BEEM057 Experimental Economics and Finance

Behavioural Game Theory

Game Theory

- Game Theory: How rational agents should behave.
- Behavioural Game theory: How actual people behave.

Behavioural Game Theory

1. What is Game Theory?
2. Coordination Games
3. Guessing Game
4. Perfect information games, trust and fairness

Game Theory

- Game theory models strategic behavior by agents who understand that their actions affect the actions of other agents.
- Aumann: Interactive Decision Theory
- Strategic interaction
- Been used to study
  - Company behavior
  - Military strategies.
  - Bargaining/Negotiations
  - Biology
  - Auction design
- A game consists of players, strategies, and payoffs.

Battle of Bismarck Sea

Kenney \ Imamura	sail North	sail South
search North	2, -2	2, -2
search South	1, -1	3, -3

- Imamura wants to transport troops.
- Kenney wants to bomb Japanese troops.
- Zero sum game
- Both route three days, bad visibility in North.
- It takes one day for Kenney to switch routes.

Imamura wants to run convoy from Rabaul to Lae

Equilibrium

- A cautious, rational Imamura will go North because it is always as good as going South and possibly better.
- If Kenny knows that Imamura is cautious and rational, and if he himself is rational, he will choose North
- Kenny's decision depends on what he thinks Imamura is doing

Nash equilibrium

- Not a self-destroying prophecy (Selten)
- A combination of strategies for each player such that it is optimal for each player to stick to his strategy if he expects everybody else to do so.

Pareto efficiency

- Allocation of utilities:
  - A: (1,6,6)
  - B: (2,2,2)
- Utilitarian (Bentham) prefers A
- Rawls prefers B (improve utility of the weakest)
- Pareto cannot rank them
  - C: (2,6,7) Pareto-dominates A because it makes some people better, but nobody worth off
  - Pareto-efficient: not dominated

Coordination games

- These are games “plagued” with a multiplicity of Nash equilibria.
- See Camerer, ch 7

Coordination Problem

Sean \ Jim	VHS	Beta
VHS	1, 1 *	0, 0.5
Beta	0.5, 0	2, 2 *

- Jim and Sean want to have the same VCR.
- Beta is a better technology than VHS.

Battle of the sexes

		Alice	
		Boxing	**Ballet**
Bob	**Boxing**	3 / * 1	0 / 0
	Ballet	0 / 0	1 / 3 *

All these games have also mixed strategy equilibria. Here: Both play their preferred strategy with 2/3 Probability. Then each party gets the same expected payoff with each strategy and so all strategies are optimal

Chicken

		Teen 2	
		Chicken	Dare
Teen 1	Chicken	5, 5	4, 7 *
	Dare	7, 4 *	0, 0

Bertrand Russel

Stag hunt

Hunter 2

Hunter 1	Stag	Rabbit
Stag	9, 9 *	0, 7
Rabbit	7, 0	7, 7 *

Rousseau
Bank run

Battle of the sexes

Column

Row	1	2
1	0 / 0	200 / 600 *
2	600 / 200 *	0 / 0

Cooper et al:

1. Simultaneous play
2. Outside options
3. Communication
4. Sequential play

Table 7.9. *Battle of the sexes game: Last eleven periods*

Game	Outside option	(1,2)	(2,1)	(1,1) or (2,2)	Total
BOS	—	37	31	97	165
		(22%)	(19%)	(59%)	
STRAUB	—	24	13	53	90
		(26%)	(14%)	(60%)	
BOS-300	33	0	119	13	165
		(0%)	(90%)	(10%)	
BOS-100	3	5	102	55	165
		(3%)	(63%)	(34%)	
BOS-1W	—	1	158	6	165
		(1%)	(96%)	(4%)	
BOS-2W	—	49	47	69	165
		(30%)	(28%)	(42%)	
BOS-SEQ	—	6	103	56	165
		(4%)	(62%)	(34%)	

Sources: Cooper et al. (1994); Straub (1995).
Note: Numbers in parentheses refer to proportions of play of each outcome.

Stag hunt

Hunter 2

Hunter 1	Stag	Rabbit
Stag	9, 9 *	0, 7
Rabbit	7, 0	7, 7 *

Rousseau

Table 7.23. Stag hunt results: Last eleven periods

Game	Outside option	(1,1)	(2,2)	(1,2) or (2,1)	Total
CG	—	160	0	5	165
		(97%)	(0%)	(3%)	
CG-900	65	2	77	21	165
		(2%)	(77%)	(21%)	
CG-700	20	119	0	26	165
		(82%)	(0%)	(18%)	
CG-1W	—	26	88	51	165
		(16%)	(53%)	(31%)	
CG-2W	—	0	150	15	165
		(0%)	(91%)	(9%)	

Source: Cooper et al. (1994).
Note: Numbers in parentheses refer to proportions of play in the subgame of the outside option treatments.

Keynesian Coordination Problems

- Keynes: “involuntary” unemployment
- Monetarist: unemployment is either frictional or “voluntary”
- New Keynesian models: multiplicity f equilibria
  - low expectations -> low demand -> high unemployment -> low expectations
  - high expectations -> high demand -> low unemployment -> high expectations

A Keynesian Coordination Game

- n, say 16 players
- Effort levels $e_i=1,\ldots,7$
- Payoff:

$$0.2\min[e_1,\ldots,e_n]-0.1e_i+0.6$$

- "weakest link"
- 7 symmetric Pareto-ranked Nash equilibria
- which, if any, is chosen?
- Van Huyck, Battalio, Beil 1990

Table 7.24. Weak-link game payoffs in Van Huyck et al.

Your choice of X	Smallest value of X chosen (including own)						
	7	6	5	4	3	2	1
7	1.30	1.10	0.90	0.70	0.50	0.30	0.10
6	—	1.20	1.00	0.80	0.60	0.40	0.20
5	—	—	1.10	0.90	0.70	0.50	0.30
4	—	—	—	1.00	0.80	0.60	0.40
3	—	—	—	—	0.90	0.70	0.50
2	—	—	—	—	—	0.80	0.60
1	—	—	—	—	—	—	0.70

Source: Van Huyck, Battalio, and Beil (1990).

Table 7.25. Total frequencies of choices in large-group weak-link games of Van Huyck et al.

	Period									
Choice	1	2	3	4	5	6	7	8	9	10
7	33	13	9	4	4	4	6	3	3	8
6	10	11	7	0	1	2	0	0	0	0
5	34	24	10	12	2	2	4	1	0	1
4	17	23	24	18	15	5	3	3	2	2
3	5	18	25	25	17	9	8	3	4	2
2	5	13	17	23	31	35	39	27	26	17
1	2	5	15	25	37	50	47	70	72	77

Source: Van Huyck, Battalio, and Beil (1990).

Table 7.26. Choices in weak-link games for two-person groups of Van Huyck et al.

	Period						
Choice	1	2	3	4	5	6	7
7	9	13	13	17	19	19	21
6	0	1	4	2	1	1	0
5	4	1	1	1	0	0	0
4	0	1	2	0	1	1	0
3	1	2	1	1	0	0	0
2	1	2	0	0	0	0	1
1	8	4	3	3	3	3	2

Source: Van Huyck, Battalio, and Beil (1990).

Applications

- Why mergers can be bad
- Group bonuses
- Personal vs situational traits, Leadership rating

Table 7.29. Minima (MIN) after "mergers" of groups in Camerer and Knez

Three-player groups	"Merged" six-player group	
Period 5 MINs	Period 1 MIN	Period 5 MIN
Public information about other group's minimum		
1,2	(1,3) 1	1
1,4	(1,1) 1	1
1,1	(1,2) 1	1
4,1	(4,1) 1	1
1,7	(1,7) 1	1
No information about other group's minimum		
2,4	(1,2) 1	1
7,3	(7,1) 1	1
3,2	(3,1) 1	2
7,3	(7,3) 3	3
7,3	(7,2) 2	1

Source: Camerer and Knez (1994).

Table 7.30. *Choices and leadership ratings in weak-link game of Weber et al.*

	Large group				Small group			
	0	1	2	3	0	1	2	3
Rounds 1–2								
Frequency of choices (percent)	25	24	20	32	5	24	26	45
Leadership rating (before)		5.88				5.80		
Rounds 3–8								
Frequency of choices (percent)	47	4	0	49	6	6	6	83
Leadership rating (after)		4.53				6.17		

Source: Weber et al. (2001).

Median Action Games

- Median M: 50% choose M or higher, 50% choose M or less

$$0.6 + 0.1M - 0.05(M - x_i)^2$$

- van Huyck, Battalio, Beil 1991

Table 7.31. Payoffs in median-action game of Van Huyck et al.

	Median value of X chosen						
Your choice of X	7	6	5	4	3	2	1
7	1.30	1.15	0.90	0.55	0.10	−0.45	−1.10
6	1.25	1.20	1.05	0.80	0.45	0.00	−0.55
5	1.10	1.15	1.10	0.95	0.70	0.35	−0.10
4	0.85	1.00	1.05	1.00	0.85	0.60	0.25
3	0.50	0.75	0.90	0.95	0.90	0.75	0.50
2	0.05	0.40	0.65	0.80	0.85	0.90	0.65
1	−0.50	−0.05	0.30	0.55	0.70	0.75	0.70

Source: Van Huyck, Battalio, and Beil (1991).

Table 7.32. *Results in median-action games (six sessions pooled)*

	Period									
Choice	1	2	3	4	5	6	7	8	9	10
7	8	2	2	0	0	1	1	0	0	0
6	4	6	6	6	3	3	4	1	3	1
5	15	15	22	19	22	20	20	24^{1}	23^{1}	26^{2}
4	19	26	22	29^{1}	27^{1}	30^{2}	30^{2}	28^{2}	28^{3}	27^{3}
3	8	3	2	0	0	0	0	1	0	0
2	0	1	0	0	1	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0

Source: Van Huyck, Battalio, and Beil (1991).

Note: Superscripts denote the number of groups fully equilibrated (all choosing the same number).

Median Action Games

- Convergence to initial median
- van Huyck, Battalio, Beil 1992: Auction to participate increases initial median (“Forward induction”)
- Cachon / Camerer: a fixed fee does the same (sunk costs).

Sunk Costs

- Costs, once paid, cannot be recovered

$$\frac{d}{dx}(F + x^2) = 2x$$

- Once paid they should be irrelevant for future decision making
- Arkes and Blumer (1985) surprise discounts on subscriptions for theatre tickets

Nash Equilibrium as a self-enforcing recommendation

- van Huyck, Gilette, Battalio
- Works perfectly if all equilibria yield the same
- Some assignments not credible

Table 7.16. Results of assignments in games A, B, and C

Game	Assignment	Choices (percent)		
		1	2	3
A payoffs		(5,5)	(5,5)	(5,5)
	None	30	51	19
	1	99	0	1
	2	1	99	0
	3	0	0	100
B payoffs		(9,9)	(5,5)	(1,1)
	None	97	2	1
	1	99	1	0
	2	51	48	1
	3	62	0	38
C payoffs		(7,3)	(5,5)	(3,7)
	None	10	82	8
	3 (row play)	1	63	35
	3 (column play)	0	54	46

Source: Van Huyck, Gillette, and Battalio (1992).

Market Entry

- Experiments confirm theory
- Kahneman: “To a psychologist it looks like magic”
- Camerer and Lavallo: skill in trivia quiz
- Top c entrants share $50, other entrants lode $10
- Rank determined by luck / skill
- Overconfidence
- Reference group neglect

Sender – Receiver games

- Games with incomplete information
- Sender can be of two types, not known to receiver
- The type of sender and the action of receiver determines both player's payoff
- Sender can send a payoff irrelevant message.

Table 7.10. Payoffs in sender–receiver game 1 of Blume et al.

Sender types	Receiver actions	
	a_1	a_2
t_1	0,0	0.7, 0.7
t_2	0.7, 0.7	0,0

Source: Blume et al. (1998).

Table 7.11. Payoffs in sender–receiver game 2 of Blume et al.

Sender types	Receiver actions		
	a_1	a_2	a_3
t_1	0,0	0.7,0.7	0.4,0.4
t_2	0.7,0.7	0,0	0.4,0.4

Source: Blume et al. (1998).

Table 7.12. Payoffs in sender–receiver game 3 of Blume et al.

	Receiver actions		
Sender types	a_1	a_2	a_3
t_1	0,0	0.2,0.7	0.4,0.4
t_2	0.2,0.7	0,0	0.4,0.4

Source: Blume et al. (1998).

Table 7.13. Percentage of plays consistent with separating in sender–receiver games 1 and 2 of Blume et al.

Game	Period 1	5	10	15	20
First session					
Game 1	48	65	74	88	95
	(.14)	(.12)	(.17)	(.13)	(.07)
Second session					
Game 1	49	72	61	89	100
	(.28)	(.09)	(.19)	(.09)	(.00)
Game 1NH	55	55	28	55	72
	(.25)	(.09)	(.19)	(.09)	(.19)
Game 2					
Separating	44	88	88	88	94
	(.19)	(.09)	(.09)	(.09)	(.09)
Pooling	39	05	00	05	05
	(.25)	(.09)	(.00)	(.09)	(.09)

Source: Blume et al. (1998).
Note: Standard deviations are in parentheses.

Table 7.14. Results in sender–receiver game 3 of Blume et al.

Number of messages	Behavior	Periods 1–10	11–20	21–30	31–40	41–50	51–60
Second session (after game 1)							
2	Separating	43	53	38	39		
	Pooling	33	34	41	43		
3	Separating	43	38	33	24		
	Pooling	33	37	42	60		
First session							
2	Separating	39	27	23	24	24	23
	Pooling	39	48	51	60	63	61
3	Separating	23	22	23	25	22	24
	Pooling	55	61	58	56	57	61

Source: Blume et al. (1999).

Focal point

- Schelling: “The Strategy of Conflict”
- Choice of Nash equilibrium may depend on something unrelated to game theory, cues to make an outcome prominent
- E.g. where to meet in London?
- Mehta et all: Pick versus coordination
- Bacherach / Bernasconi: subtlety of attributes

Matching game

		Column	
		Left	Right
Row	Left	1, 1	0, 0
	Right	0, 0	1, 1

Table 7.3. *Results of picking (P) and coordinating (C)*

	Group P ($n = 88$)		Group C ($n = 90$)	
	Response	Proportion	Response	Proportion
Years	1971	8.0	1990	61.1
	1990	6.8	2000	11.1
	2000	6.8	1969	5.6
	1968	5.7		
	$r = 43$	$c = 0.026$	$r = 15$	$c = 0.383$
Flowers	Rose	35.2	Rose	66.7
	Daffodil	13.6	Daisy	13.3
	Daisy	10.2	Daffodil	6.7
	$r = 36$	$c = 0.184$	$r = 11$	$c = 0.447$
Dates	25 December	5.7	25 December	44.4
	10 December	1.1	10 December	18.9
	1 January	1.1	1 January	8.9
	$r = 75$	$c = 0.005$	$r = 19$	$c = 0.258$
Towns	London	15.9	London	55.6
	Norwich	12.5	Norwich	34.4
	Birmingham	8.0		
	$r = 56$	$c = 0.064$	$r = 8$	$c = 0.238$
Numbers	7	11.4	1	40.0
	2	10.2	7	14.4
	10	5.7	10	13.3
	1	4.5	2	11.1
	$r = 28$	$c = 0.052$	$r = 17$	$c = 0.206$

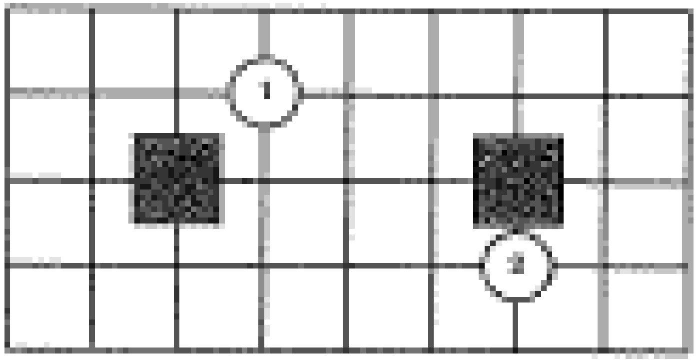
	[illegible]	[illegible]	[illegible]	[illegible]
	Birmingham	8.0		
	$r = 56$	$c = 0.064$	$r = 8$	$c = 0.238$
Numbers	7	11.4	1	40.0
	2	10.2	7	14.4
	10	5.7	10	13.3
	1	4.5	2	11.1
	$r = 28$	$c = 0.052$	$r = 17$	$c = 0.206$
Colors	Blue	38.6	Red	58.9
	Red	33.0	Blue	27.8
	Green	12.5		
	$r = 12$	$c = 0.269$	$r = 6$	$c = 0.422$
Boys' names	John	9.1	John	50.0
	Fred	6.8	Peter	8.9
	David	5.7	Paul	6.7
	$r = 50$	$c = 0.002$	$r = 19$	$c = 0.264$
Coin toss	Heads	76.1	Heads	86.7
	$r = 5$	$c = 0.618$	$r = 3$	$c = 0.764$
Gender	Him	53.4	Him	84.4
	$r = 6$	$c = 0.447$	$r = 2$	$c = 0.734$

Source: Mehta et al. (1994a).

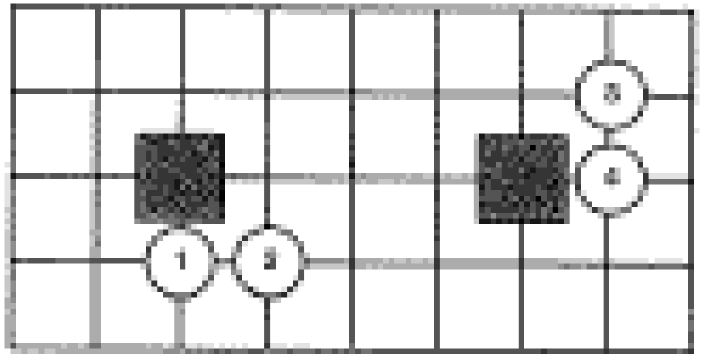
Hume: property conventions

- Closeness
- Equality
- accession

QUESTION 11



QUESTION 12



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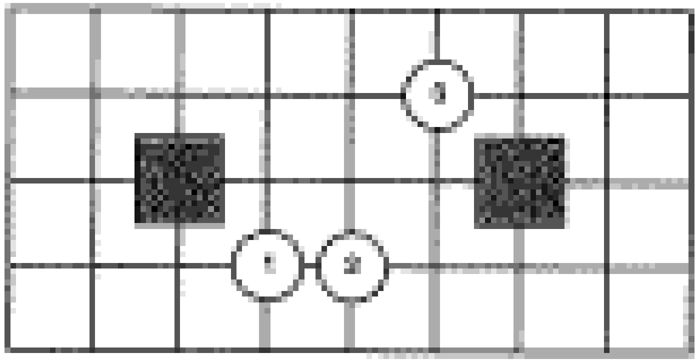

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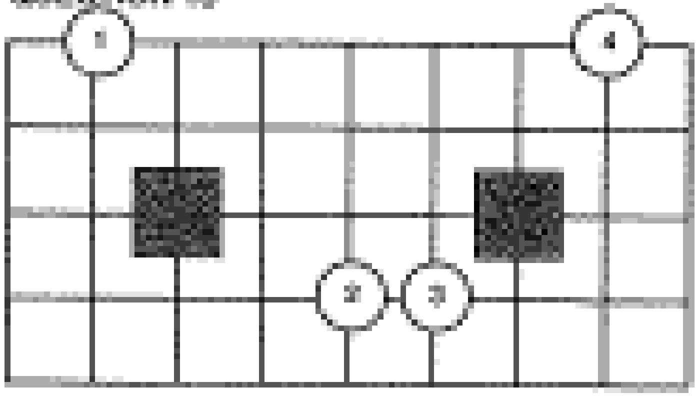

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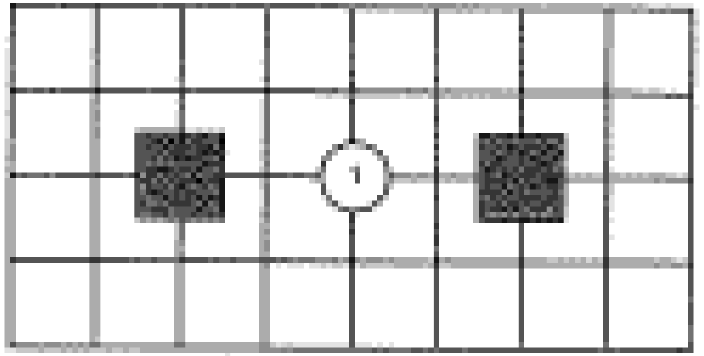

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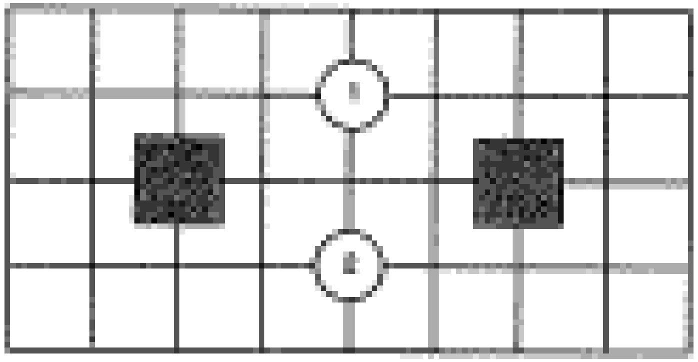


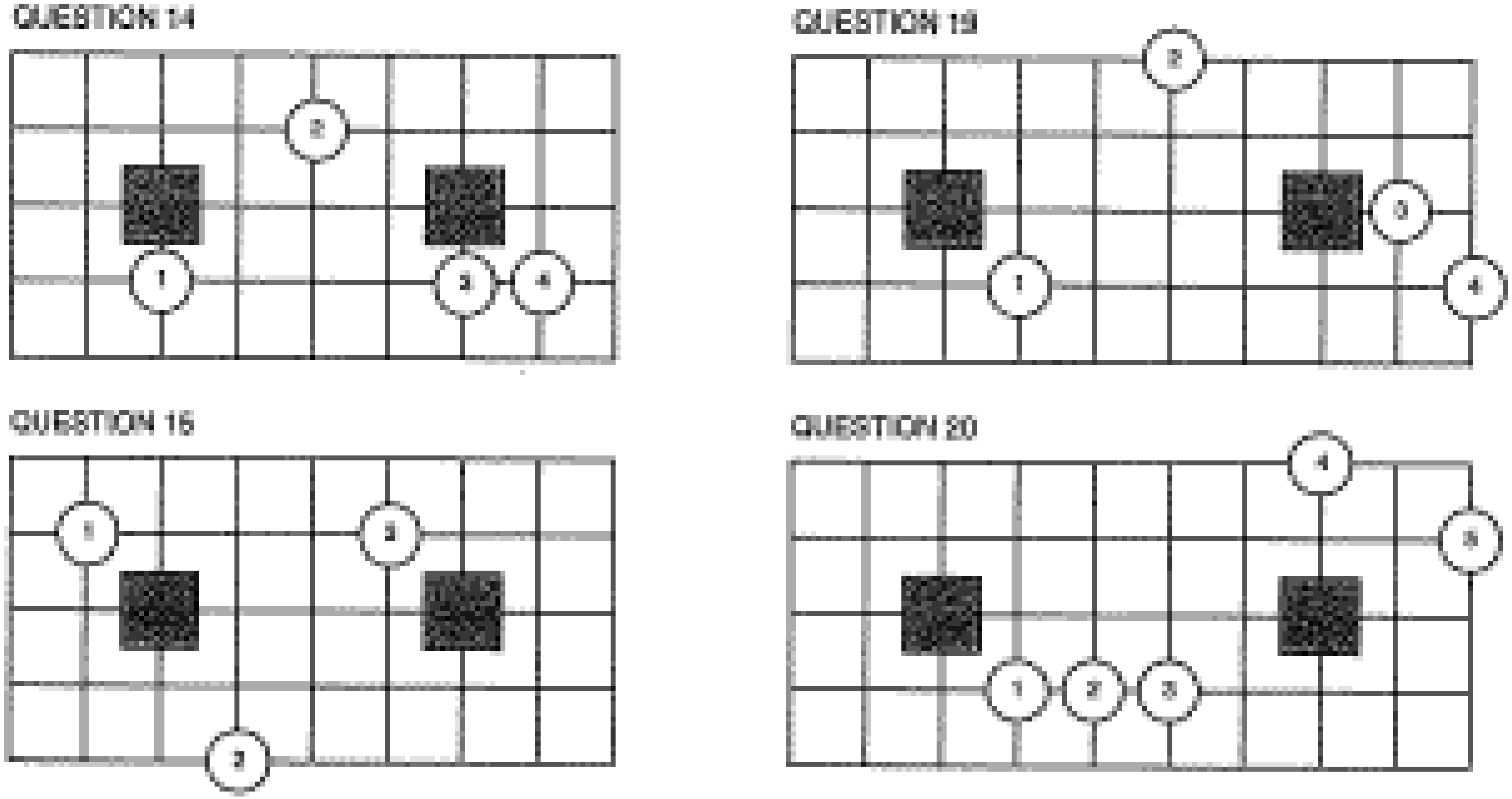

QUESTION 14
QUESTION 19
QUESTION 15
QUESTION 20

Table 7.4. *Choices consistent with various assignment rules*

Question	Closeness	Accession	Equality
11	LR (74)	LR (74)	LR (74)
12	LLRR (68)	LLRR (68)	LLRR (68)
13	L*R (70+)	LLR (70)	None
14	L*RR (76)	**RR (76+)	LLRR (68)
15	LLR (71)	LLR (71)	None
16	L*RR (73)	LRRR (5)	LLRR (68)
19	LRRR (29)	LRRR (29)	LLRR (45)
20	LLRRR (32)	LLLRR (43)	None

Source: Mehta et al. (1994b).

Note: Figures in parentheses show the percentage of subjects choosing consistently with each rule. * Denotes *either* L or R permitted.

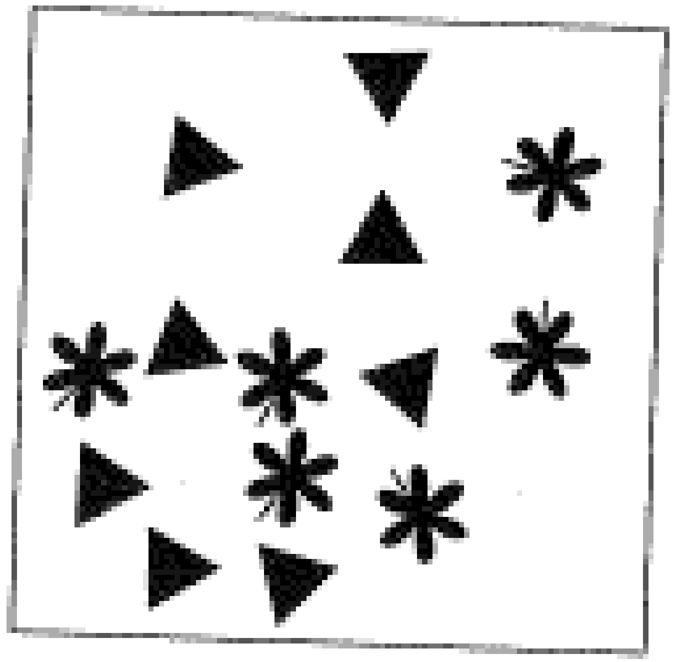


Figure 7.2. Example of a picture used to test "rarity preference" in matching games. Source: Based on Bacharach and Bernasconi (1997).

Table 7.5. Frequency of choices of rare versus frequent actions (percent)

	Number of rare/frequent options			
	6/8	2/3	6/18	1/15
Rare	65	76	77	94
Frequent	35	24	23	6

Source: Bacharach and Bernasconi (1997).

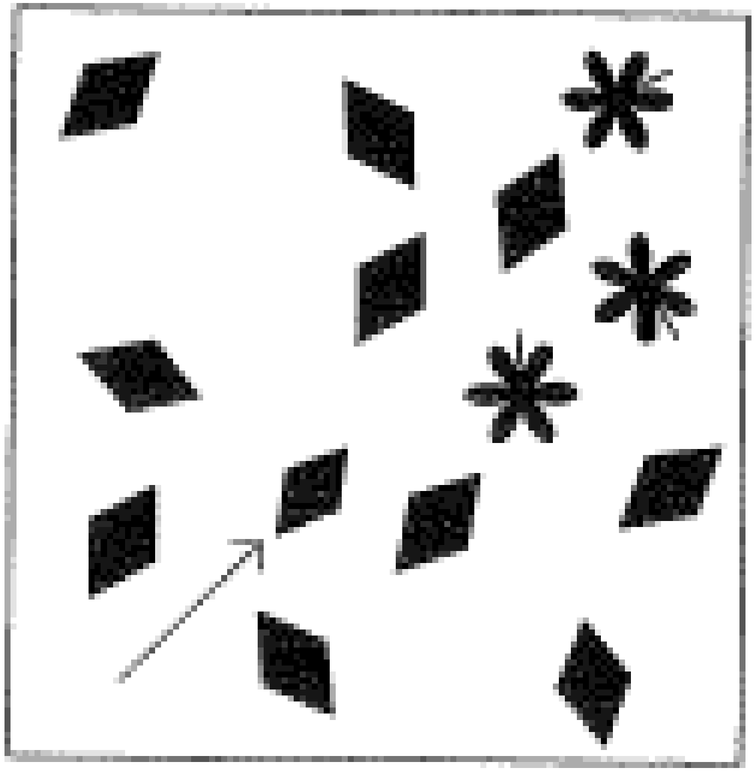


Figure 7.3. *Example of a picture with object size differences used to test "tradeoff." Source: Based on Bacharach and Bernasconi (1997).*

Table 7.6. Frequency of choices in tests of tradeoff, fourteen actions in total (percent)

	Subtlety of oddity attribute								
	Number of rare options r								
	Obvious				Subtle				
	2	3	4	5	2	3	4	5	6
Rare	14	19	9	7	77	55	45	69	55
Oddity	83	79	91	88	23	31	45	19	20
Other	2	2	0	5	0	14	10	12	25
$p(F)$	0.95	0.91	0.96	0.93	0.55	0.40	0.62	0.25	0.25

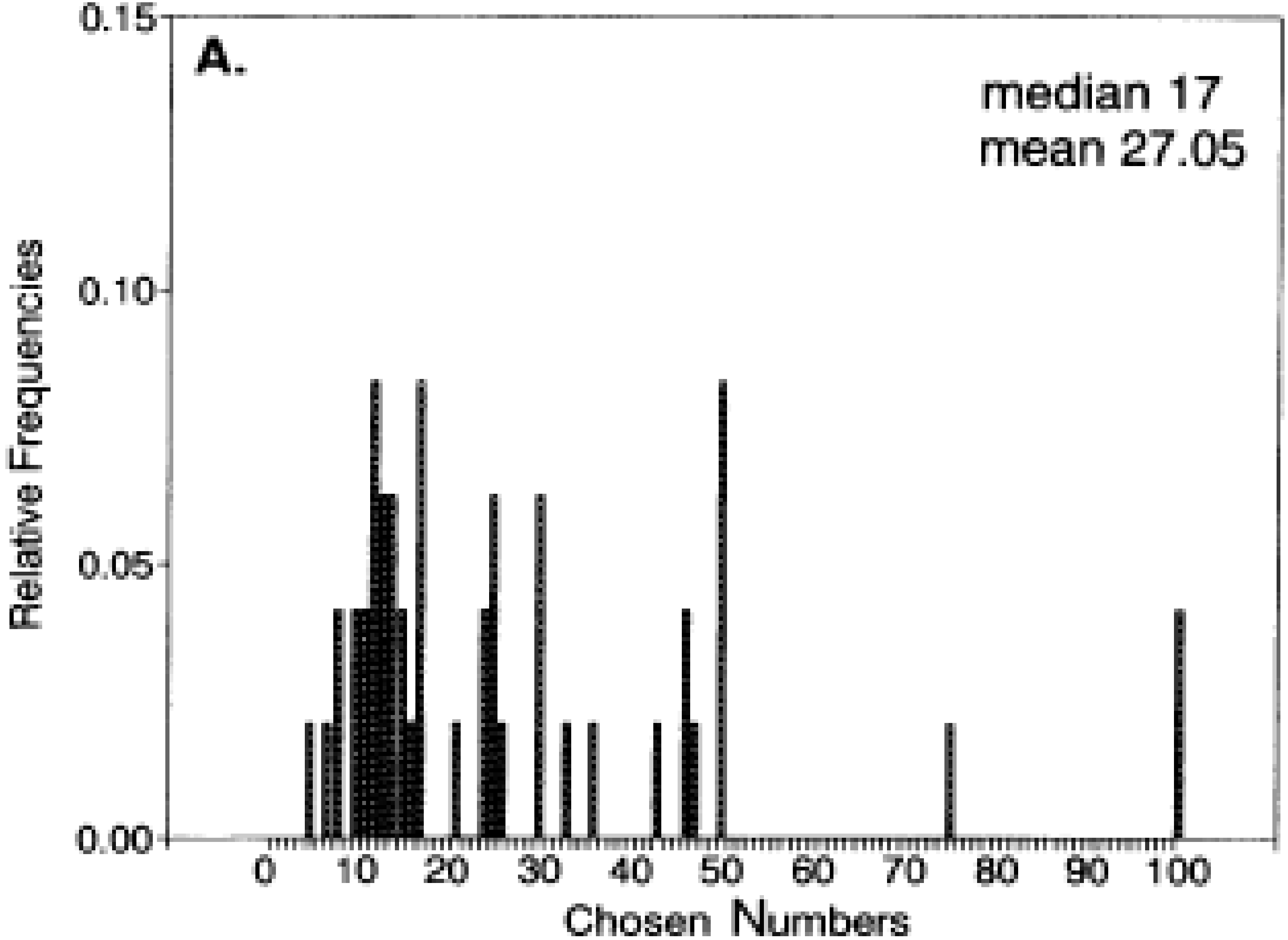
Source: Bacharach and Bernasconi (1997).

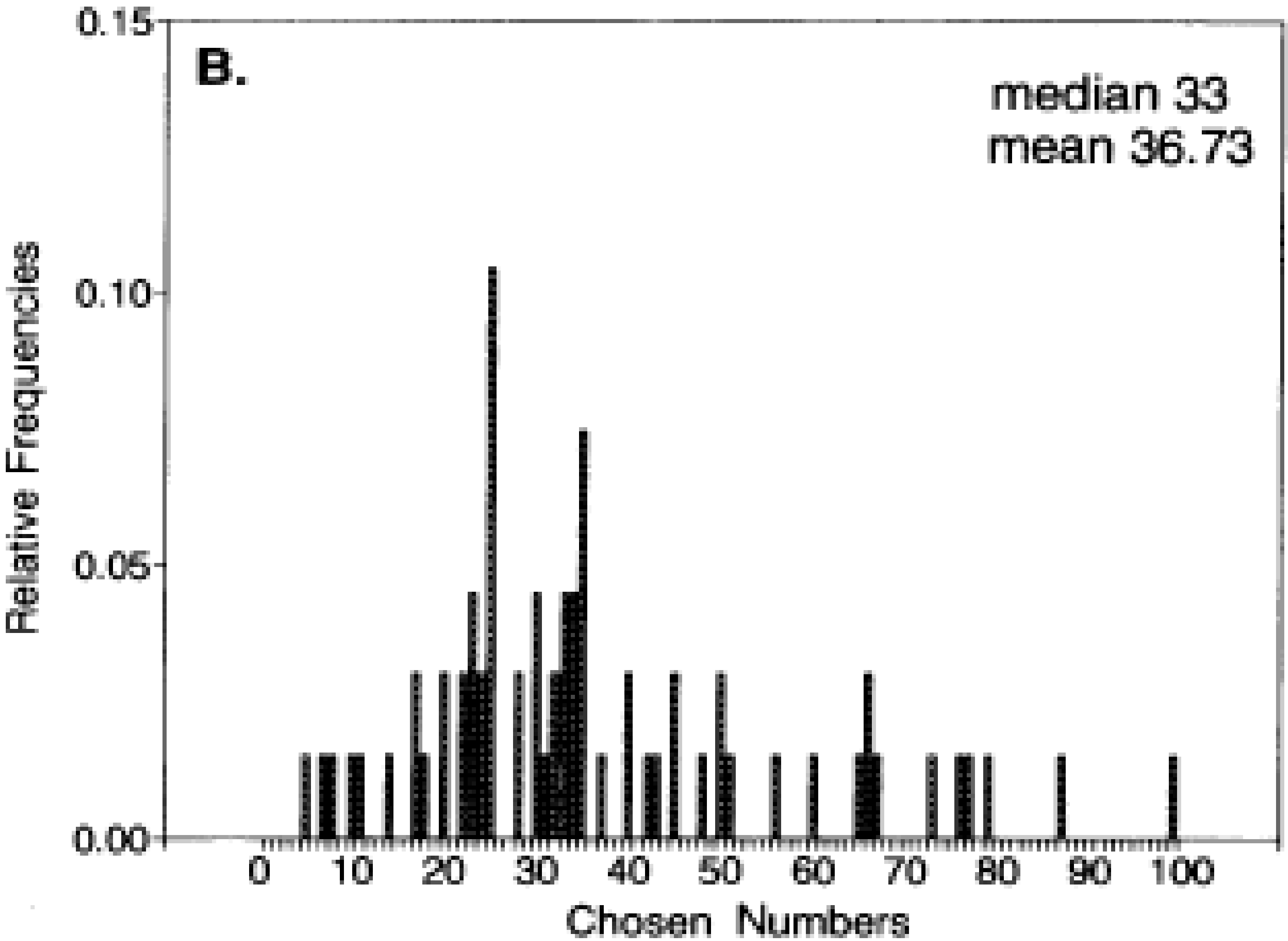
1.2.3 *Example 3: "Beauty Contests" and Iterated Dominance*

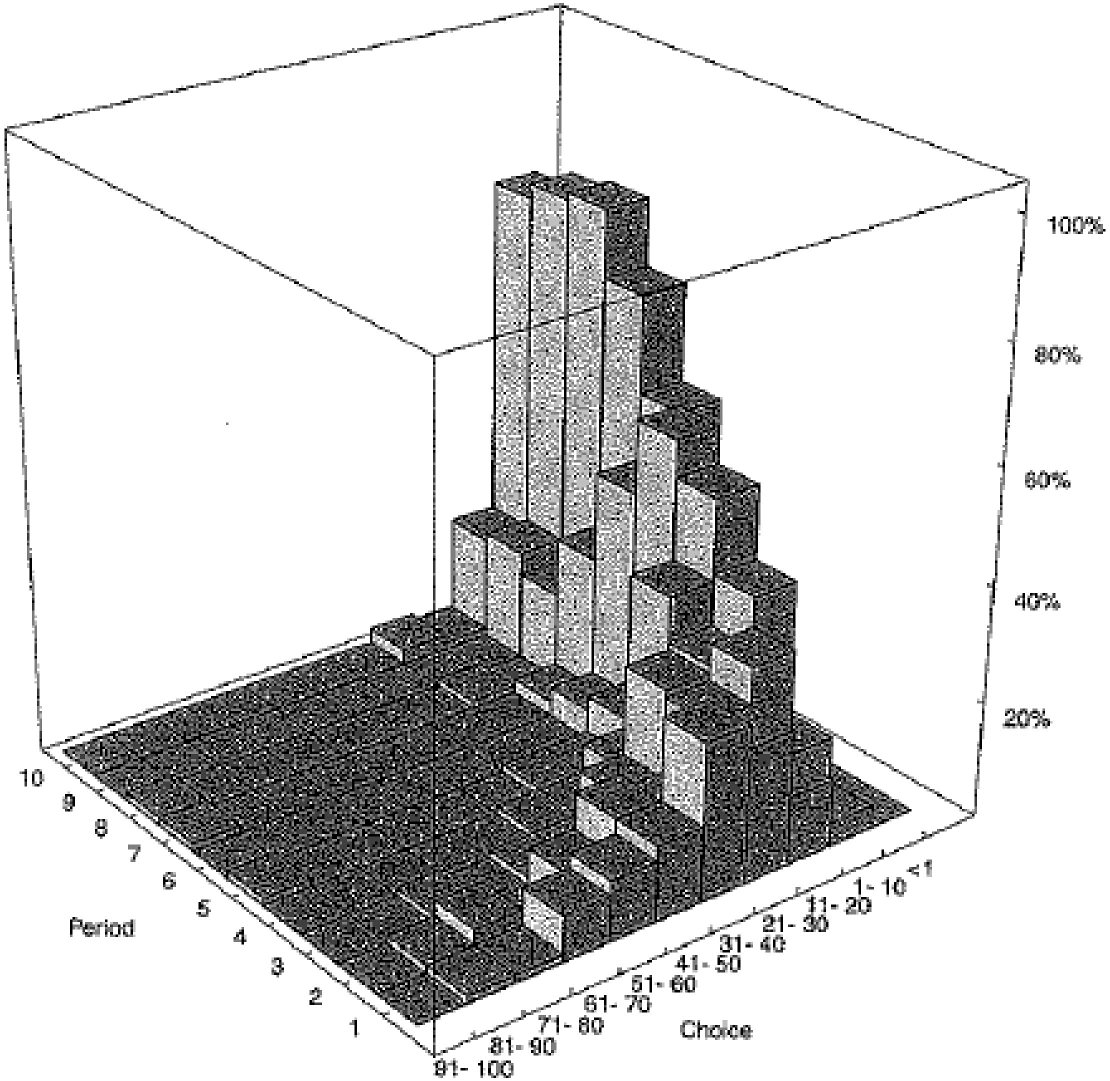
In Keynes's famous book *General Theory of Employment, Interest, and Money*, he draws an analogy between the stock market and a newspaper contest in which people guess what faces others will guess are most beautiful: "It is not a case of choosing those which, to the best of one's judgment, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree, where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practise the fourth, fifth, and higher degrees" (1936, p. 156). This quote is perhaps no more apt than in the year 2001 (when I first wrote this), just after prices of American internet stocks soared to unbelievable heights in the largest speculative bubble in history. (At one point, the market valuation of the e-tailer bookseller Amazon, which had never reported a profit, was worth more than all other American booksellers combined.)

A simple game that captures the reasoning Keynes had in mind is called the "beauty contest" game (see Nagel, 1995, and Ho, Camerer, and Weigelt, 1998). In a typical beauty contest game, each of N players simultaneously chooses a number x_i in the interval [0,100]. Take an average of the numbers and multiply by a multiple $p < 1$ (say $p = 0.7$). The player whose number is closest to this target (70 percent of the average) wins a fixed prize. Before proceeding, think about what number you would pick.

The beauty contest game can be used to distinguish whether people "practise the fourth, fifth, and higher degrees" of reasoning as Keynes wondered. Here's how. Most players start by thinking, "Suppose the average is 50". Then you should choose 35, to be closest to the target of 70 percent of the average and win. But if you think all players will think this way the average will be 35, so a shrewd player such as yourself (thinking one step ahead) should choose 70 percent of 35, around 25. But if you think all players think that way you should choose 70 percent of 25, or 18.


A.
median 17
mean 27.05
0.15
0.10
0.05
0.00
Relative Frequencies
0
10
20
30
40
50
60
70
80
90
100
Chosen Numbers


B.
median 33
mean 36.73
Relative Frequencies
0.15
0.10
0.05
0.00
0
10
20
30
40
50
60
70
80
90
100
Chosen Numbers



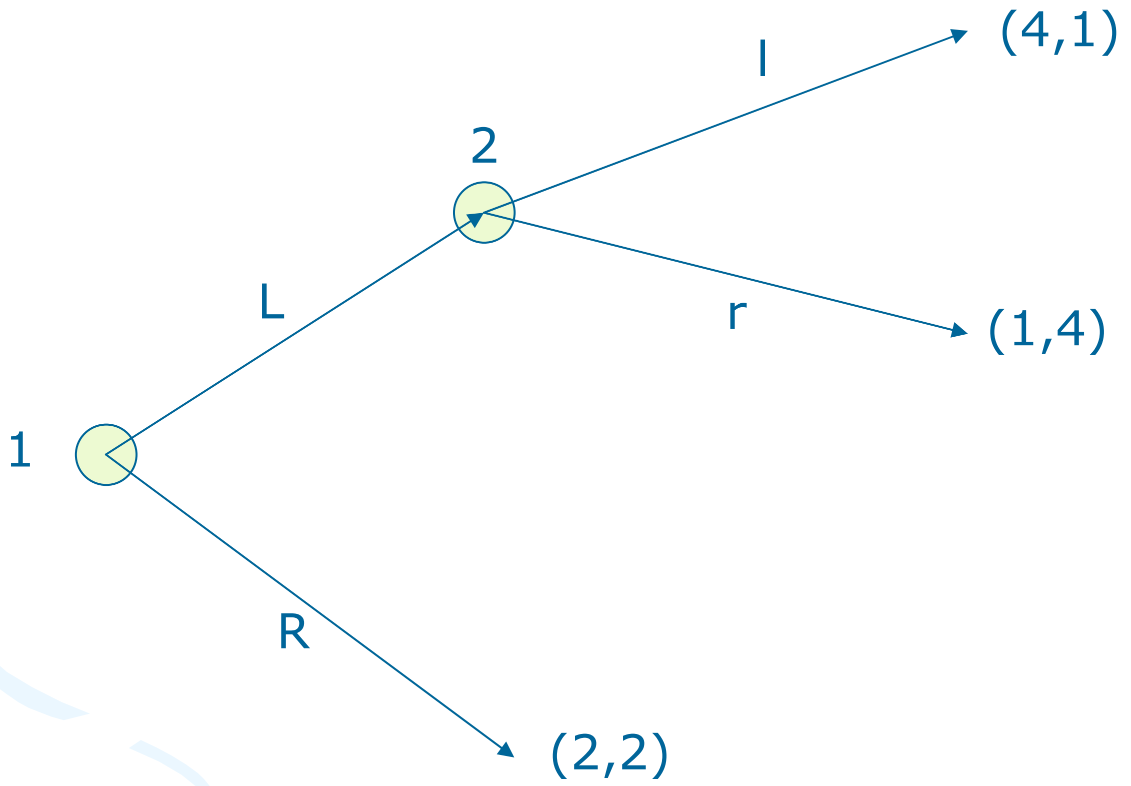
(a)

Figure 1.3. *Convergence in low-stakes and high-stakes "beauty contest" games. Source: Unpublished data from Ho, Camerer, and Weigelt.*

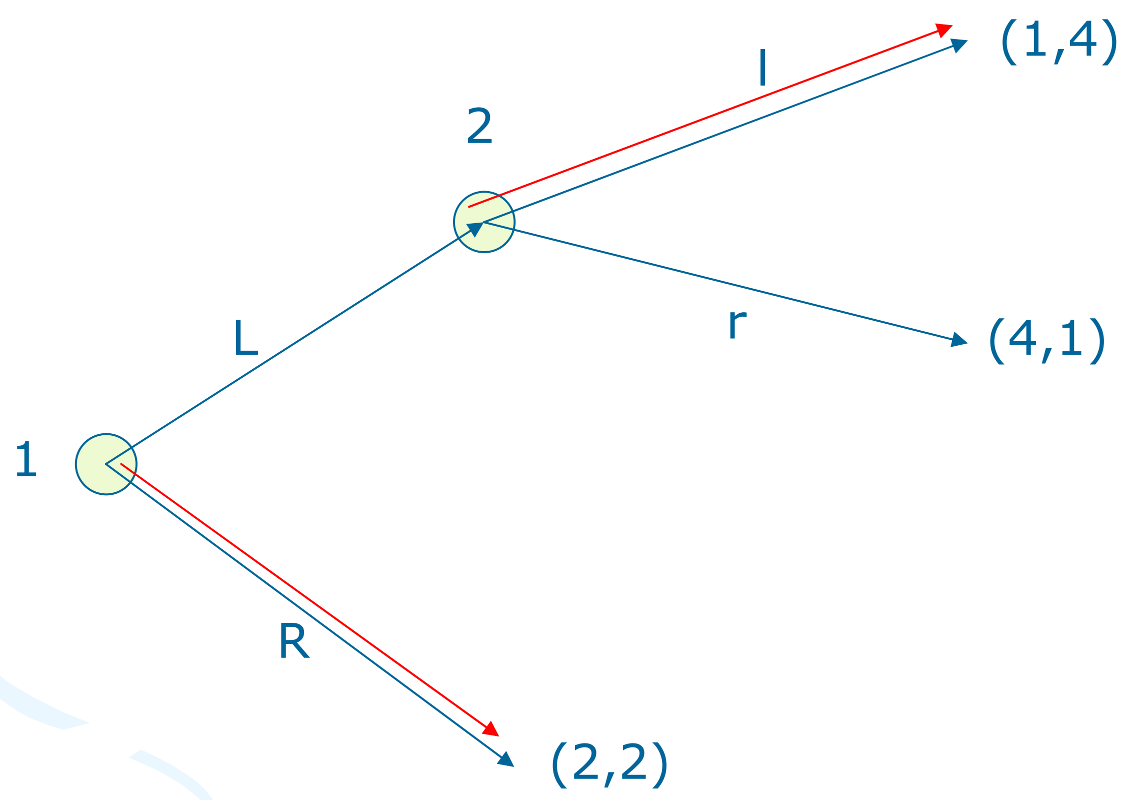
BEEM109 Experimental Economics and Finance

How selfish are people?

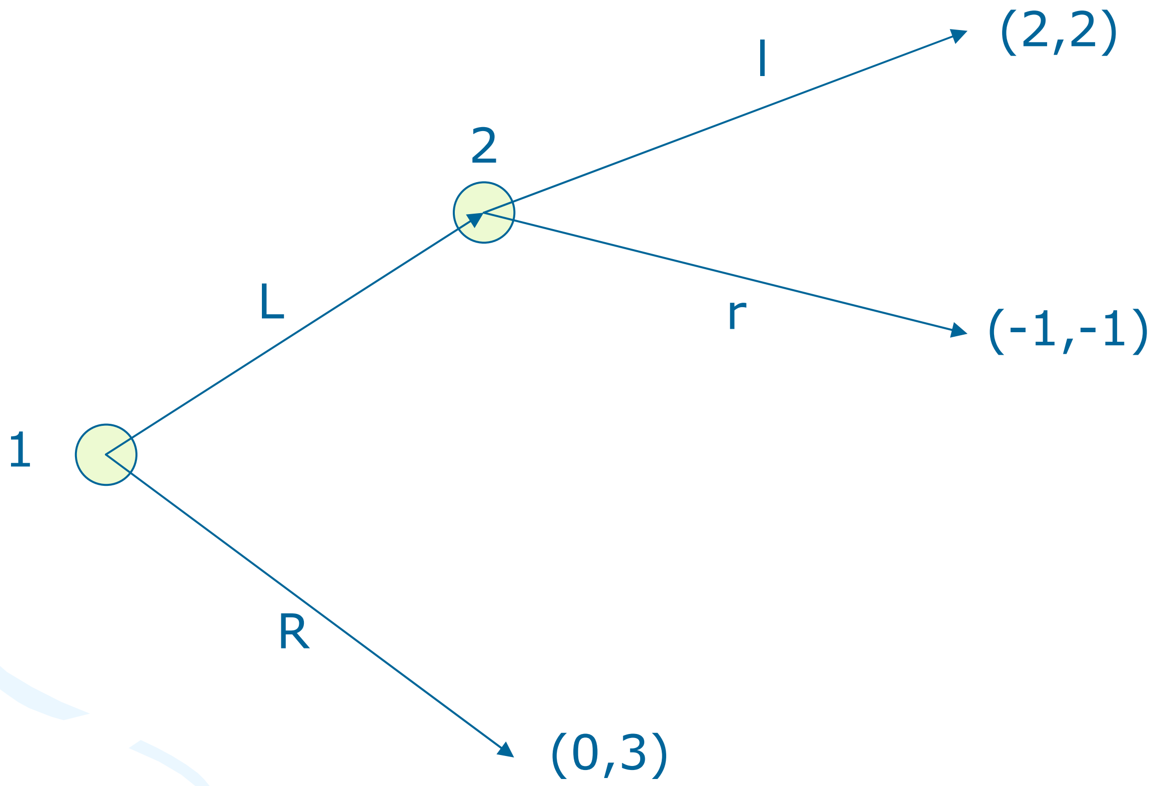
Extensive games



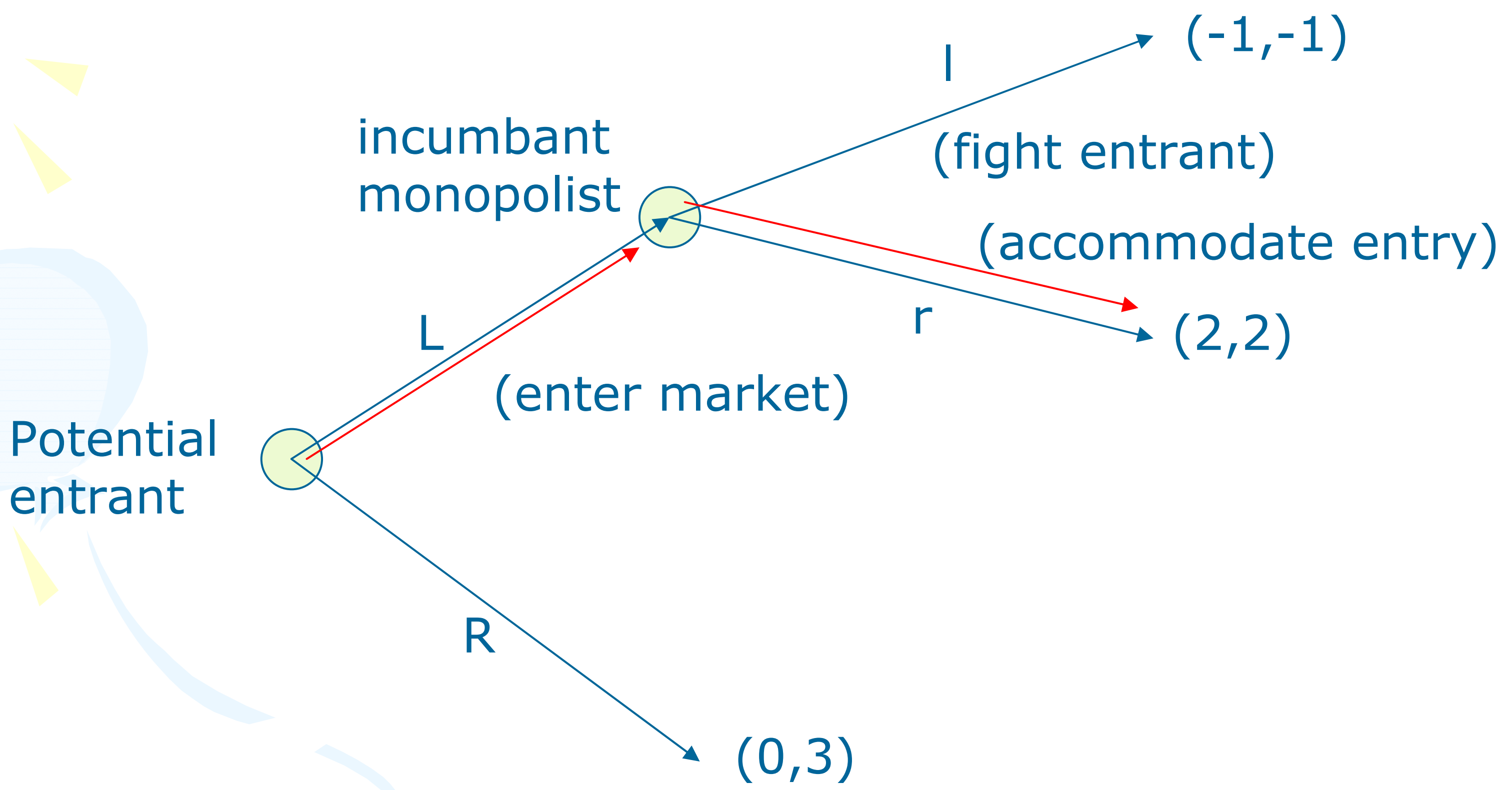
The subgame-perfect equilibrium point (Selten 1965): (R,l)



Extensive games

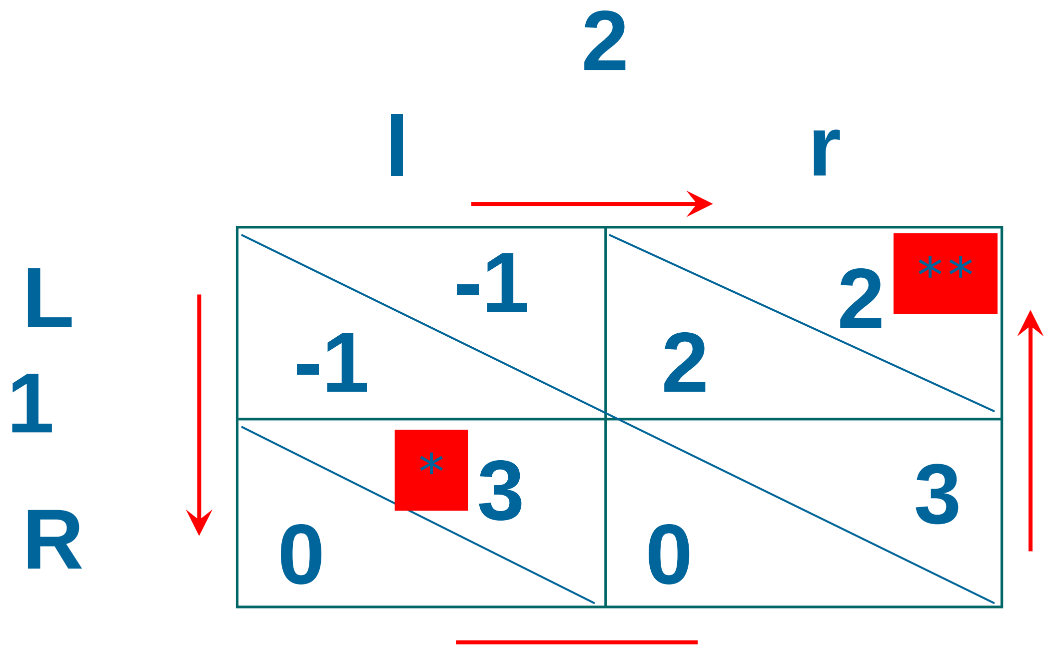


Potential entry



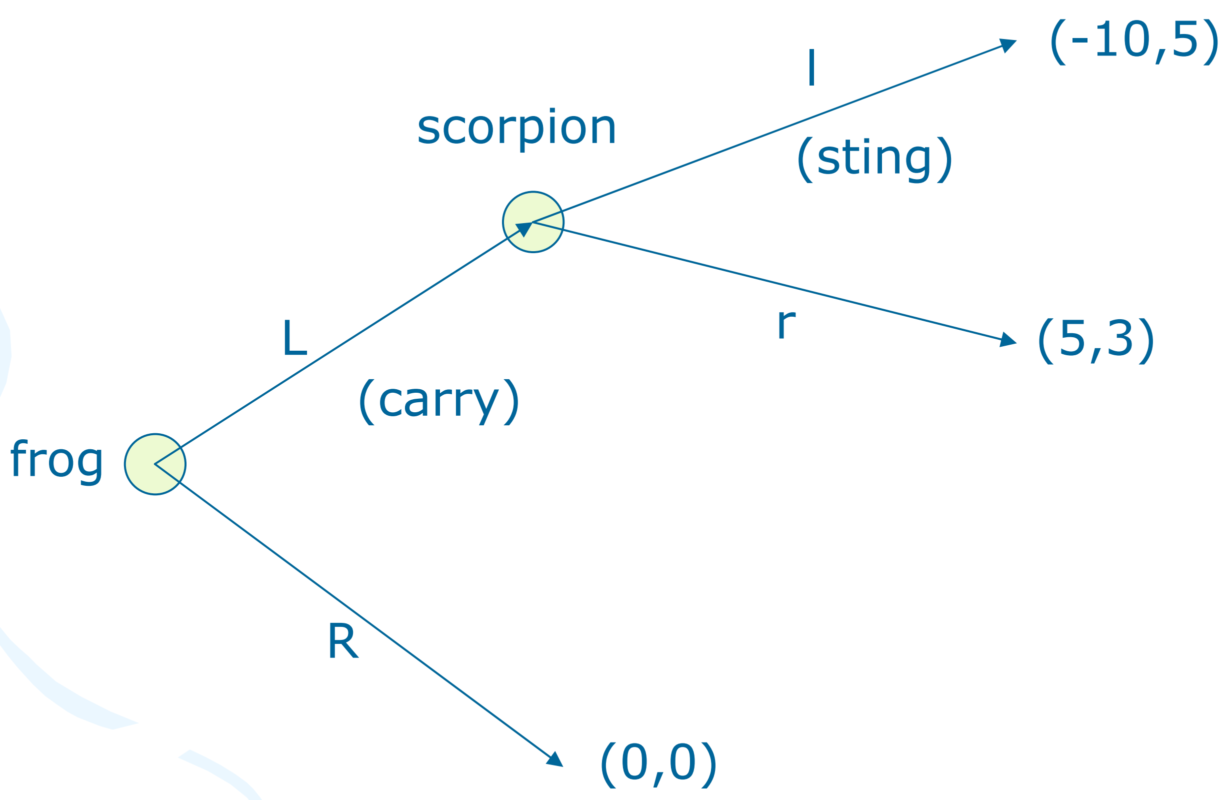
Subgame perfect Nash equilibrium: (L,r)

Other Nash equilibria?

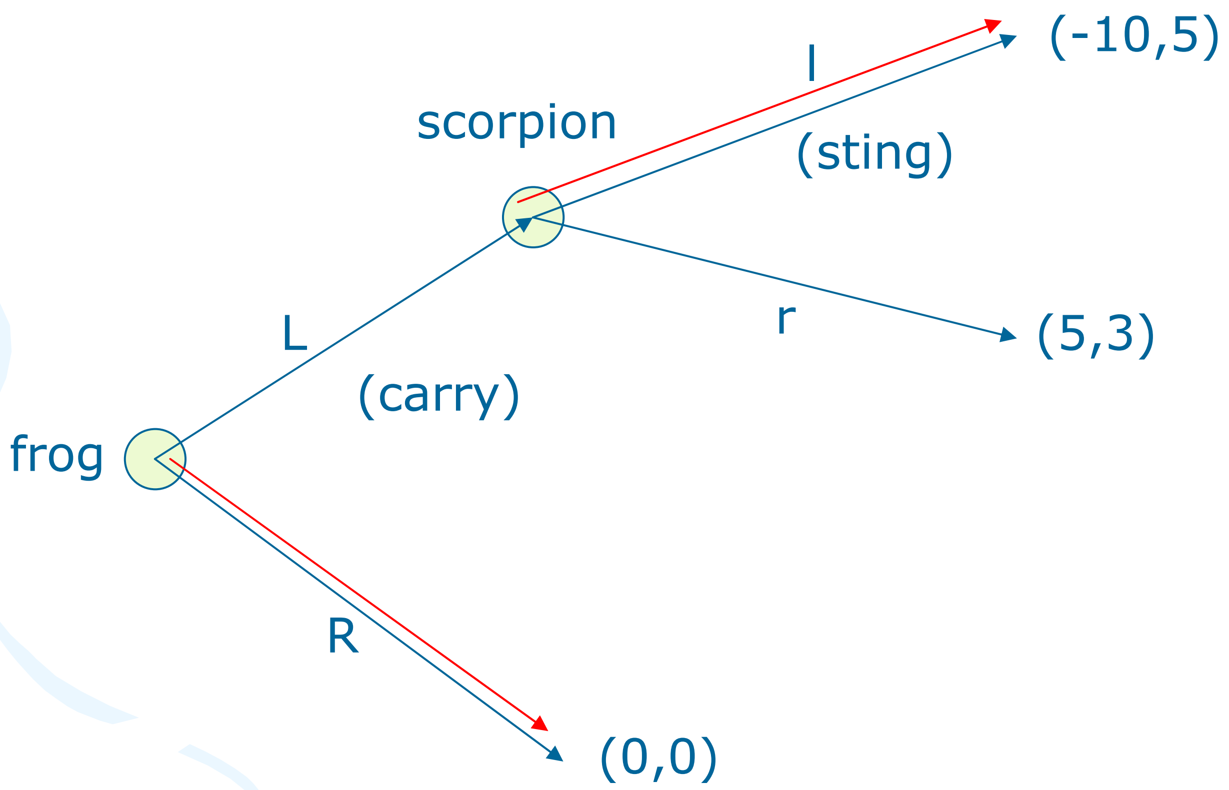


(L,r) subgame-perfect Nash equilibrium, (R,r) also Nash equilibrium, but not subgame perfect.
Schelling, Selten: (L,l) is not a credible Nash equilibrium because if 2 would have to move he would play R. (non-credible threat)

The frog and the scorpion

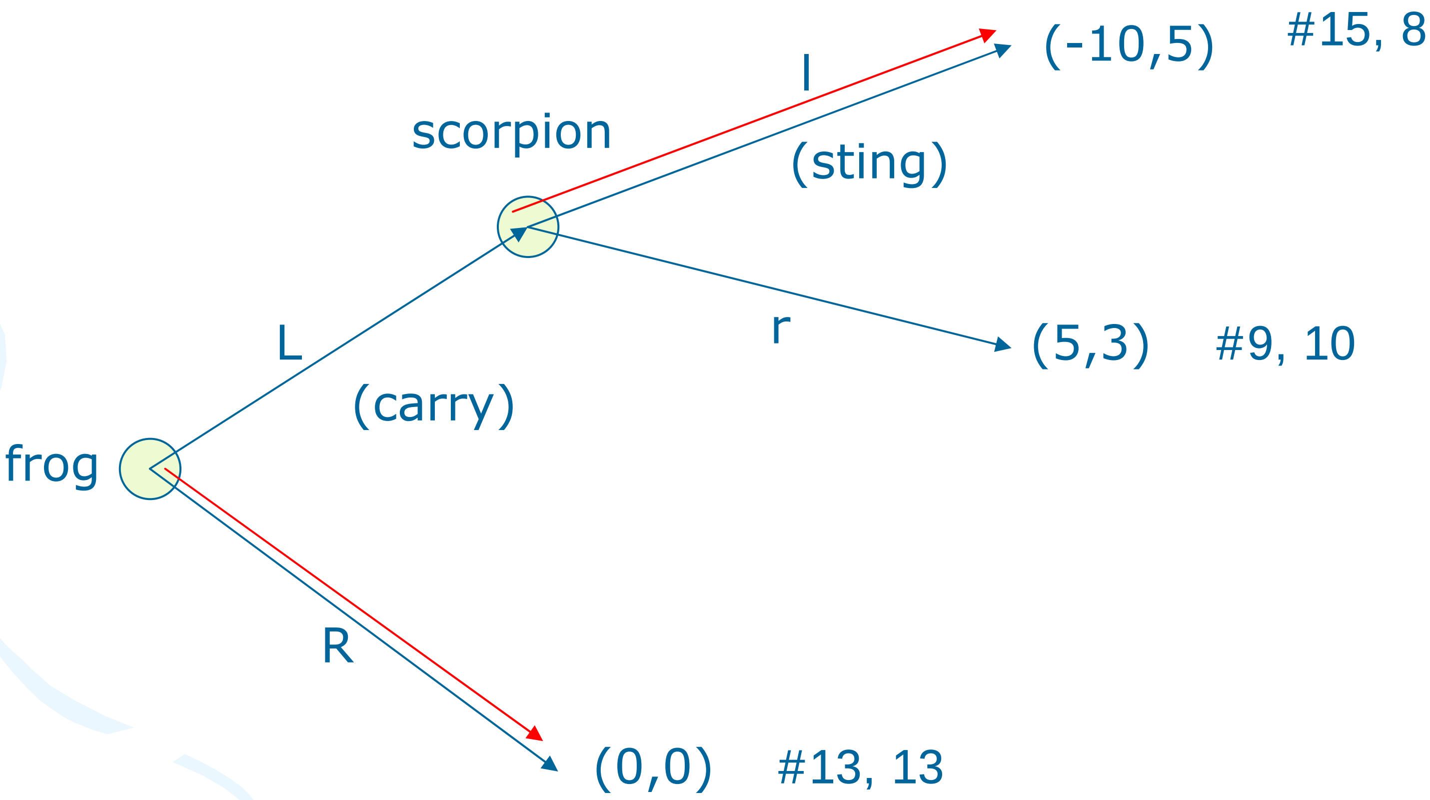


The scorpion and the frog



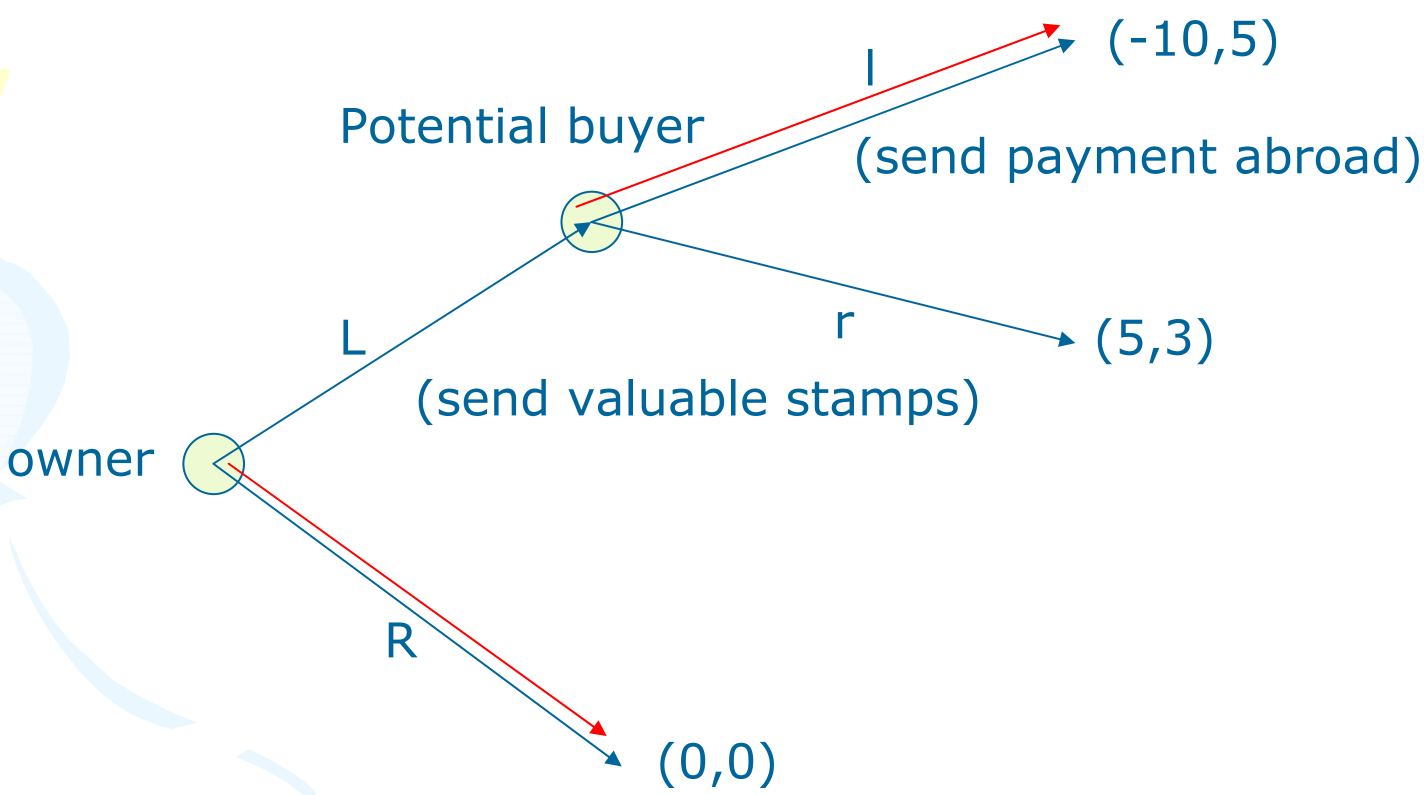
(do not carry, sting)
Incredible promise?

The scorpion and the frog



Results from classroom experiment

Trade on the internet



Problem: incredible promise

The trust game

- Berg, Dickhaut and McCabe
  - Investor invest T and keeps X-T
  - Allocator splits (1+r)T between himself and the investor
  - Subgame perfect equilibrium?
  - Average repayment aroun 95%, except in Bulgaria
- Fehr, Kirchsteiger, Reidl: gift exchange game, labour markets

Ultimatum Bargaining

- Güth, Schmittberger, Schwarz (1982) £10 to divide
- Proposer specifies a division
- Responder has to accept division or reject
- In case of rejection, both get zero

Ultimatum Bargaining

- Subgame perfect Nash-equilibrium: Proposer leaves a penny
- Actual (typical) result:
  - Proposers offer between 50% and 60%
  - Responders reject demands above 70% with probability 40% -66%

Camerer:

If I had a dollar for every time an economist claimed that raising the stakes would drive ultimatum behavior toward self-interest, I'd have a private jet on standby all day. Many experimental studies *have* raised stakes (see Camerer and Hogarth, 1999).[5] In simple tasks such as ultimatum games, paying extra

Dictator game

- £10 to divide
- Proposer specifies a division
- This is automatically accepted
- Subgame perfect Nash-equilibrium: Proposer leaves zero

Dictator games

- Theory: dictator takes all
- Experiments: this is indeed often the case
- Still, in some experiments around 20% split 50%-50%

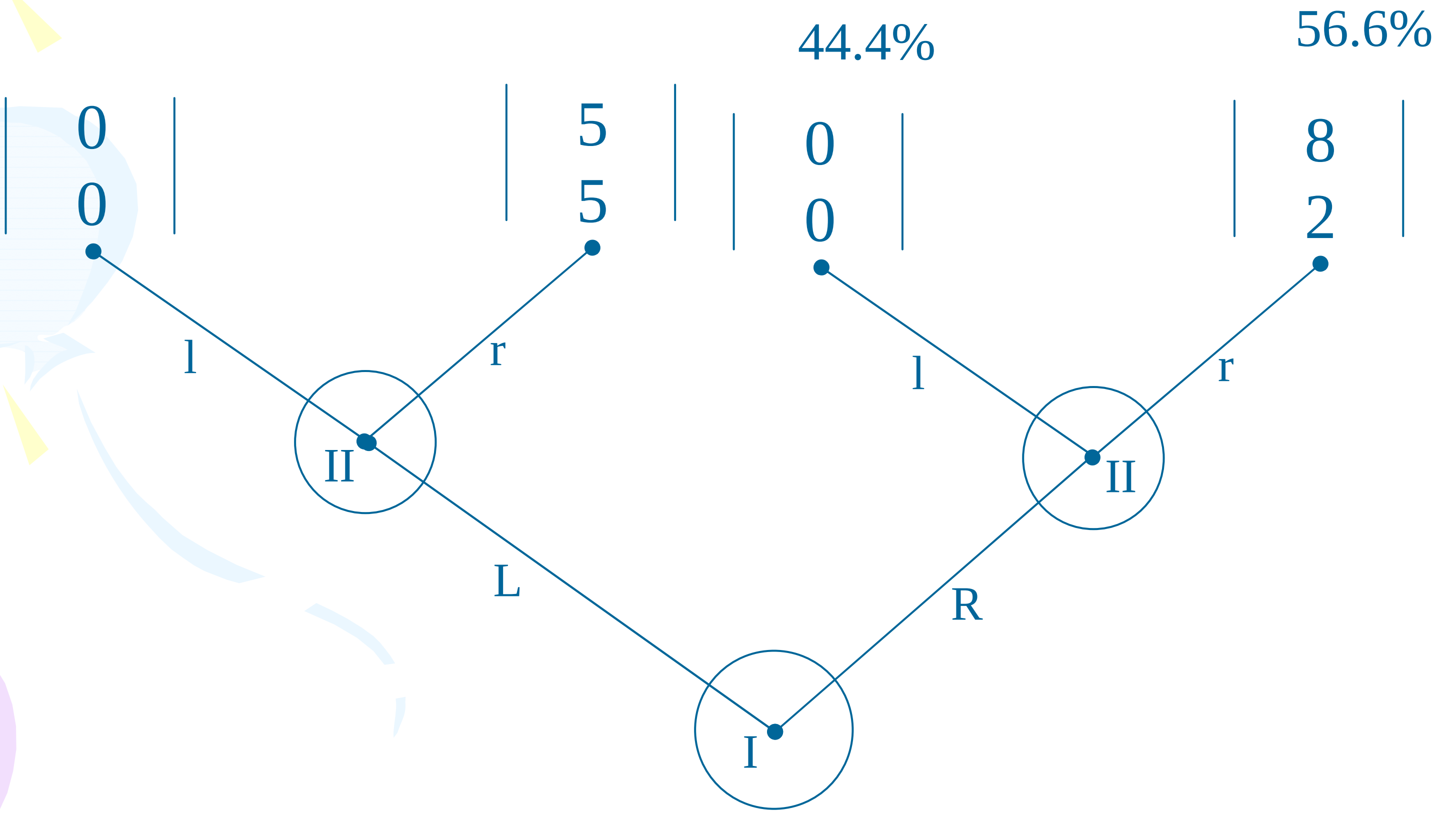
Variables

- Methodological variables
  - Repetition
  - Stakes (Cameron) Roth / Aumann
  - Anonymity and Experimenter “Blindness”
- Demographic variables
  - Gender
  - Race
  - Academic major (education or self-selection?)
  - Age !

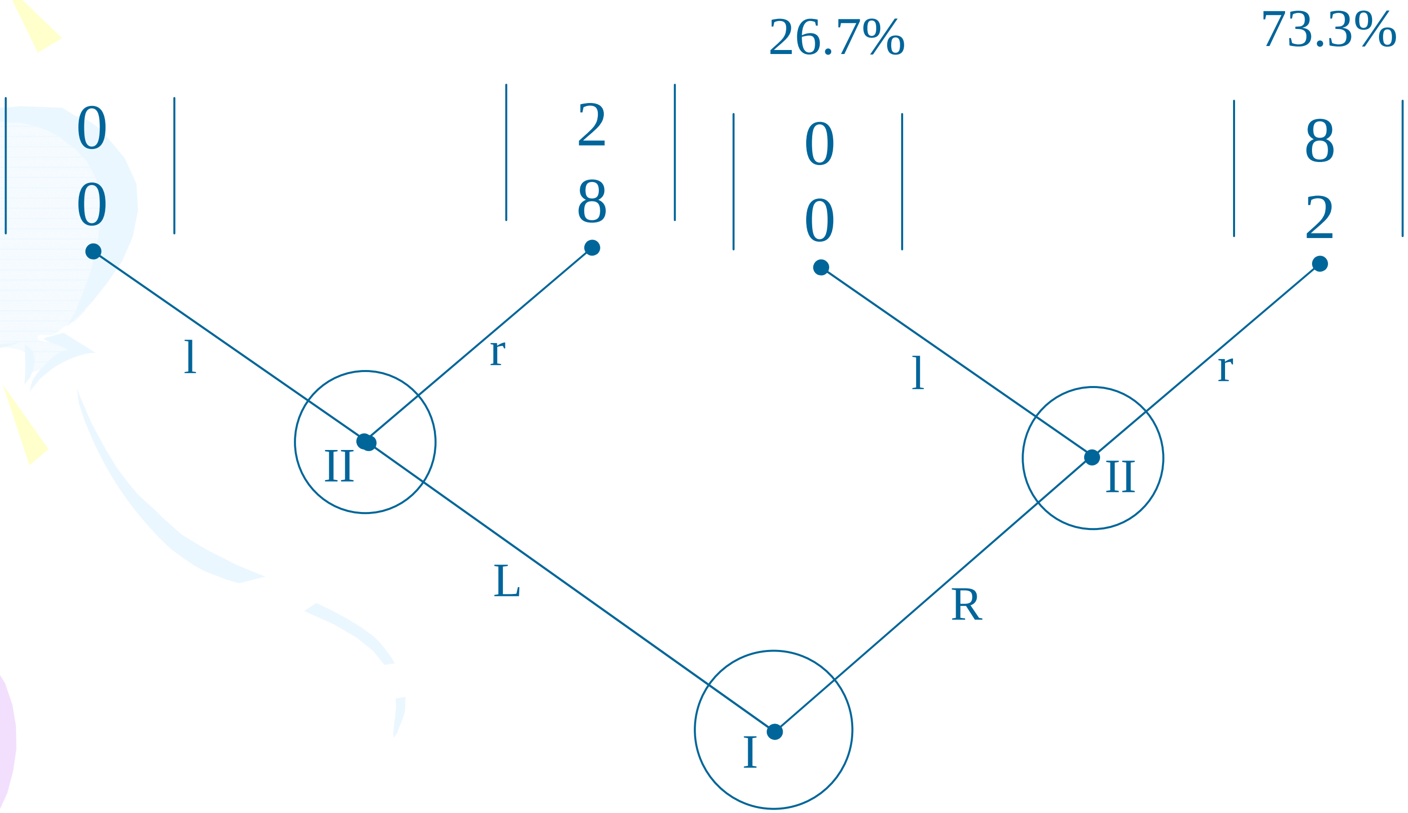
Variables

- Culture
- Labeling and context
- Structural Variables
  - When is an UG still and UG?
  - Restriction of alternatives: Intentions

Falk Fehr Fischbacher I



Falk Fehr Fischbacher II



Fairness

- The results contradict selfishness, but not rationality
- Fehr / Schmidt; Bolten / Ockenfels: fairness preferences
- Key: different fairness attitude of players
- Game with “incomplete information”
- Shaked’s critique

Fehr / Schmidt preferences

- x: my monetary payment, y: your monetary payment
- My utility:
  - if $x<y$: $u(x,y)=x-\alpha*(y-x)$ (e.g. envy)
  - if $x>=y$: $u(x,y)=y-\beta(x-y)$ (e.g. guilt)
- "inequity aversion", not altruism!
- α, β vary among individuals