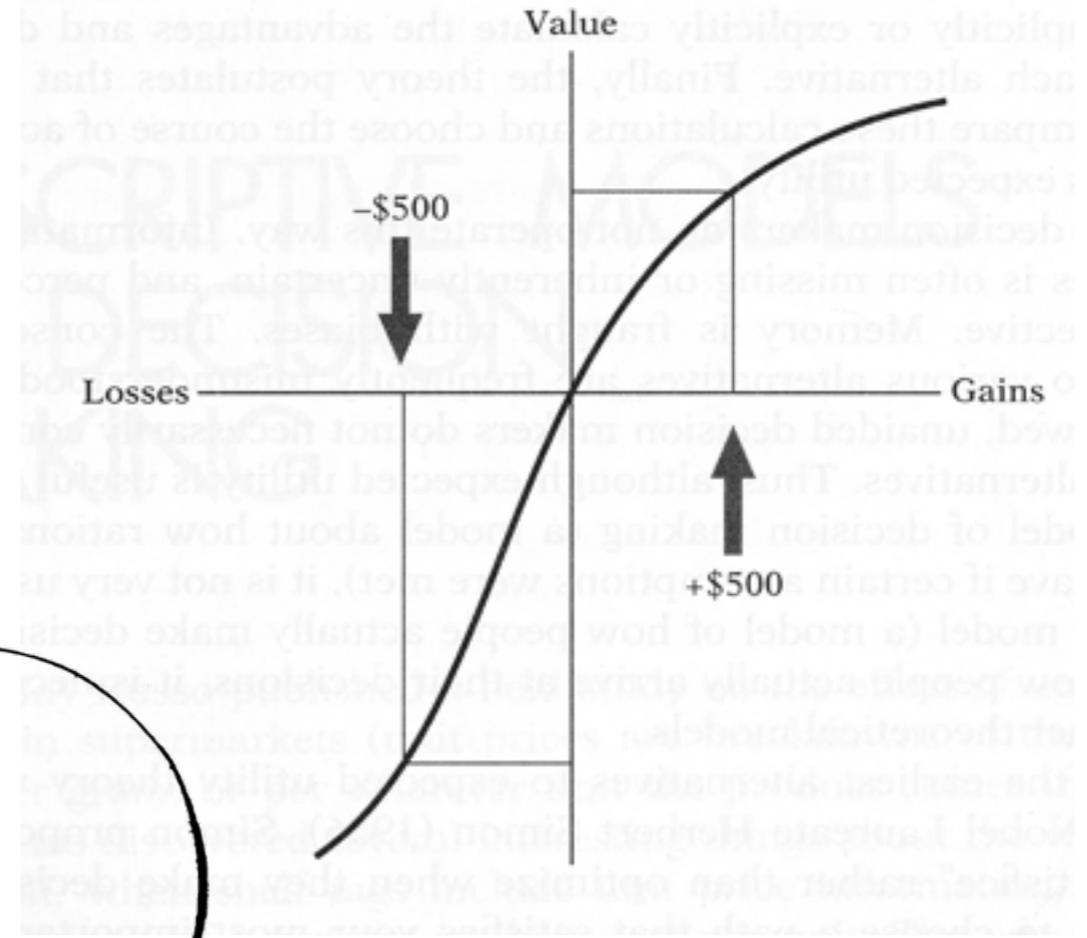
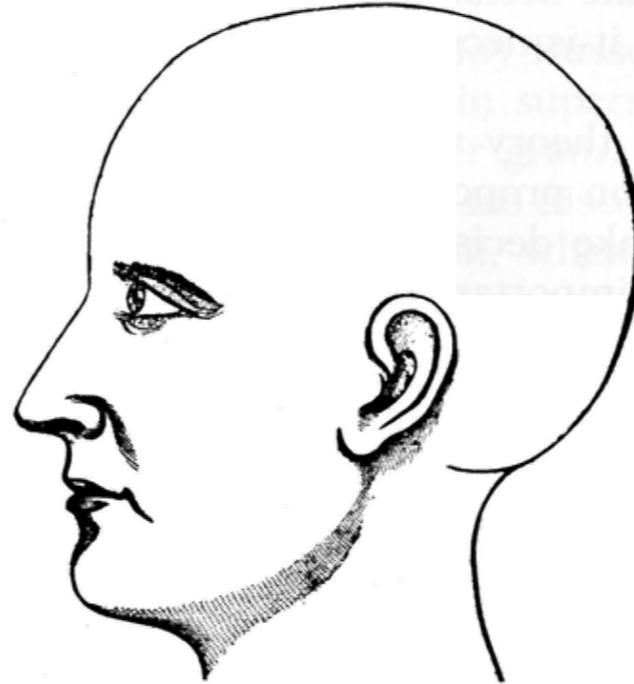
A “losses” curve that emerges because of the structure of my past experience

This curve isn't a primitive: it emerges from the structure of my experiences of the world



... suggests that prospect theory has a deeper explanation.

Value functions aren't "real" things in the head, they're a consequence of our experiences of the world



Wrap up

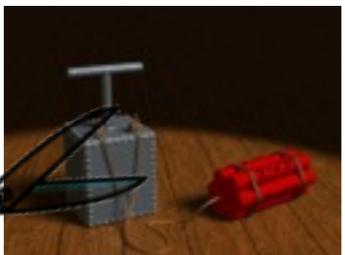
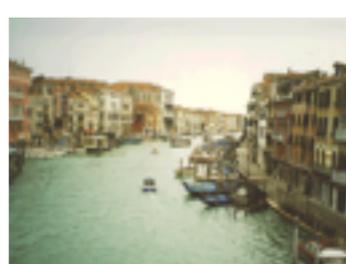
What have we done?

- We started with a simple, elegant theory
 - Make choices by maximising expected utility
 - Decision makers must know the probabilities of events
 - Decision makers must be able to assign utilities to events
- We broke that theory
 - Calculating probabilities is hard
 - Utility functions don't seem to exist

What have we done?

- We replaced it with prospect theory
 - Make choices by assessing values relative to a single “reference” point
 - (The full version of prospect theory doesn’t require people to know all the probabilities. It requires them to estimate “decision weights”)
- We simplified that theory
 - You may not need actual “value” curves in the head
 - Maybe you just need “memories” and the “simple” ability to assess whether one experience is better or worse than another
 - No actual values are needed.

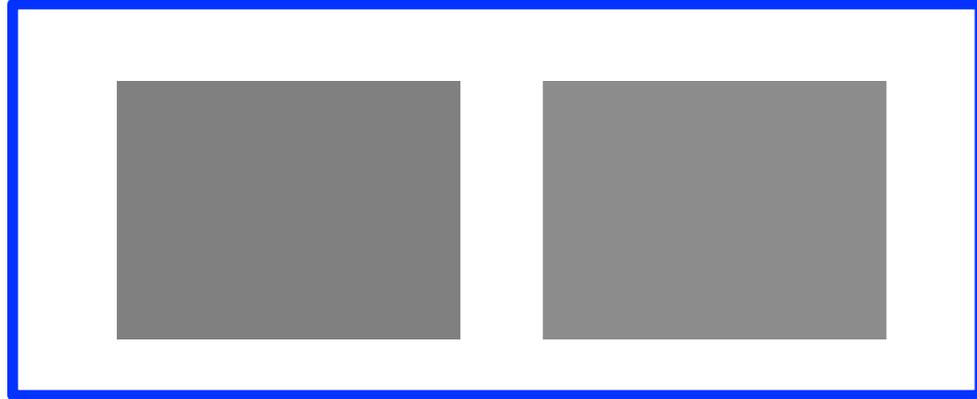
Where to next?



Decision by sampling hints that “simple” comparison processes might underpin a lot of these complex-looking decisions



Where to next?



So that's what we're going to look at next...

