Behavioral Game Theory

Outline
(September 3, 2007)

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- Introduction
- Examples of laboratory experiments
  ① "Beauty contest", iterated elimination of dominated strategies, depth of reasoning
  ② Coordination and convention
  ③ Testing mixed strategies
  ④ Ultimatum game
- Experimental protocol

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What is Behavioral Game Theory?

Recent branch of game theory using an *experimental approach*

Empirical/descriptive analysis based on *data* (laboratory experiments) and *psychological facts*

➥ What is the *real* behavior of individuals in games

Why using such approach?

➢ Underline empirical regularities in human strategic behavior

➢ Characterize favorable/unfavorable conditions for the theory to work

➢ Suggest extensions of the theory (errors, imperfect expectation, imperfect memory, learning, framing effects, . . .)

➢ Evaluate new policies or institutions before implementing them in the field

➢ Teaching tool of game theory and market mechanisms

The Experimental Economics Methodology

- Provide the best conditions for the theory to work in the laboratory
- Each subject takes the role of a player and makes *real* decisions
- Give to the subject the same incentives as the corresponding player in the game (monetary payoff, grade, . . .)
- Show and explain how subjects behave by using statistical methods

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Advantages

① Highly controlled environment ($\neq$ field studies)

② Easy to replicate

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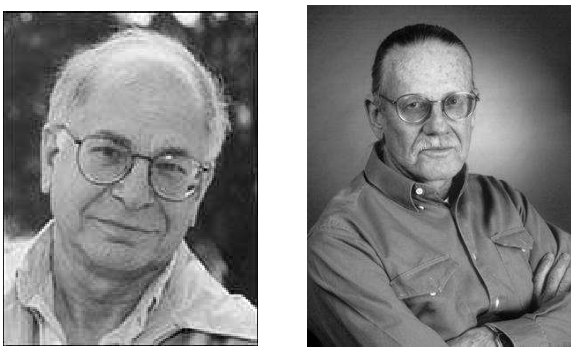

Figure 1: Daniel Kahneman (1934–) and Vernon L. Smith (1927-), Nobel Prize in Economics in 2002

“Beauty contest” and Depth of Reasoning

In “The General Theory of Employment, Interest, and Money”, Keynes (1936) compares asset markets with beauty contests of some newspapers:

“Professional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole; so that each competitor has to pick, not those
5/ *faces which he himself finds prettiest, but those which he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point of view. It is not a case of choosing those which, to the best of one' s judgment, are really the prettiest, nor even those which the average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligence to anticipating what the average opinion expects the average opinion to be . And there are some, I believe, who practice the fourth, fifth and higher degrees.”* (Keynes, 1936, Chapter 12).

Moulin (1986): Simple game underlining such reasoning

Each player must announce a number in $[0, 100]$

The player who is the closest to 70% of the average announcement wins

. . . Take your decision! . . .

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Iterated elimination of dominated strategies:

- Announcing more than 70 is (weakly) dominated by 70
- With this reasoning, every player's announcement is in $[0, 70]$, so 70% of the average is not larger than 49
- Announcing more than 49 becomes (weakly) dominated
- Announcing more than 35 becomes (weakly) dominated
- 7/ then 25, 18, ...

  which converges to 0

It is also easy to verify that announcing 0 is the unique Nash equilibrium

Experimental Results.

➢ Average announcements between 20 and 40 in the first round

➢ Approach 0 after approximately five rounds

Optimal strategy: one step of reasoning more than the others (to choose 70% of others' choices), *but not further*

Remarks.

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- Experimental results are robust to the levels of monetary incentives (but faster convergence for high monetary incentives)
- Apply for most types of subjects: undergraduate students, best graduate students in mathematics, Ph.D. students in economics, real traders, ...

Further readings: Camerer (2003, chap. 5), Nagel (1995) and Ho et al. (1998)

Coordination and Convention

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	Median choice													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	45	49	52	55	56	55	46	-59	-88	-105	-117	-127	-135	-142
2	48	53	58	62	65	66	61	-27	-52	-67	-77	-86	-92	-98
3	48	54	**60**	66	70	74	72	1	-20	-32	-41	-48	-53	-58
4	43	51	58	65	71	77	80	26	8	-2	-9	-14	-19	-22
5	35	44	52	60	69	77	83	46	32	25	19	15	12	10
6	23	33	42	52	62	72	82	62	53	47	43	41	39	38
7	7	18	28	40	51	64	78	75	69	66	64	63	62	62
8	-13	-1	11	23	37	51	69	83	81	80	80	80	81	82
9	-37	-24	-11	3	18	35	57	88	89	91	92	94	96	98
10	-65	-51	-37	-21	-4	15	40	89	94	98	101	104	107	110
11	-97	-82	-66	-49	-31	-9	20	85	94	100	105	110	114	119
12	-133	-117	-100	-82	-61	-37	-5	78	91	99	106	**112**	118	123
13	-173	-156	-137	-118	-96	-69	-33	67	83	94	103	110	117	123
14	-217	-198	-179	-158	-134	-105	-65	52	72	85	95	104	112	120

Two (pure strategy) Nash equilibria: everyone chooses 3 or everyone chooses 12

Evolution of the median choice in 10 groups of subjects in Van Huyck et al. (1997) :

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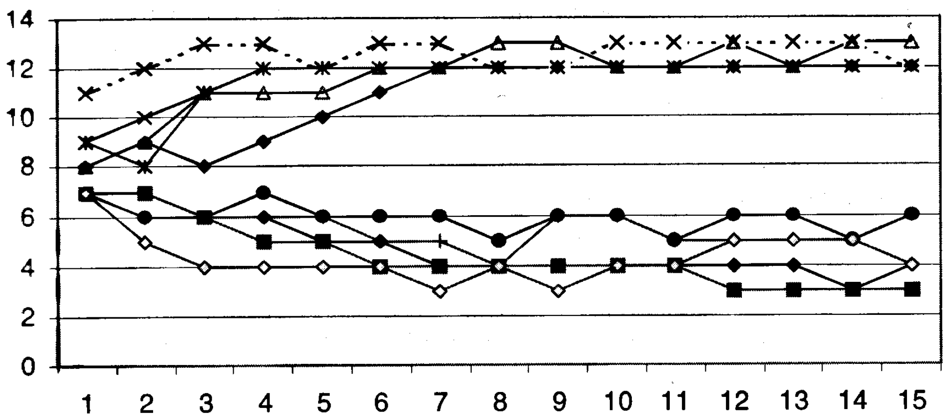

Conclusions of the experiment:

- Players' choices do not converge more often to the efficient equilibrium than to the inefficient equilibrium
- Final outcomes are very sensitive to initial conditions

11/ Further readings: Camerer (2003, chap. 7)

Testing Mixed Strategies

Can we empirically observe behavior consistent with a (non-degenerate) mixed strategy equilibrium, even when there is no equilibrium selection problem?

A priori, lots of difficulty :

- Mixed strategy equilibrium ⇒ players are indifferent between several actions ⇒
12/ no strict incentive to play the equilibrium strategy
- Random strategies ⇒ further assumptions on players' preferences (VNM)
- . . . + assumptions on attitude towards risk
- Biases of human perception of probabilities, and difficulty to make independent choices

Some solutions :

- A mixed strategy equilibrium can be seen as a *population equilibrium* where no single individual makes random choices

- Non-independent choices is consistent with an *equilibrium in beliefs* (Brandenburger, 1992; Aumann and Brandenburger, 1995)

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- No assumption on risk attitude is required if there is only two possible payoffs in the game (cardinality of VNM utility functions)

O'Neill (1987) Experiment

	a	b	c	J	Nash equilibrium	Empirical frequencies
a	-5	5	5	-5	0.20	0.221
b	5	-5	5	-5	0.20	0.215
c	5	5	-5	-5	0.20	0.203
J	-5	-5	-5	5	0.40	0.362
Nash equilibrium	0.20	0.20	0.20	0.40		
Empirical frequencies	0.226	0.179	0.169	0.426		

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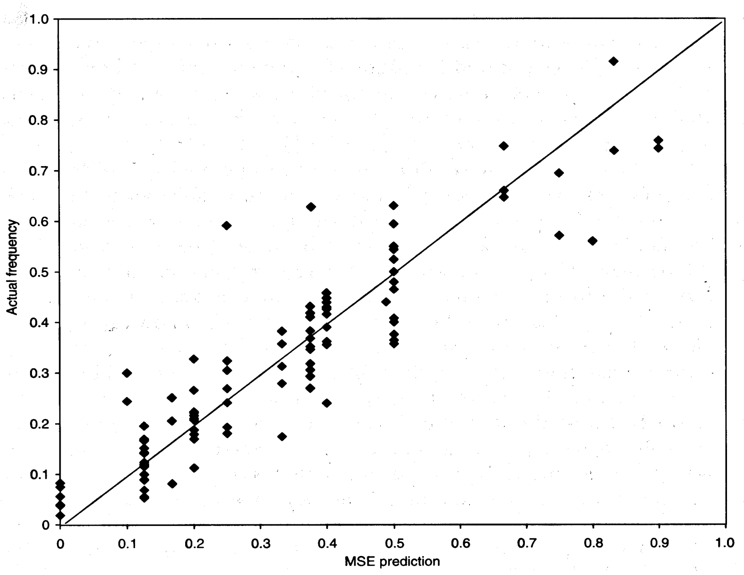
(105 rounds with 25 pairs of subjects)

➥ Aggregate behavior remarkably close to equilibrium predictions

Camerer (2003, Figure 3.1, page 121) : General idea of the predictive power of mixed strategy Nash equilibrium in various experiments with a unique Nash equilibrium

15/ 

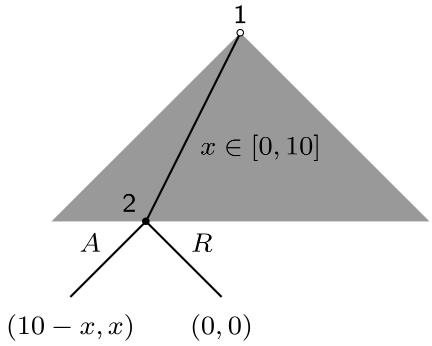
Ultimatum Game

☞ Simplest version of a sequential bargaining situation

- Two negotiators
- Positive trading surplus, e.g., 10 €
- 16/ The first player makes a "take it or leave it" offer $(10 - x, x)$ to player 2
- The second player accepts or rejects the offer
- If the offer is rejected the surplus is loss (0 for both)

➥ Last step of a more complicated negotiation problem

Game tree:



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Backward Induction:

The second player accepts every positive offer

$\Rightarrow$ The first player keeps 10 euros (or 9.99 euros): $x \simeq 0$

Empirically, does the first mover really have all the bargaining power?

More precisely:

- Do the receivers accept all positive offer, or do their reject low or unfair offers?
- Do the senders correctly anticipate the receivers' responses?

Experimental Evidence. In almost all experiments around the world:

- Average offers around 4-5 euros, with low variance
18/ • Offers smaller or equal to 2 are rejected half of the time

Plausible explanation: reciprocity, aversion towards inequality (*social preferences*)

Remark. This explanation is NOT inconsistent with standard game theoretical models and expected utility theory

Experimental Protocol

Describes concretely and precisely the rules of the experimental game

The way the experiment is implemented is extremely important because it can radically influence subjects' behavior even if the game theoretical model is formally equivalent (e.g., framing effects)

There are some conventions on the way the experiment is implemented in order to appropriately compare several experiments

Instructions.

- Clear, detailed, and understandable for everyone
- Read publicly (common knowledge)
- In general, all information that is available to the game theorist should be made available to the subjects ($\neq$ experiments in psychology)

Anonymity.

- Subjects should not be able to identify the other participants
- No communication is allowed, except if communication is explicitly specified into the rules of the game (e.g., experiments on "*cheap talk games*")

Matching and Reputation.

- Repetition of the game should not interfere with the original rules of the game (supergame effects: reputation, threat, punishment)

Incentives.

- Less errors and variance in behavior is usually observed with sufficiently high monetary incentives (especially for problems with medium difficulty)

Ordering Effect.

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- Several games can be implemented in the same experiment but all subjects should not play them in the same order because the order may significantly influence their behavior (learning, framing, . . .)

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