LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

MAY 5, 2025

REAL LIFE GAMES:
HOW GAME THEORY SHAPES HUMAN DECISIONS

GAME THEORY

NASH EQUILIBRIA

Adrian Haret
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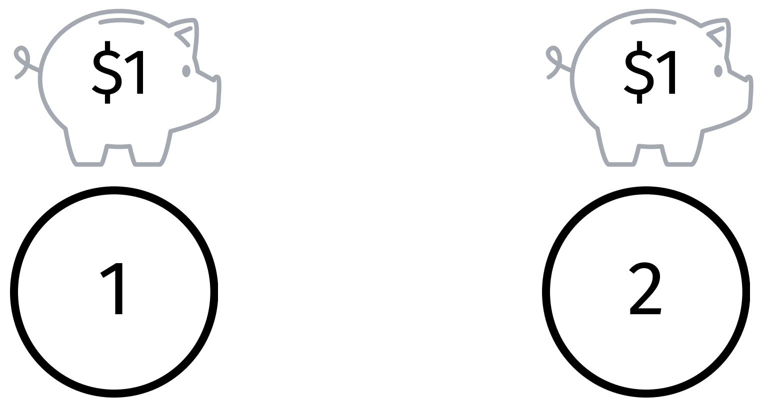
Let's play a game!

The Trust Game

Two players, with initial endowment of 1 each.

payoffs



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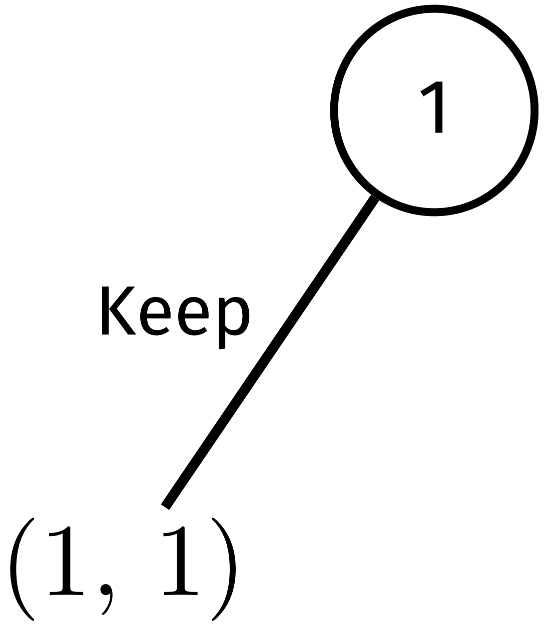

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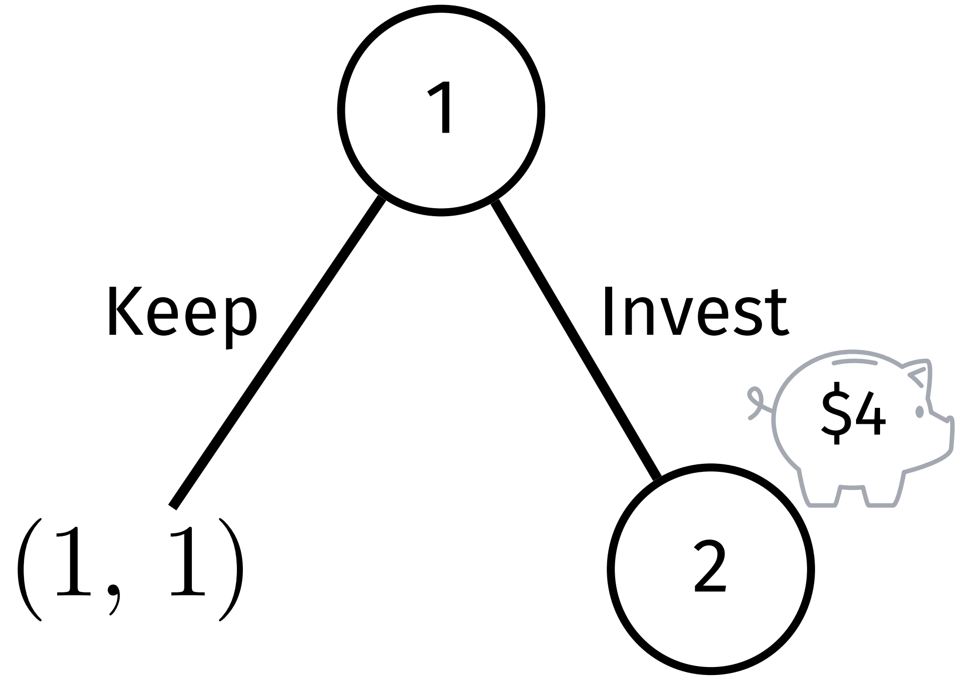

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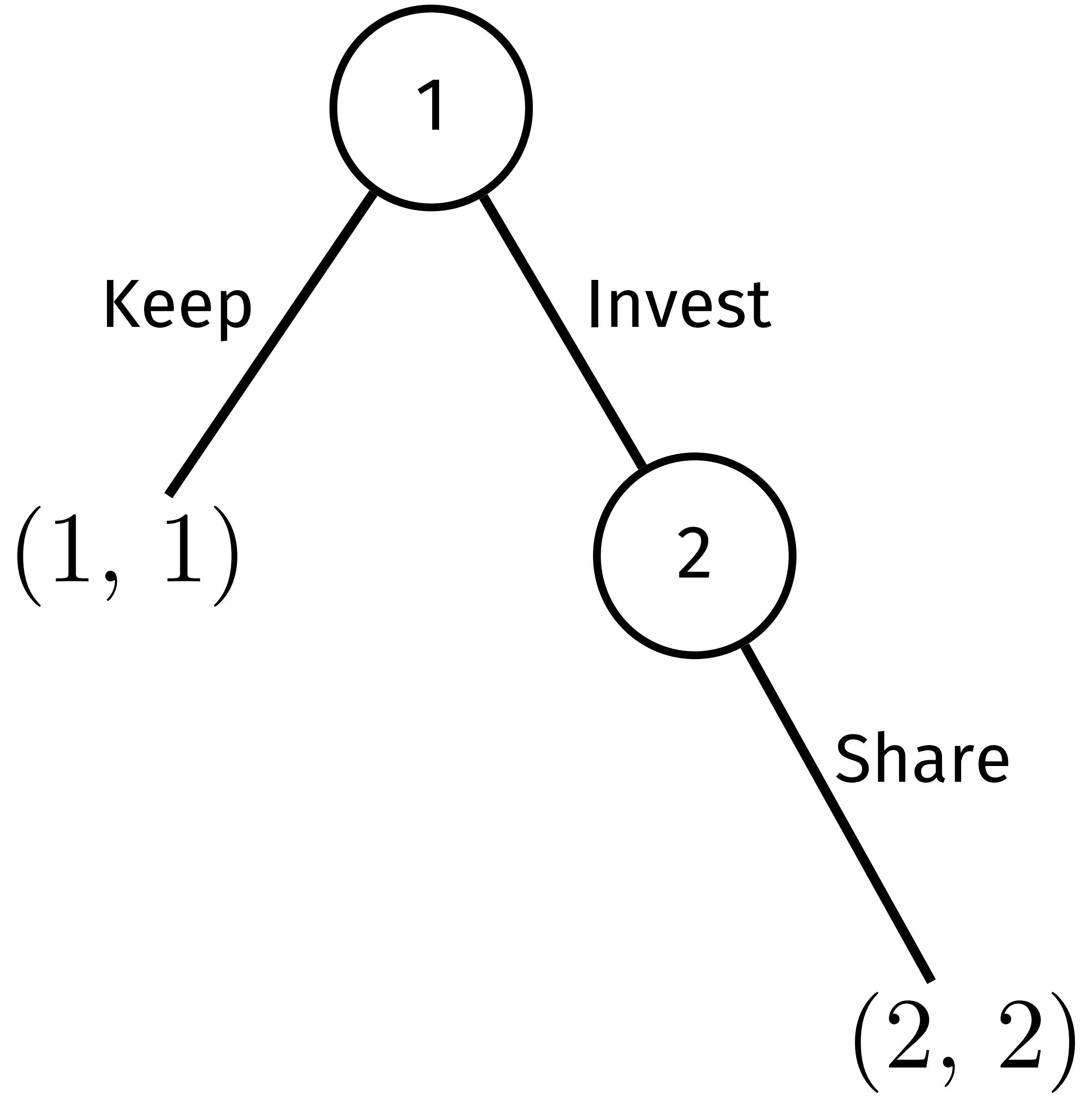

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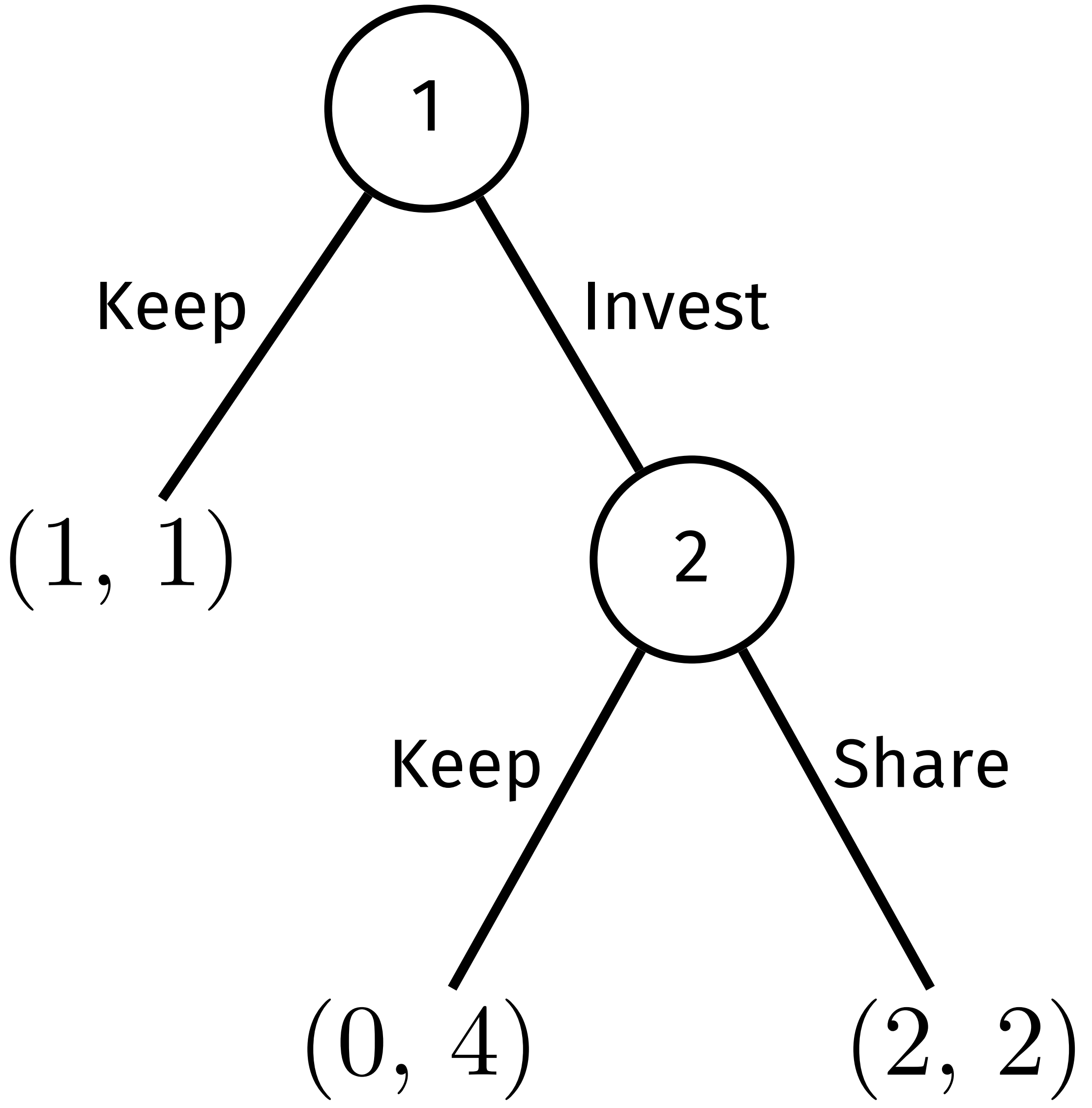

Did you trust your co-player?

Did you trust your co-player? Do people trust each other across the world?

THE TRUST GAME IN EXPERIMENTS

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Player 1 could send any amount between \$0 and \$10. Player 2 could return anything between \$0 and \$20.

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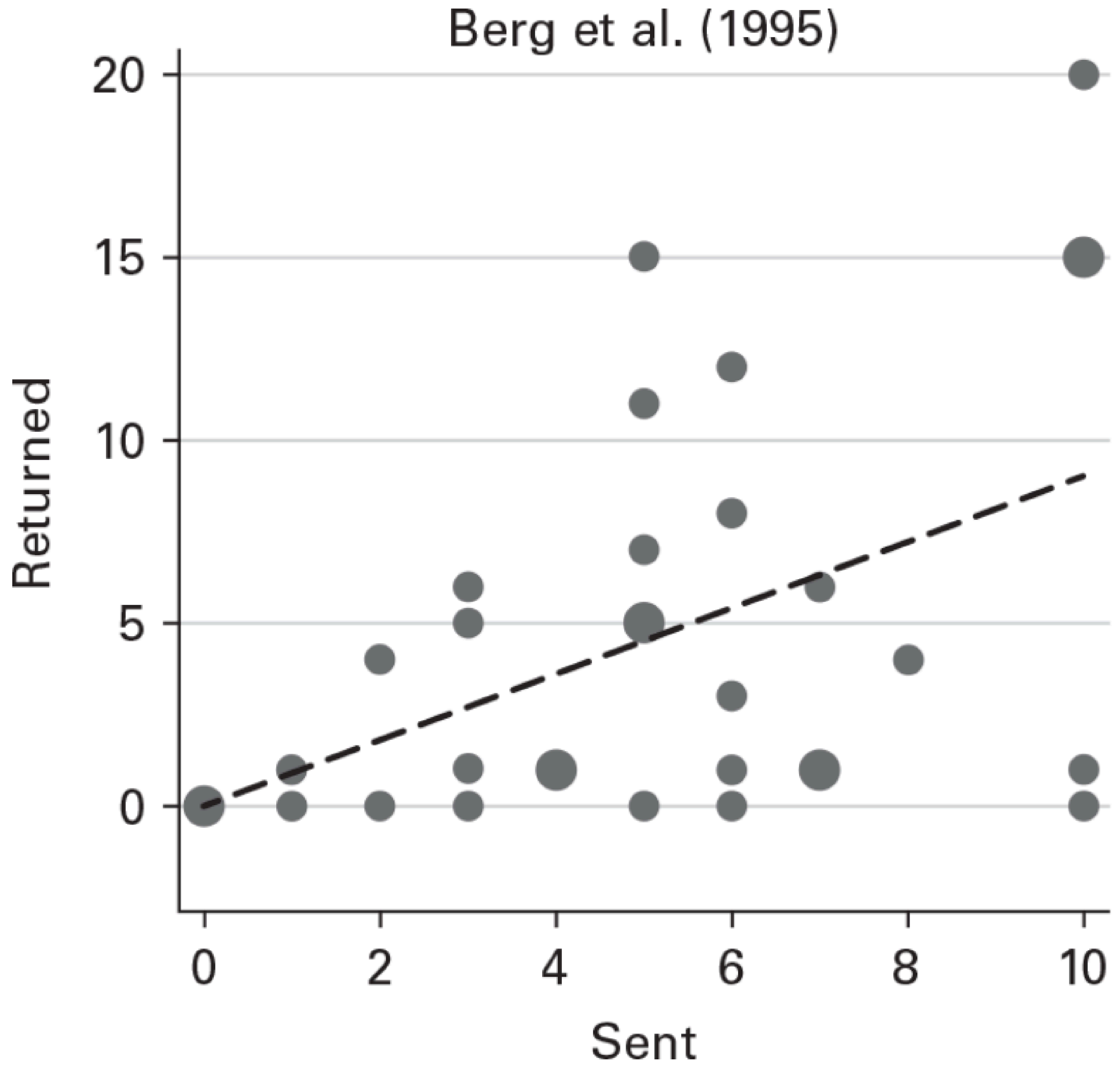

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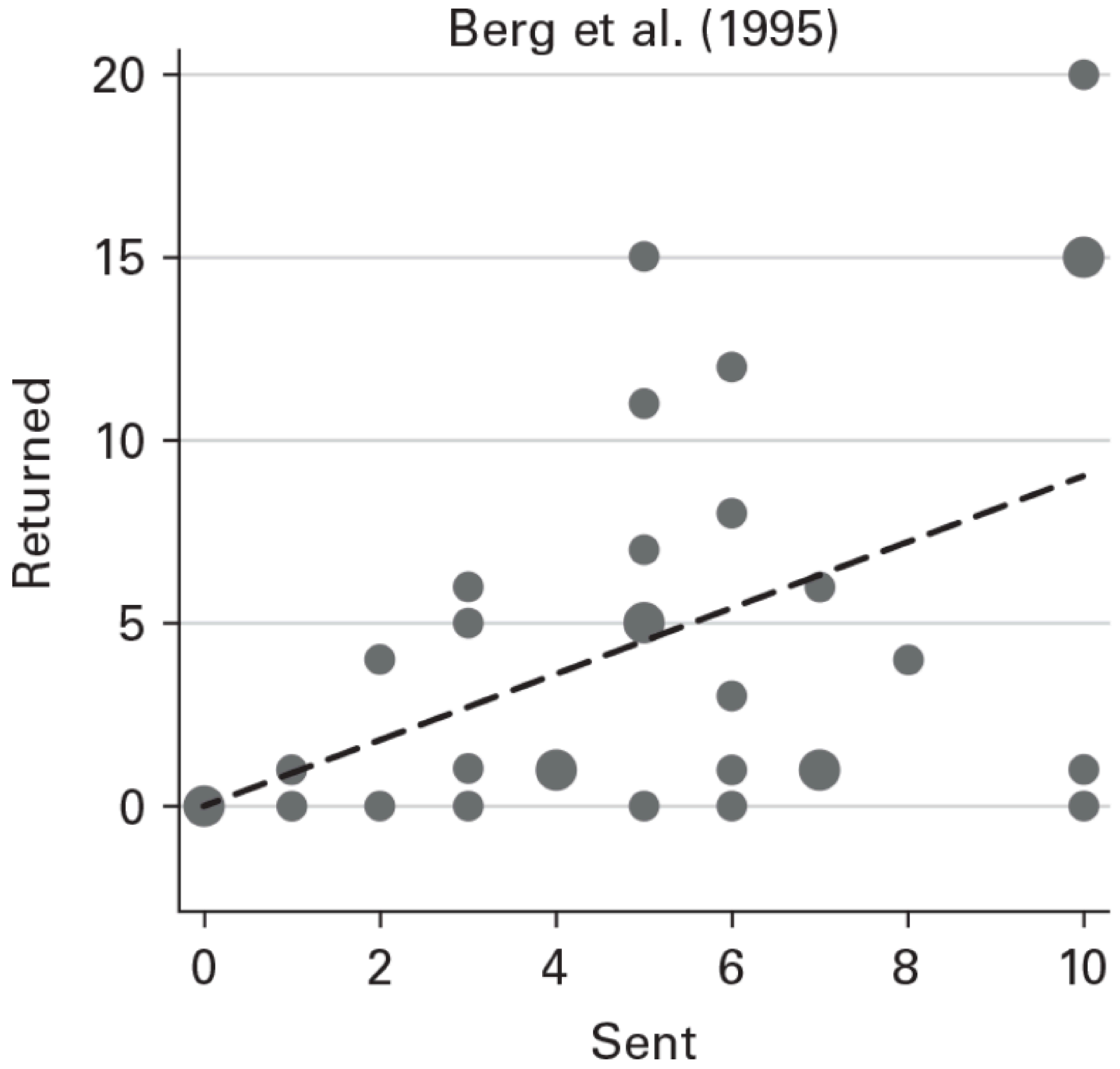
Average amount sent by Player 1 was \$5,16.

Average amount returned by Player 2 was \$4,66.



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RESULTS FROM A META-STUDY

These results have been replicated across many other instances and cultures.

Variable name	Obs.	Sum *N*	Mean
Panel A: Sent fraction (trust)			
All regions	161	23,900	0.502
North America	46	4579	0.517
Europe	64	9030	0.537
Asia	23	3043	0.482
South America	13	4733	0.458
Africa	15	2515	0.456
Panel B: Proportion returned (trustworthiness)			
All regions	137	21,529	0.372
North America	41	4324	0.340
Europe	53	7596	0.382
Asia	15	2361	0.460
South America	13	4733	0.369
Africa	15	2515	0.319

Johnson, N. D., & Mislin, A. A. (2011). Trust games: A meta-analysis. *Journal Of Economic Psychology*, 32(5), 865–889.

The Trust Game is a workhorse for the study of prosocial traits, e.g., trust in others.

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CAN PEOPLE BE TRUSTED?

Countries ranked by proportion agreeing that ‘most people can be trusted’.

Country/area	Share agreeing "Most people can be trusted" percent • 2022
Denmark	73.9%
Norway	72.1%
Finland	68.4%
China	63.5%
Sweden	62.8%
Iceland	62.3%
Switzerland	58.5%
Netherlands	57.0%
New Zealand	56.6%
Austria	49.8%
Australia	48.5%
Canada	46.7%
United Kingdom	43.3%
Germany	41.6%
Macao	41.4%

Interpersonal trust vs. GDP per capita. (n.d.). Our World in Data. Retrieved May 4, 2025.

CAN PEOPLE BE TRUSTED?

Countries ranked by proportion agreeing that ‘most people can be trusted’.

Country/area	Share agreeing "Most people can be trusted" percent • 2022
Zimbabwe	2.1%
Albania	2.8%
Trinidad and Tobago	3.2%
Peru	4.2%
Nicaragua	4.3%
Colombia	4.5%
Indonesia	4.6%
Ghana	5.0%
Philippines	5.3%
Ecuador	5.8%
Brazil	6.5%
Cyprus	6.6%
Egypt	7.3%
Greece	8.4%

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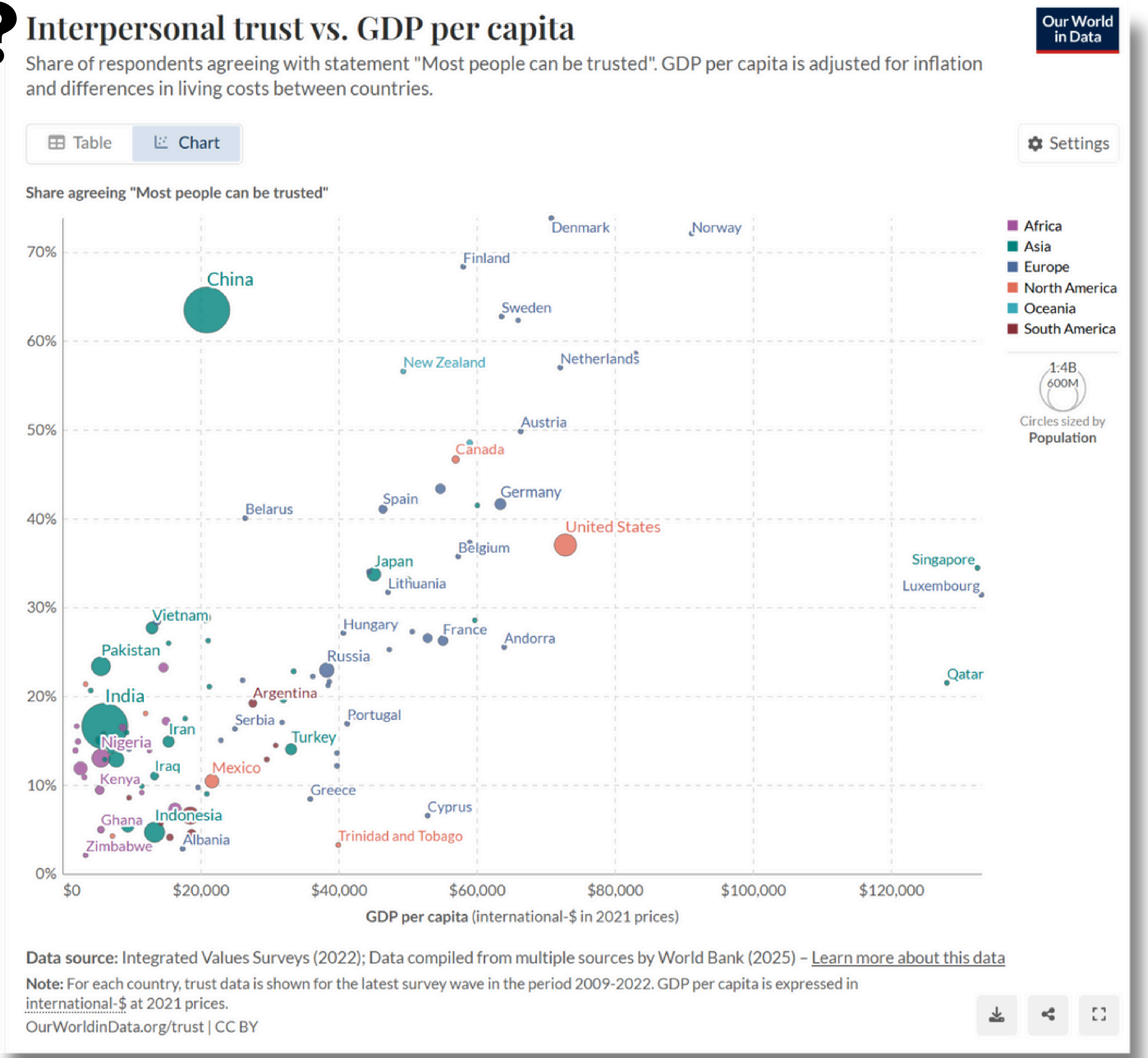
Countries ranked by proportion agreeing that ‘most people can be trusted’.

Turns out there is a correlation between levels of trust and GDP per capita.*



*There is a similar correlation between trust and levels of inequality.

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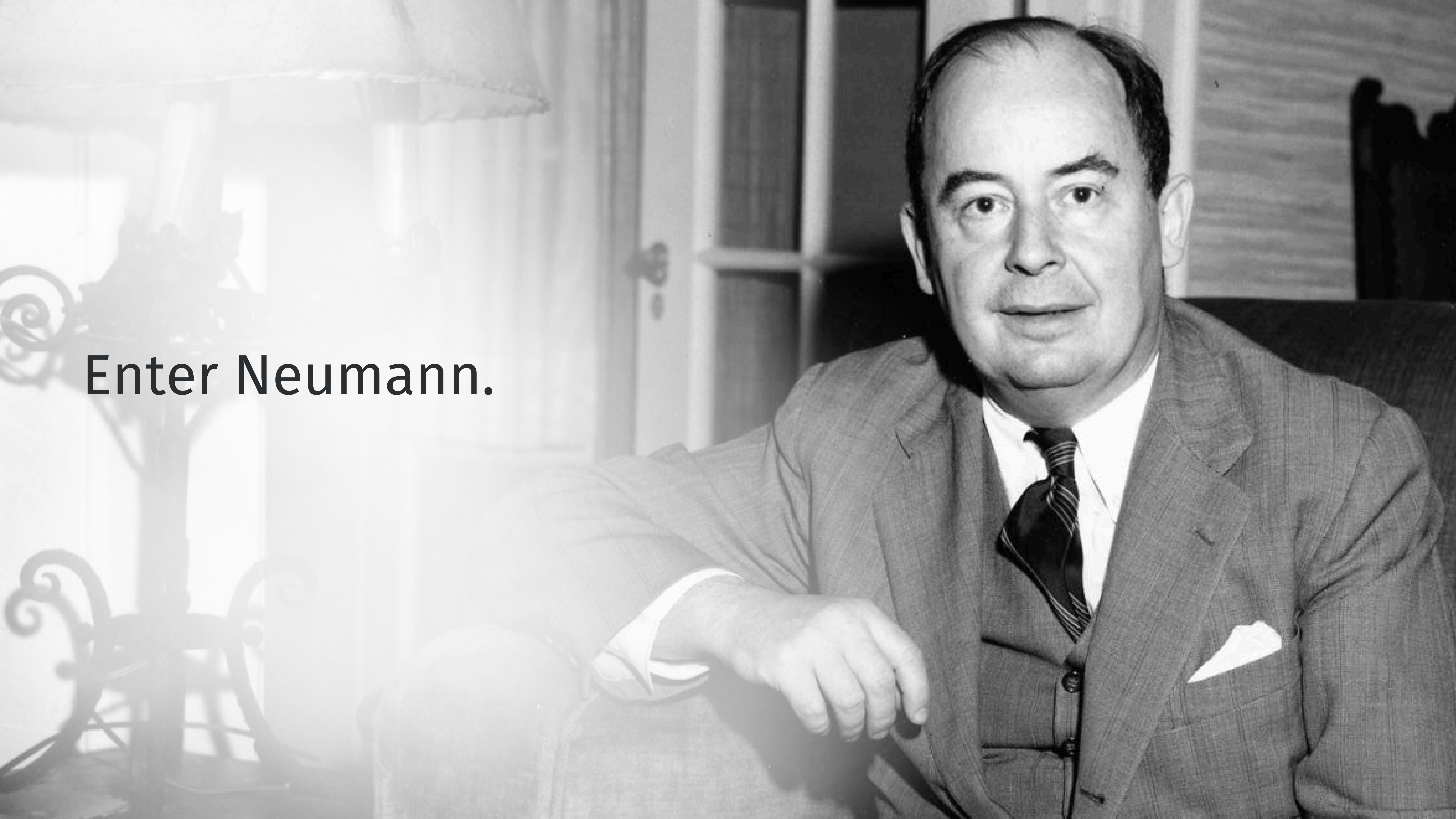
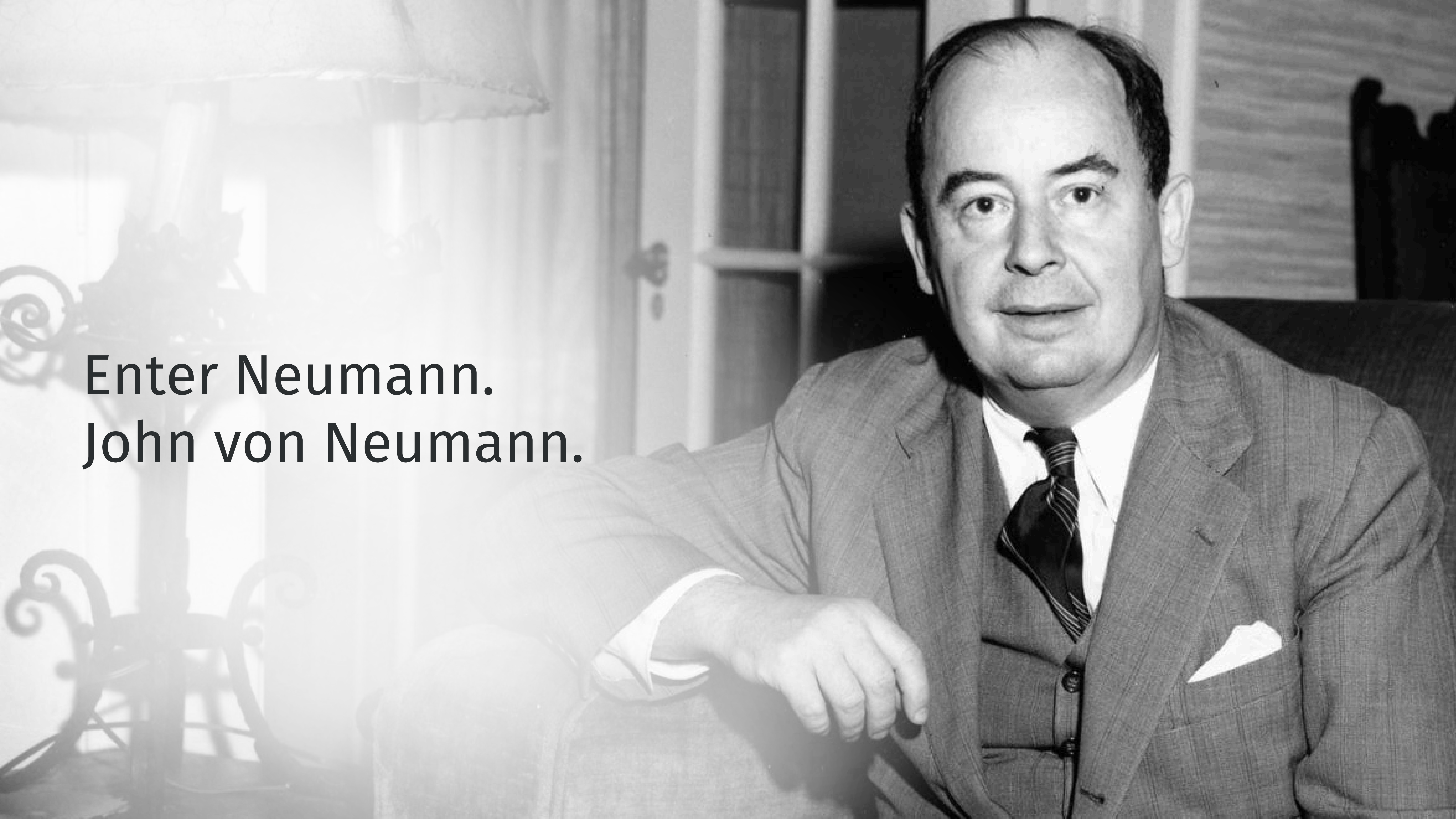
How do we think about interactive decision situations like these, more generally?

Enter Neumann.




Enter Neumann.
John von Neumann.

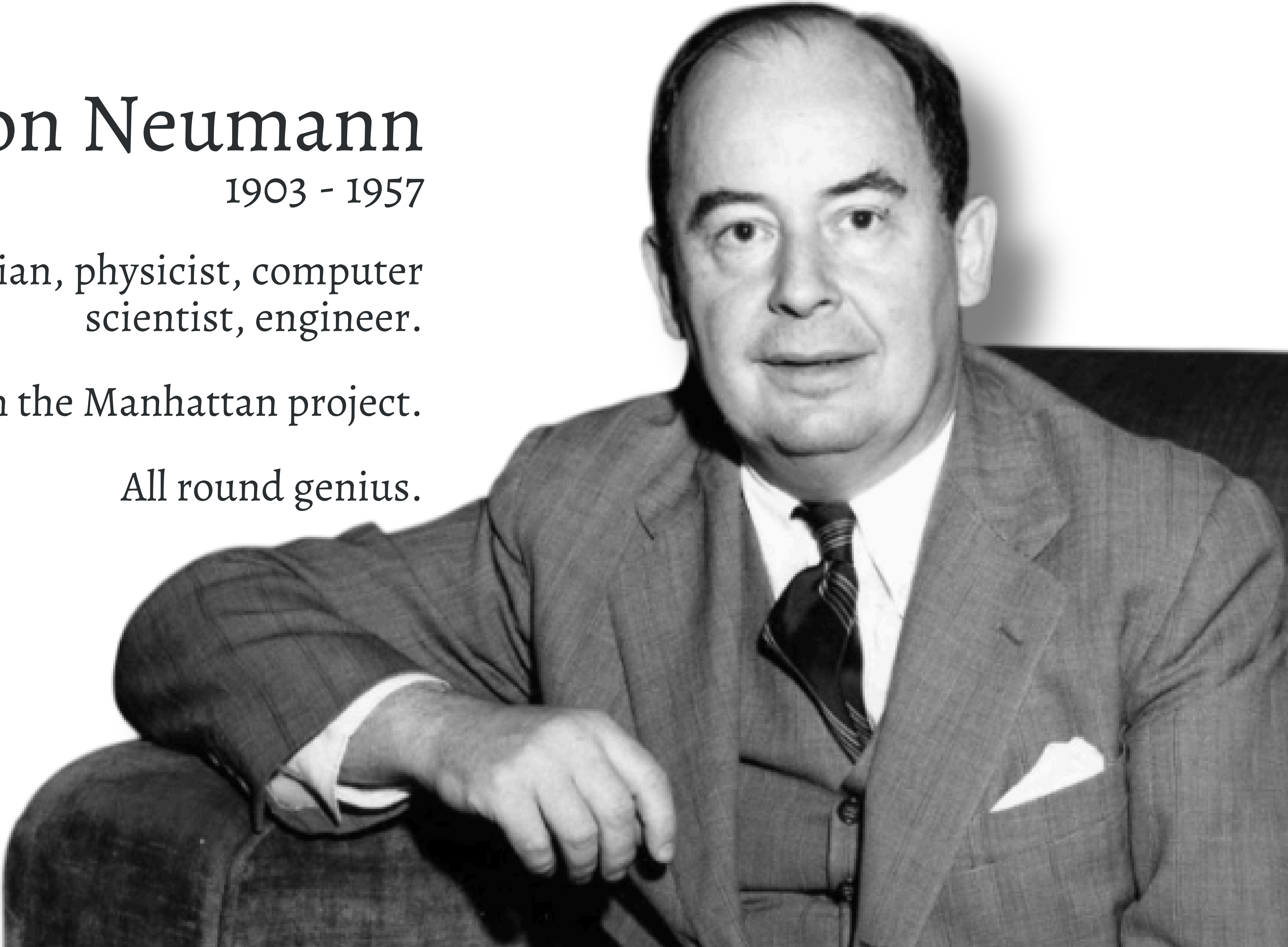
John von Neumann

1903 - 1957

Mathematician, physicist, computer scientist, engineer.

Instrumental in the Manhattan project.

All round genius.



JOHN VON NEUMANN

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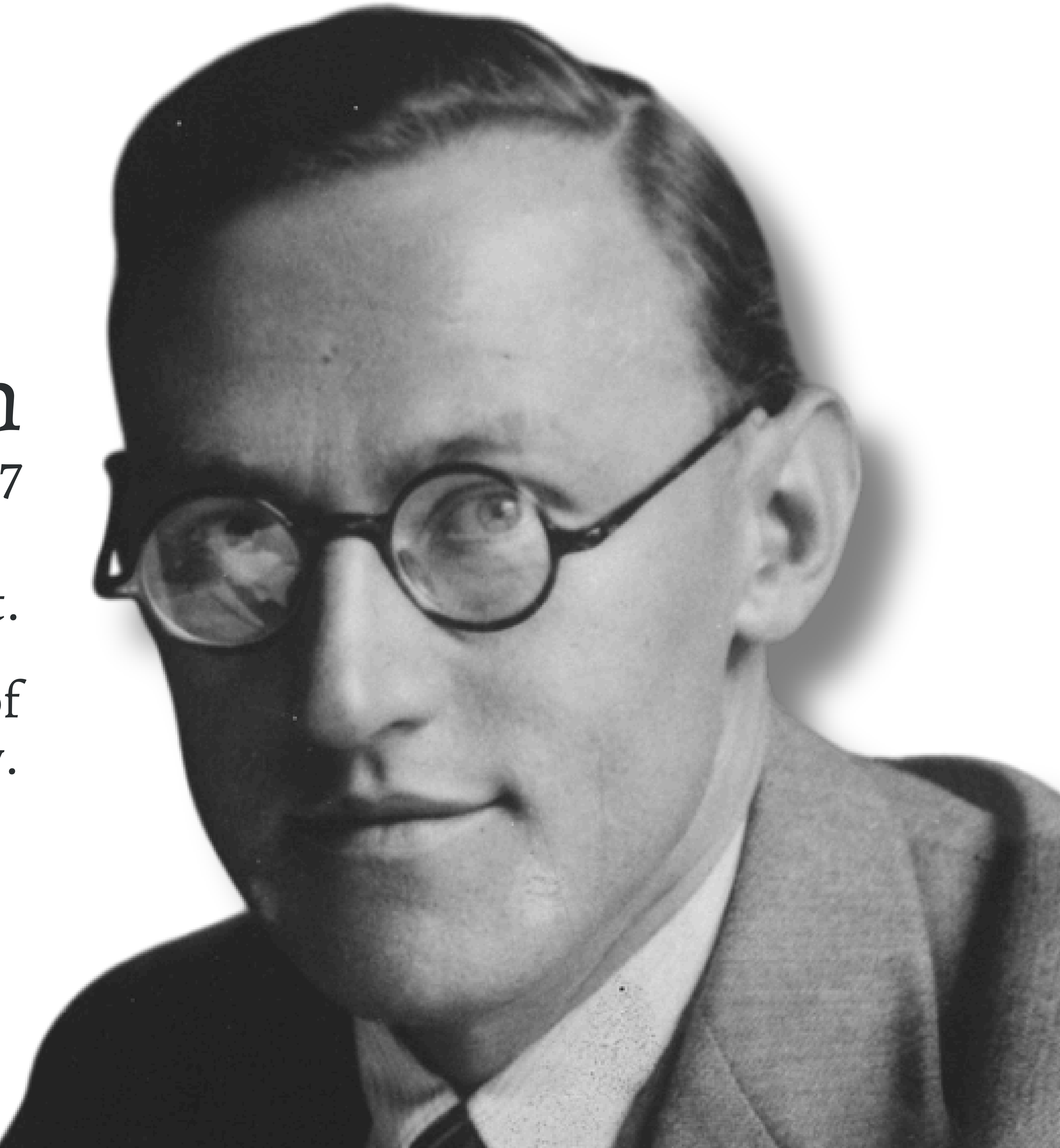
Oskar Morgenstern

1902 - 1977

Economist.

Together with von Neumann, founder of game theory.



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OSKAR MORGENSTERN

And economics!

von Neumann, J., & Morgenstern, O. (1953). *Theory of Games and Economic Behavior.* Princeton University Press.

What do all these situations have in common?

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Let's start with the most basic type of game:
games in *normal form*.

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The basic ingredients of a game in normal form are the *players*, their *strategies* and the *utility* each player derives from a combination of strategies.

NOTATION

players	$N = \{1, \ldots, n\}$
strategy of player i	s_i
profile of strategies	$\boldsymbol{s} = (s_1, \ldots, s_n)$
utility of player i with strategy profile $\boldsymbol{s}$	$u_i(\boldsymbol{s}) \in \mathbb{R}$
strategy profile $\boldsymbol{s}$ without s_i	$\boldsymbol{s}_{-i} = (s_1, \ldots, s_{i-1}, s_{i+1}, \ldots, s_n)$
$\boldsymbol{s}$, alternatively	$\boldsymbol{s} = (s_i, \boldsymbol{s}_{-i})$

When there are only two players, we can represent the game using a table.

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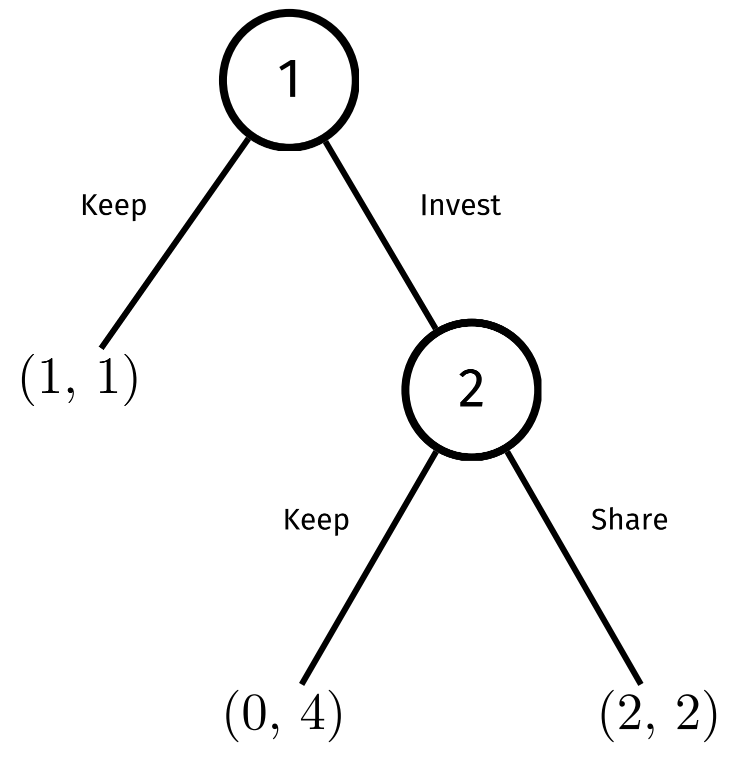
Player 2 can either divide the sum equally, or keep everything.

payoffs



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payoff table (matrix)

	Keep	Share
Keep	$1, 1$	$1, 1$
Invest	$0, 4$	$2, 2$

players

1 and 2.

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(Keep, Keep), (Keep, Share), (Invest, Keep), (Invest, Share).

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payoffs

$u_1(\text{Keep}, \text{Keep}) = 1$, $u_2(\text{Invest}, \text{Keep}) = 4, \ldots$

WE TYPICALLY ASSUME...

... that Player 1 is the row player...

Player 1		Keep	Share
	Keep	$1, 1$	$1, 1$
	Invest	$0, 4$	$2, 2$

WE TYPICALLY ASSUME...

... that Player 1 is the row player...

... Player 2 is the column player...

Player 2

	Keep	Share
Keep	1, 1	1, 1
Invest	0, 4	2, 2

WE TYPICALLY ASSUME...

... that Player 1 is the row player...

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... a *strategy* consists in choosing one available action and playing it with 100% probability.*

		Player 2	
		Keep	**Share**
Player 1	Keep	$1,\ 1$	$1,\ 1$
	Invest	$0,\ 4$	$\boxed{2,\ 2}$

*For now.

WE TYPICALLY ASSUME...

... that Player 1 is the row player...

... Player 2 is the column player...

... a *strategy* consists in choosing one available action and playing it with 100% probability.*

Oh, and players want to maximize their payoffs, given the other player's strategy.

		Player 2	
		Keep	Share
Player 1	Keep	$1, 1$	$1, 1$
	Invest	$0, 4$	$2, 2$

*For now.

Now we know what a game (in normal form) is. What do we do with it?

FROM UTILITIES TO STRATEGIES

If we knew what strategies players would play, we could compute utilities, etc.

Player 1 \ Player 2	Keep	Share
Keep	$1,\ 1$	$1,\ 1$
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If we knew what strategies players would play, we could compute utilities, etc.

But we're assuming players have to figure out what to do without knowing what the others are doing, but assuming that the others are also maximizing their own payoffs.

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For instance, if it becomes known that Player 2 shares, then Player 1 wants to invest.

		Player 2	
		Keep	**Share**
Player 1	Keep	1, 1	1, 1
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For instance, if it becomes known that Player 2 shares, then Player 1 wants to invest.

But if Player 1 invests, then Player 2 wants to switch to keeping.

We need to reason the other way around: from utilities to strategies.

		Player 2	
		Keep	Share
Player 1	Keep	$1,\ 1$	$1,\ 1$
	Invest	$0,\ 4$	$2,\ 2$

We need to reason about *solution concepts*.

We need to reason about *solution concepts*. These describe the strategies we can expect players to play.

Enter Nash.


Enter Nash. John Nash.

John Forbes Nash Jr.

1928 - 2015

Mathematician.

In 1994, won the Nobel prize in Economics.

JOHN NASH

In a Nash equilibrium no one has an incentive to change their strategy, given the other players' strategies.

BEST RESPONSE & NASH EQUILIBRIUM

DEFINITION (BEST RESPONSE)

Player i's *best response* to the other players' strategies $\boldsymbol{s}_{-i} = (s_1, \ldots, s_{i-1}, s_{i+1}, \ldots, s_n)$ is a strategy s_i^* such that $u_i(s_i^*, \boldsymbol{s}_{-i}) \geq u_i(s_i, \boldsymbol{s}_{-i})$, for any strategy s_i of player i.

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DEFINITION (PURE NASH EQUILIBRIUM)

A strategy profile $\boldsymbol{s}^* = (s_1^*, \dots, s_n^*)$ is a *pure Nash equilibrium* if s_i^* is a best response to $\boldsymbol{s}_{-i}^*$, for every player i.

In other words, $\boldsymbol{s}^*$ is a pure Nash equilibrium if there is no player i and strategy s_i' such that $u_i(s_i', \boldsymbol{s}_{-i}^*) > u_i(s_i^*, \boldsymbol{s}_{-i}^*)$.

profitable deviation

And now for the moment we've all been waiting for.

The Prisoner's Dilemma

You and a friend are at the police station. You are the main suspects in a string of Oktoberfest beer thefts.

You are interrogated at the same time, in separate rooms.

If both of you stick to the common story (Cooperate), you get off with a smallish fine.

But if you tell on your friend (Defect) you get off free, while they get a hefty fine.

Your friend faces the same situation.

If you rat each other out, you split the large fine.

payoff table

	Cooperate	Defect
Cooperate	-20, -20	-100, 0
Defect	0, -100	-50, -50

pure Nash equilibria

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The Prisoner’s Dilemma

You and a friend are at the police station. You are the main suspects in a string of Oktoberfest beer thefts.

You are interrogated at the same time, in separate rooms.

If both of you stick to the common story (Cooperate), you get off with a smallish fine.

But if you tell on your friend (Defect) you get off free, while they get a hefty fine.

Your friend faces the same situation.

If you rat each other out, you split the large fine.

payoff table

	Cooperate	**Defect**
Cooperate	-20, -20	-100, 0
Defect	0, -100	-50, -50

pure Nash equilibria

- ✗ (Cooperate, Cooperate)
- ✗ (Cooperate, Defect)
- ✗ (Defect, Cooperate)
- ✓ (Defect, Defect)

At equilibrium both players rat each other out!

At equilibrium both players rat each other out! What about the Trust Game?

The Trust Game

Two players, with initial endowment of 1 each.

Player 1 makes the first move, by deciding whether to invest in a joint venture.

If Player 1 makes no investment, the game is over and both players retain their endowments.

If Player 1 invests, a surplus is generated and Player 2 ends up with $4.

Player 2 now has to decide how to allocate the available sum of $4.

Player 2 can either divide the sum equally, or keep everything.

payoff table

	Keep	Share
Keep	$1, 1$	$1, 1$
Invest	$0, 4$	$2, 2$

pure Nash equilibria

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payoff table

	Keep	Share
Keep	1, 1	1, 1
Invest	0, 4	2, 2

pure Nash equilibria

(Keep, Keep)

At equilibrium there's no trust!

Let's look at an example with more than two players.

Let’s look at an example with more than two players. Why do people endure the discomfort of high heels?

NOT JUST FOR WOMEN BTW

For men at the court of Louis XIV high heels were a marker of status and importance.

Louis XIV, by Hyacinthe Rigaud (1701)

NOT JUST FOR WOMEN BTW

For men at the court of Louis XIV high heels were a marker of status and importance.

Loui

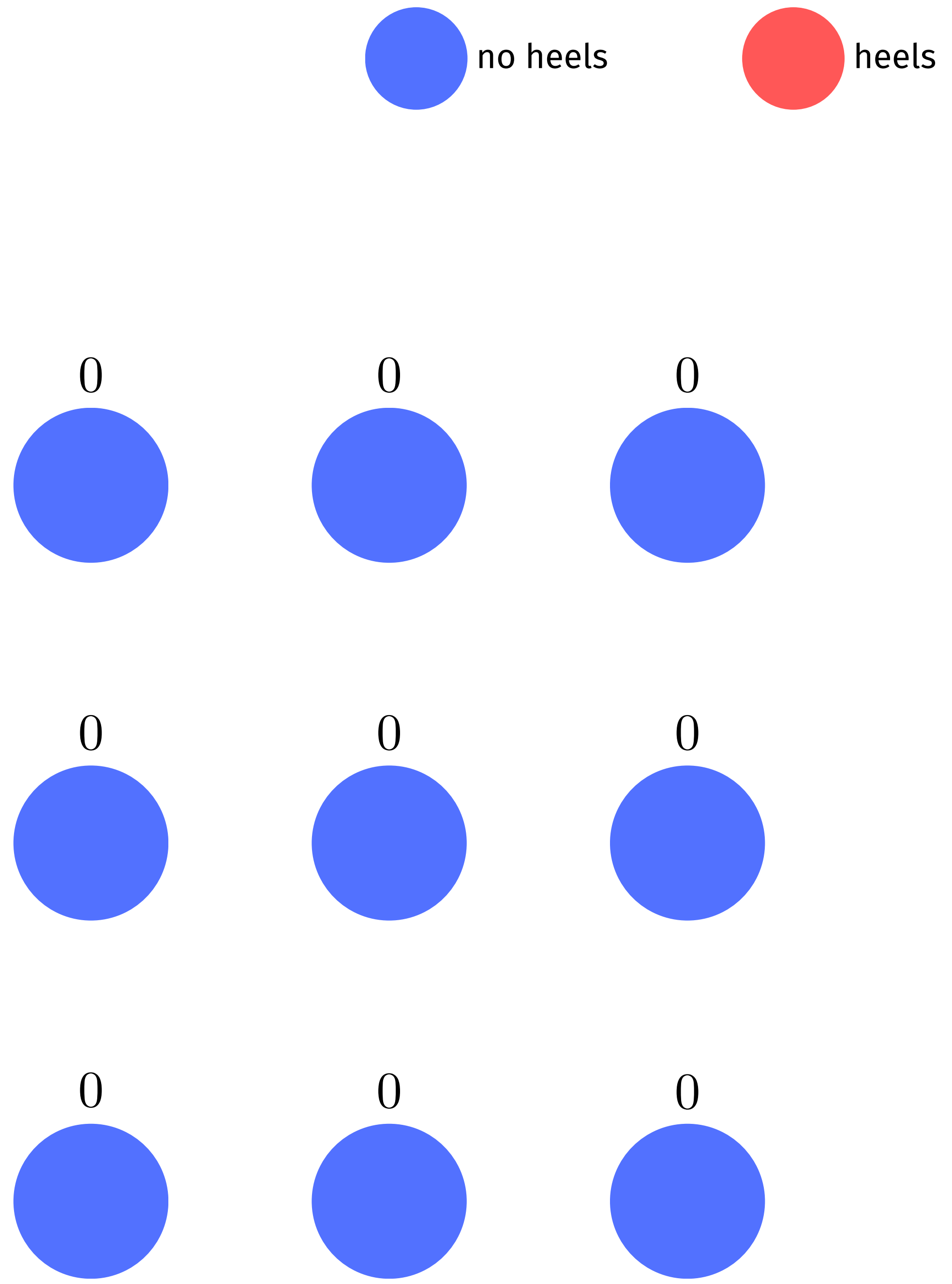
JANE AUSTEN

[Marianne], in having the advantage of height, was more striking [than her sister].

Austen, J. (1811). *Sense and Sensibility.*

THE DILEMMA OF HIGH HEELS

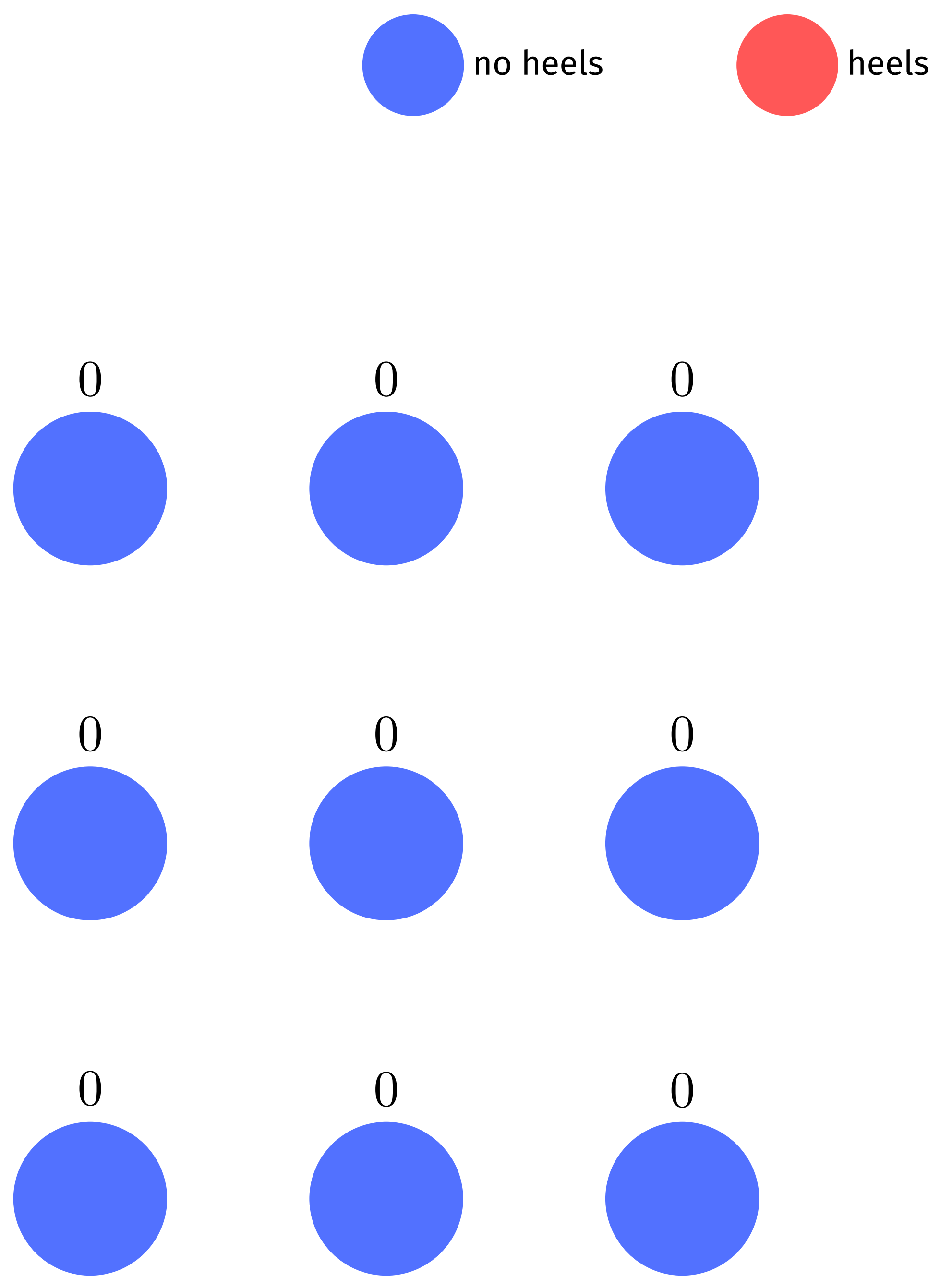
Let’s assume that a height advantage makes one more attractive (+3), and a disadvantage is bad (-3).



THE DILEMMA OF HIGH HEELS

Let's assume that a height advantage makes one more attractive (+3), and a disadvantage is bad (-3).

And that this boost overweights the discomfort of wearing heels (-2).



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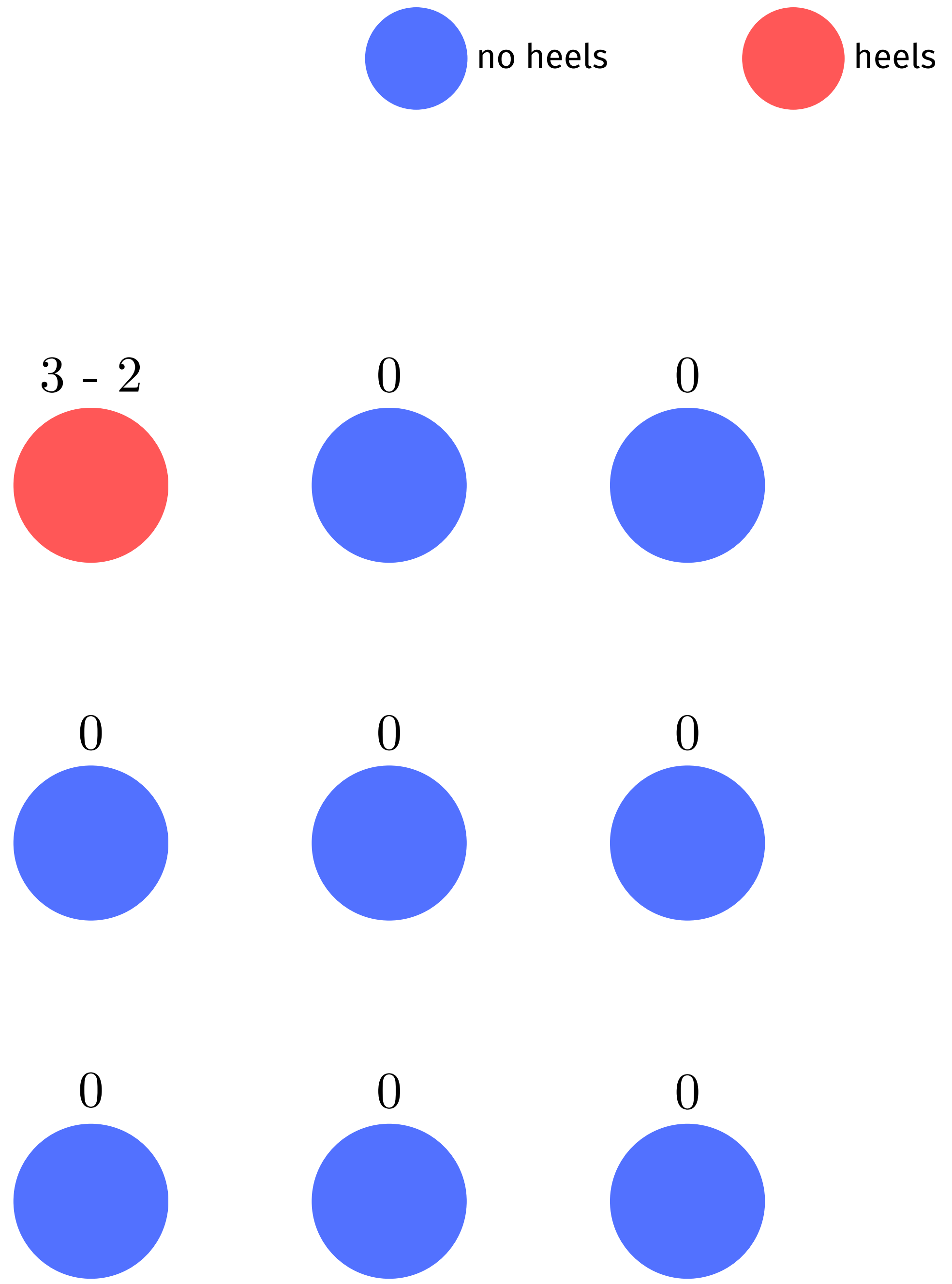

THE DILEMMA OF HIGH HEELS

Let's assume that a height advantage makes one more attractive (+3), and a disadvantage is bad (-3).

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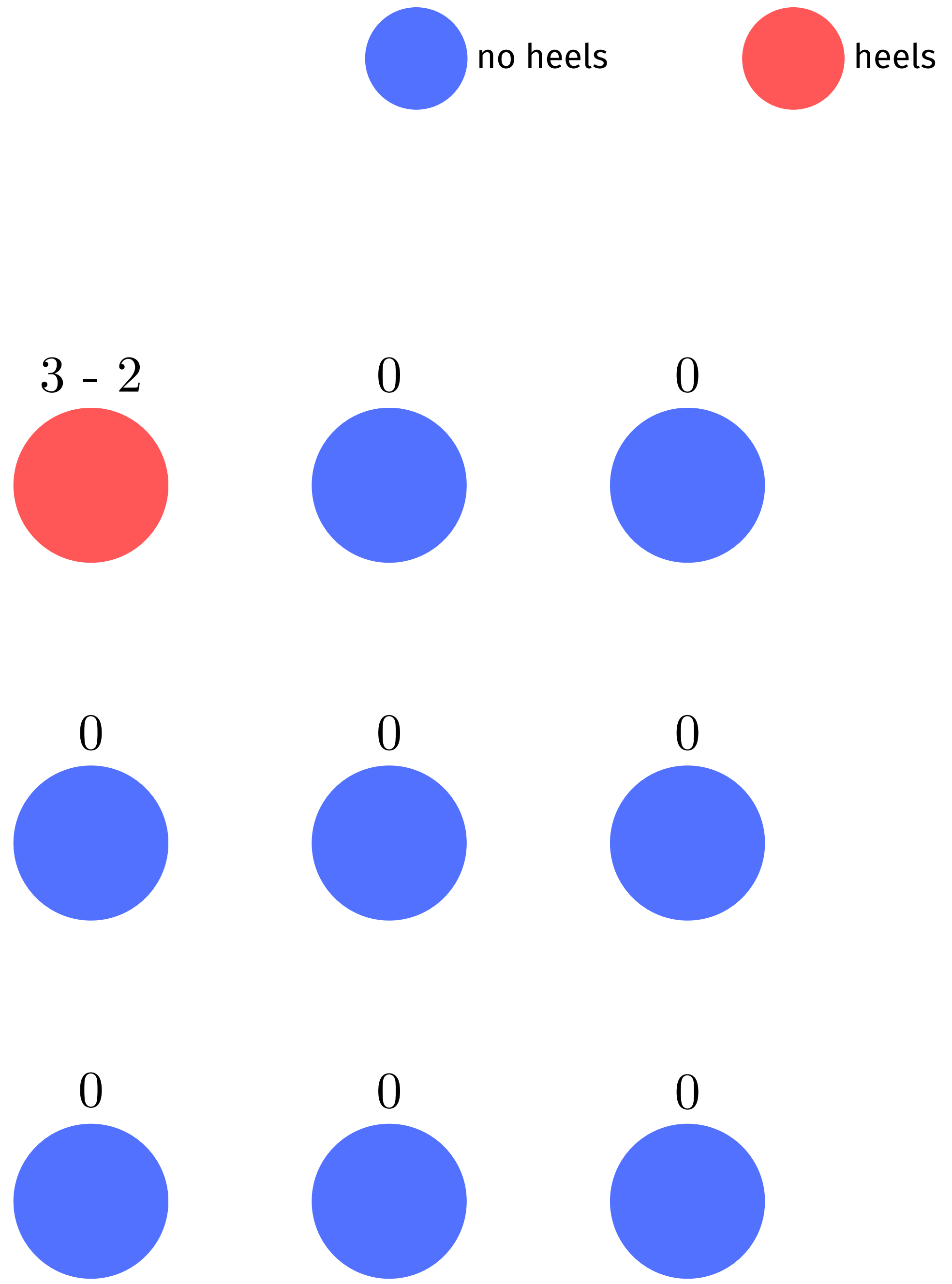
So everyone adopts high heels.



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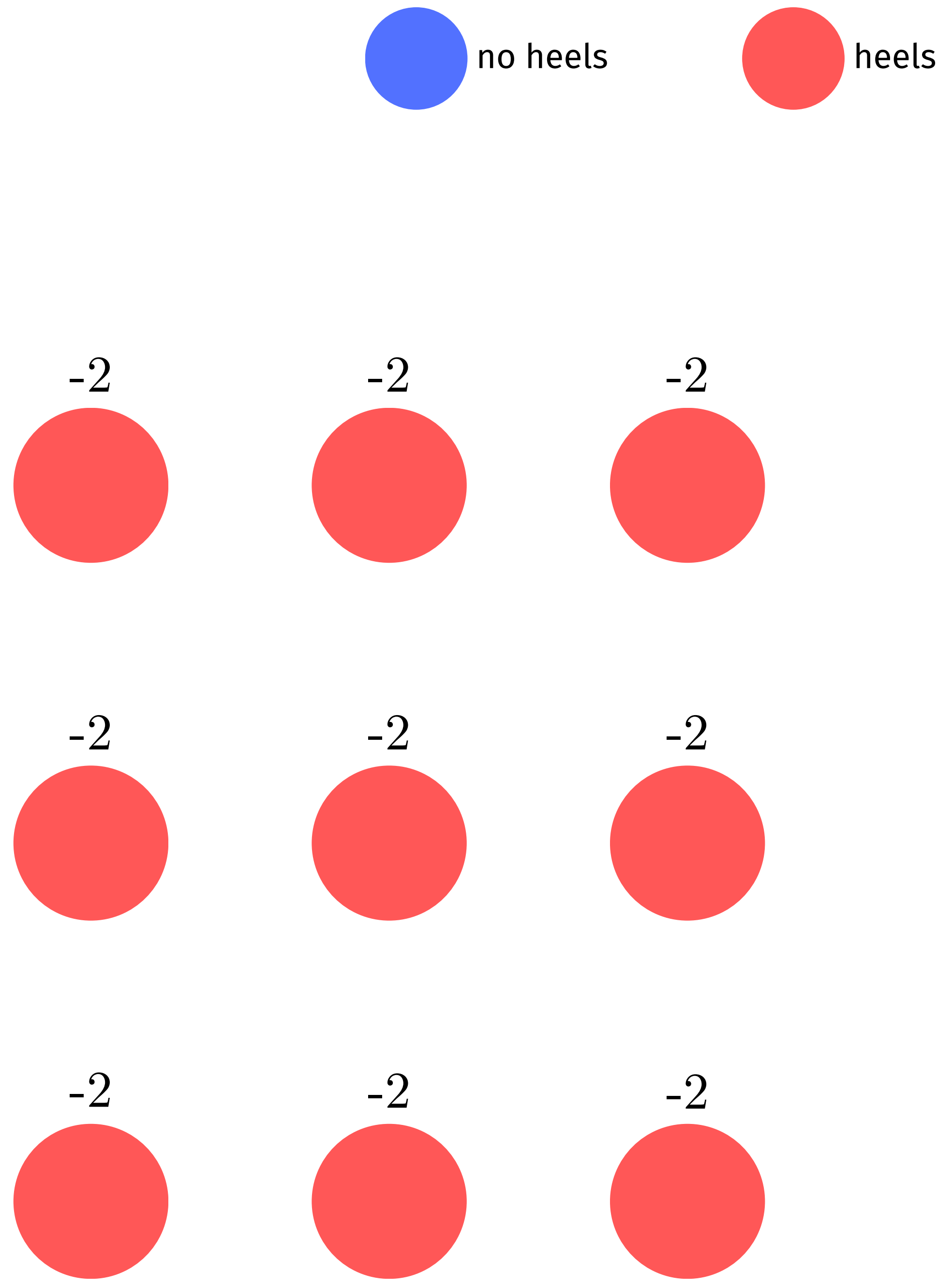

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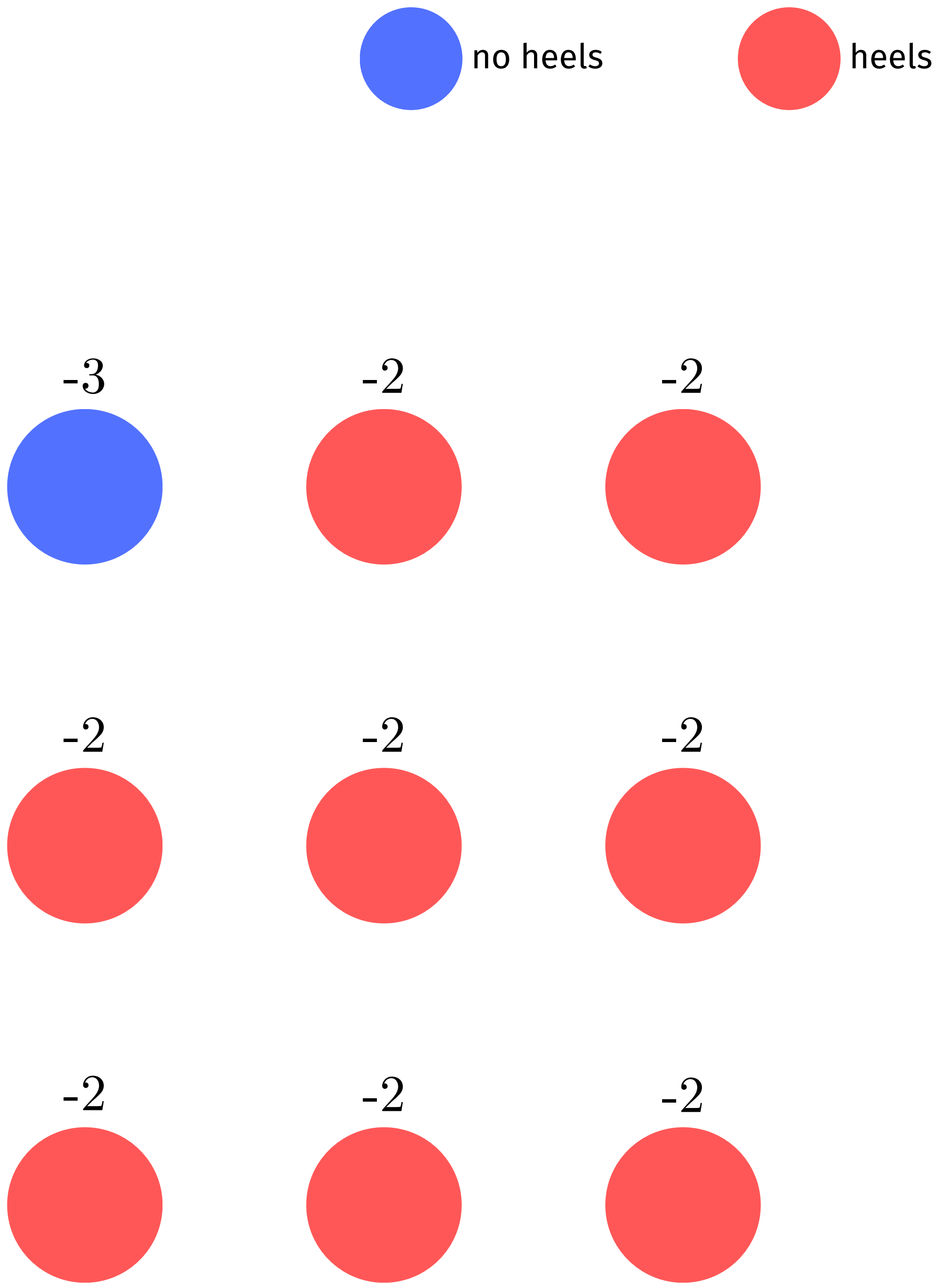
In a world of high heels, showing up without them puts one at a disadvantage.



THE DILEMMA OF HIGH HEELS

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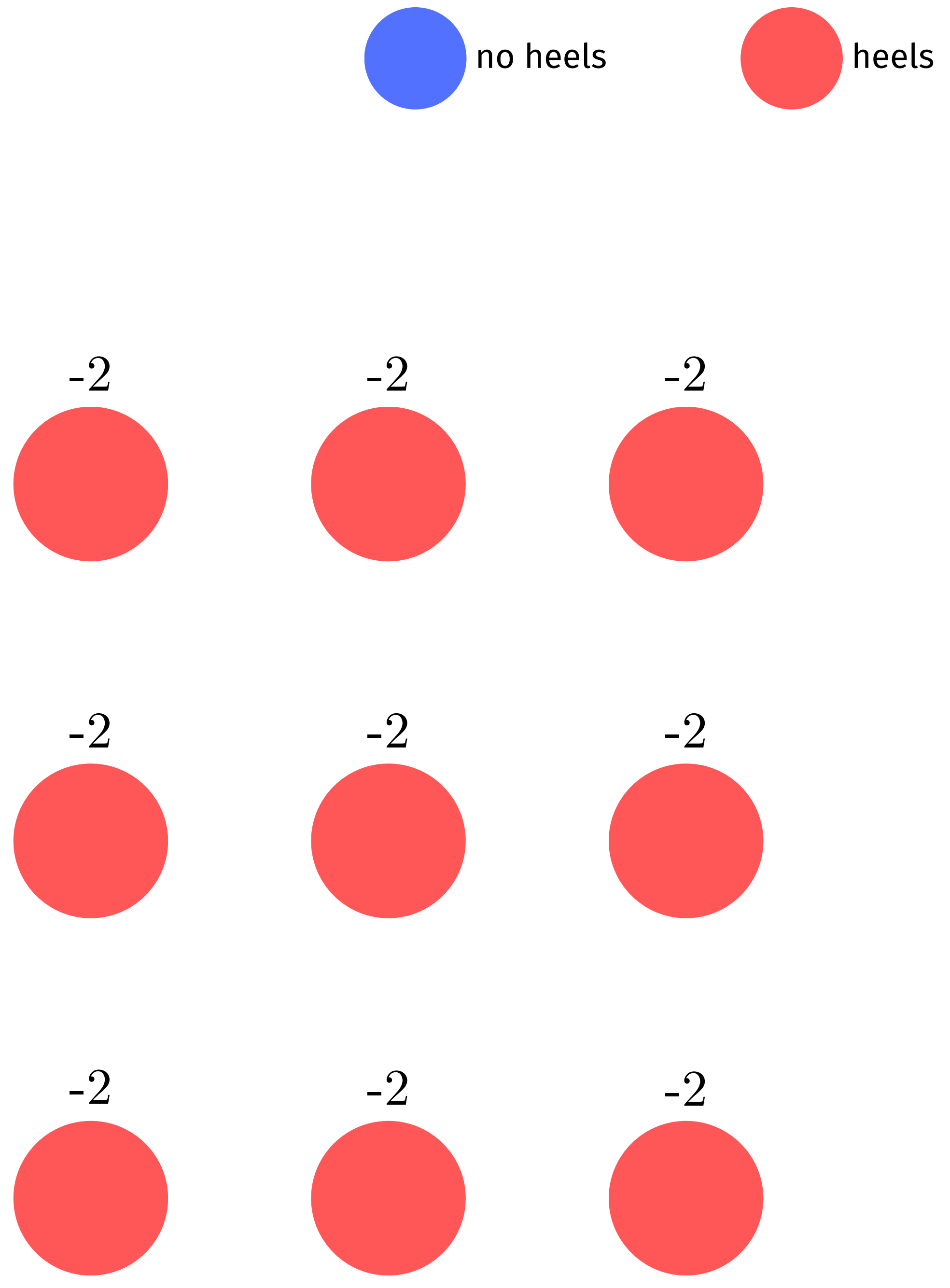
In a world of high heels, showing up without them puts one at a disadvantage.

At the Nash equilibrium, everyone puts up with the discomfort... even though the height advantage is gone!



Note that the numbers per se in the Prisoner's Dilemma are not important. What matters is the relationship between them.

The Prisoner's Dilemma

GENERAL VERSION

There are two players, each with two actions: Cooperate or Defect.

If they both cooperate they both get a payoff of R (the reward).

If they both defect, they each get a payoff of P (the punishment).

In the case of defection with cooperation, the defector gets T (the temptation), while the cooperator gets S (the sucker's payoff).

The relationship between the payoffs is T > R > P > S.

payoff table

	Cooperate	**Defect**
Cooperate	R, R	S, T
Defect	T, S	P, P

pure Nash equilibria

- (Cooperate, Cooperate)
- (Cooperate, Defect)
- (Defect, Cooperate)
- (Defect, Defect)

In Prisoner's Dilemma experiments people routinely do *not* play the Nash equilibrium.

PRISONER'S DILEMMAS IN EXPERIMENTS

Across one-shot Prisoner's Dilemmas experiments, the average cooperation rate is ≈35 %, with individual study means ranging from 4% to 84%.

Rapoport, A., & Chammah, A. M. (1965). Prisoner's dilemma: A study in conflict and cooperation. University of Michigan Press.

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Economists seem to defect more.