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INSTINCTIVE AND COGNITIVE REASONING: A STUDY OF RESPONSE TIMES*

Ariel Rubinstein

Lecture audiences and students were asked to respond to virtual decision and game situations at gametheory.tau.ac.il. Several thousand observations were collected and the response time for each answer was recorded. There were significant differences in response time across responses. It is suggested that choices made instinctively, that is, on the basis of an emotional response, require less response time than choices that require the use of cognitive reasoning.

There is growing interest among economists in the bounds on the rationality of economic agents. Economists are increasingly abandoning the 'economic man' paradigm and instead are using models that reflect what they consider to be more realistic descriptions of the way in which human beings make decisions. One can identify three approaches in the literature to 'opening the black box' of decision making.

Bounded Rationality

This approach is based on casual observations of the way in which people make decisions (and primarily of our own decision-making processes). These are used to construct abstract models which are intended to increase our understanding of the effect of certain decision-procedural elements on the outcome of an economic interaction (Rubinstein, 1998). Thus, for example, Rubinstein (1986) added an assumption to the standard model of the repeated game such that players consider not only their standard game payoff but also the complexity of their strategies. The inclusion of complexity considerations in these models is based on our intuition about the meaning of complexity in long-term strategic situations. However, the choice of the actual complexity measures has not been linked to any empirical findings.

Behavioural Economics

Daniel Kahneman and Amos Tversky carried out a study which not only refuted the standard use of the economic man paradigm but also identified psychological elements which are systematically used by decision makers. Their findings demonstrated the involvement of emotions and procedural elements which were missing from the standard application of rationality in economics. The conclusions of the Kahneman and Tversky school, as well as the feeling that traditional models had been exhausted, led in the 1990s to the establishment of the field of Behavioural Economics. Researchers in this field usually preserve the assumption that an agent is rational in the economic

* This work would not have been possible without the collaboration of Eli Zvuluny who built the site which served as the platform for the experiments. I thank Michael Ornstein, my research assistant for this project. I also thank Gur Huberman – the idea of recording response time came to us while working on a different and unfinished project. Helpful comments were received from an Associate Editor of this Journal.

sense of maximising a well-defined target function; however, they do not feel obliged to define the target as material rewards. Agents in these models maximise a utility function which also reflects psychological motives such as care, envy and reciprocity.

Note that for the most part behavioural economics does not relate to the procedural elements of decision making but rather only to the incorporation of psychological elements in the utility function; for exceptions, see, for example, Selten (1978) who proposes three levels of reasoning and Rubinstein (1988) who, following Tversky's work on similarity, analyses a procedure for constructing similarity-based preferences between vectors. Modelling the interaction between such agents could also be accomplished by applying the standard game theoretical equilibrium concepts. However, once we do not require that economic agents behave as utility maximisers the study of the interaction between agents requires the invention of new notions of equilibrium; see, for example, Osborne and Rubinstein (1998).

Brain Studies

Following the advances in brain research, and especially the increased accessibility of machines using functional magnetic resonance imaging (fMRI), some researchers have started monitoring brain activity during decision making; for an introduction to the field see, for example, Glimcher(2003). Subjects make a decisions or play a game inside the machine. Researchers then search for correlations between the choices made and the activity in various brain centres (such as the one responsible for expressing emotion or for executing cognitive operations). However, this is an expensive and speculative type of research. The technical constraints result in small samples and noisy data and the interpretation of the findings is far from indisputable.

Brain studies attempt to make inferences about our 'black box' from brain activity, but one could think of more obvious physical indicators of the way in which people reason. Previous research in game theory and decision making used information about the way in which subjects respond to game situations in order to draw conclusions about their deliberation algorithm. In particular, see Camerer *et al.* (1993) who used the order of mouse clicks to demonstrate that people analyse an extensive game forwards rather than backwards as implicitly assumed by standard game theoretical solution concepts.

The basic idea of the current research project is to explore the deliberation process of decision makers based on their response times. Measuring response time is quite common in psychology; see for example Luce (1986) and Kosinski (2005). In simple time response experiments, there is only one stimulus and response time is measured from the moment of its introduction. In symbol or tone recognition, the subject responds when he recognises a certain stimulus from among a set of symbols which appear before him. In choice experiments, the subject chooses the correct response to a given stimulus. Experiments typically employ 20 people performing a task 100–200 times. The unit of time response in these experiments is milliseconds and the typical response time is less than one second.

Very few experimental papers in game theory have reported responses times; one exception is Wilcox (1993). The problem with measuring response time in economic decisions is the huge variation in results. Most experiments in economics and game theory are done with small samples; for an exception, see Guth *et al.* (2003). Measuring time response using such samples is meaningless. It is a rare opportunity when a large population becomes available.

Such an opportunity presented itself with the inauguration of the site http://game-theory.tau.ac.il which I built together with Eli Zvuluny. The purpose of the site was 'to provide the teacher of a basic course in Game Theory with a free user-friendly didactic tool for conducting web-based thought experiments'. Teachers assign their students 'pre-class' problems that involve virtual games; see Rubinstein (1999) for a description of the teaching method used by the site. The site was launched in January 2001. Since then, almost 100 teachers from 25 countries have actively used it. Most of the users are from departments of economics although some are from computer science, political science, business or law. Almost 5,000 students have participated in at least one experiment. Most of the students respond in English but a few respond in Finnish, French, Portuguese, Russian, Slovak or Spanish.

A few months after its launch, the site was modified in order to record the subject's response time (RT). *Response time* is defined here as the number of seconds between the moment that our server receives the request for a problem until the moment that an answer is returned to the server. Subjects were not informed that RT is being recorded.

A further opportunity to collect data on a large scale arose as part of a public lecture which I delivered nine times during the period May 2002–February 2004. The lecture, entitled 'John Nash, Beautiful Mind and Game Theory', described my personal encounter with John Nash, introduced the basic ideas of Game Theory together with a critique and discussed Nasar (1998) and the movie 'A Beautiful Mind'. The members of the audience (mostly students and faculty) were approached prior to the lecture and asked to respond to several questions via the site http://game-theory.tau.ac.il. Response time was recorded in seven of the universities: the Technion (Israel); Tilburg University (Netherlands); the London School of Economics (UK); the University of British Columbia and York University (Canada); Georgetown University (US); and Sabanci University (Turkey). About 2,500 subjects responded, thus creating a huge database.

In what follows, I present the more interesting results of the research. In most cases, there were huge differences in the time response distributions of the various choices made. Often one distribution lay completely to the right of another (first order stochastic domination) and I will interpret such a configuration as evidence that it requires more response time.

I will try to explain the differences by categorising the actions as either

(1) Cognitive: an action which involves a reasoning process,
(2) Instinctive: an action which involves instinct, or
(3) Reasonless: an action which is likely to be the outcome of a random process with little or no reasoning about the decision problem.

It is the claim of this article that choices which require more cognitive activity will result in longer response times than choices which involve an instinctive response.

The obvious question is how to classify an action as cognitive, instinctive or reasonless. I have done so intuitively. It will be seen below that when the classification is intuitively clear, the response time of an instinctive action is significantly shorter than that of a cognitive action. In some cases the classification is not as clear and large response time differences provide a hint as to which is the instinctive action.

I hope that at the very least the results will demonstrate the potential usefulness of time response as a means of shedding light on the decision process and game situations.

1. Results: Matrix Games

We begin with two examples of matrix games. In these two examples, the differentiation between instinctive and cognitive actions is self-evident. Due to the sample size the data verifies unambiguously what one would expect: cognitive actions do in fact involve longer response times than instinctive ones.

Example 1: A Zero Sum Game: (No.15 on the website)

Subjects were asked to play the following virtual matrix game (in the role of the row player) against an anonymous opponent:

	L	*R*
T	2,−2	0,0
B	0,0	1,−1

The question did not specify what the numbers mean. If the subjects interpret them as vNM utilities then the unique mixed strategy Nash equilibrium predicts that the action *T* will be chosen with probability 1/3. However, note that as long as the subjects prefer a higher payoff, Nash equilibrium predicts that the proportion of subjects who play *T* will be less than that who play *B*.

2,029 students in 54 courses responded to the question: 63% of them chose the action *T*, the one which Nash equilibrium predicts will be chosen less frequently.

As shown in Table 1 and Figure 1, the response time of those who chose *T* was shorter than those who chose *B*. The *median response time* (MRT) of the subjects choosing *B* was 50 seconds, which was much higher than the MRT for *T* which was only 37 seconds. The graph of the cumulative distribution of response time for those who chose *T* is clearly (first order) stochastically dominated by the corresponding graph for *B*.

Table 1

Example 1: Results

Total	$n = 2{,}029$	41 sec
Action	%	*median*
T	63	37 sec
B	37	50 sec

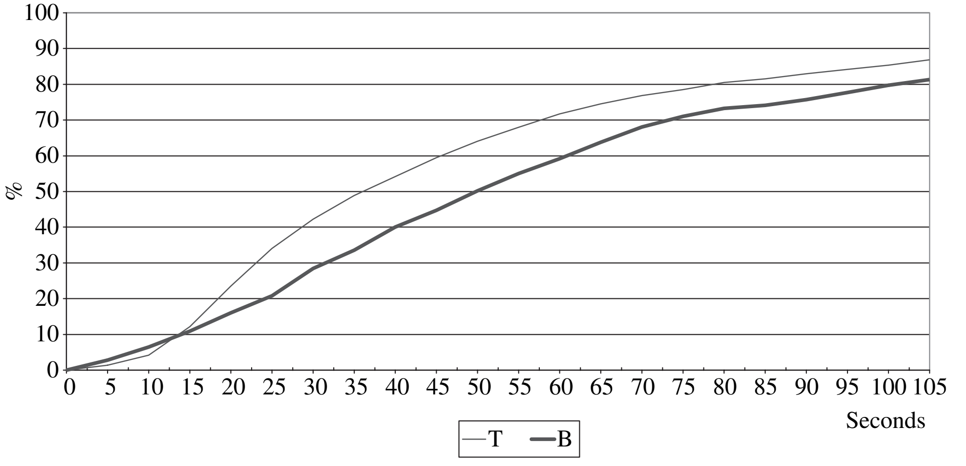

Fig. 1. *Example 1: Response Time Frequencies*

In this case it appears that *T* is the instinctive action since the player is triggered to go after the larger payoff. Playing *B*, the action predicted to be more common in Nash equilibrium, requires more reasoning. For example, it might result from the player's expectation that his opponent is not likely to play *T* in order to avoid the risk of a large loss and thus it is better for him to play *B*.

Example 2: Successive Elimination of Strategies (No. 4 on the website)

Subjects were asked to play the following two-player game as the row player:

□	*A*	*B*	*C*	*D*
A	5,2	2,6	1,4	0,4
B	0,0	3,2	2,1	1,1
C	7,0	2,2	1,5	5,1
D	9,5	1,3	0,2	4,8

Table 2

Example 2: Results

Total	100	2,543	96 *sec*
Action	*%*	*number*	*median*
A	3	82	64 *sec*
B	32	822	161 *sec*
C	33	843	76 *sec*
D	31	796	83 *sec*

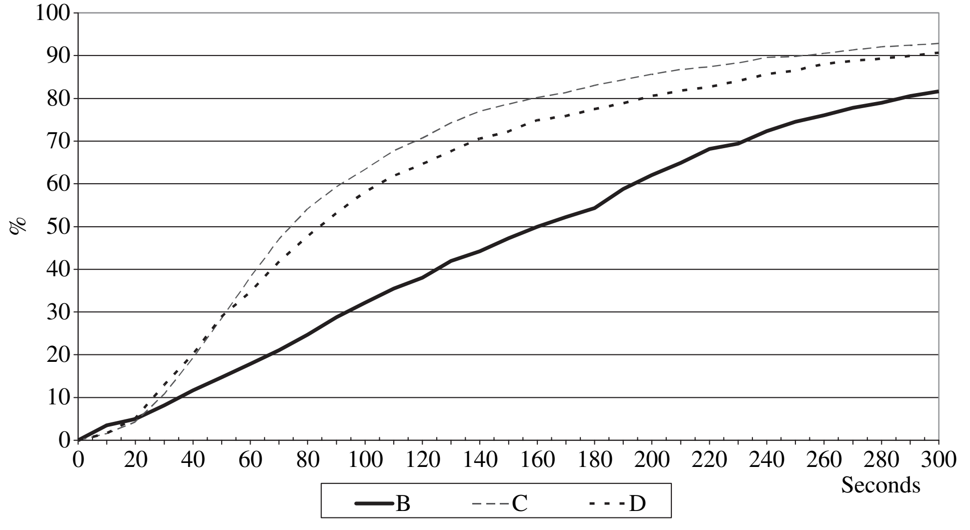

Fig. 2. *Example 2: Response Time Frequencies*

The sample included 2,543 subjects in 76 courses and the results are summarised in Table 2 and Figure 2. The response time of *A* is very low though the small number of subjects who chose *A* makes it difficult to draw conclusions in this case. Each of the other three choices was selected by about 800 subjects. It appears that the action *B* required about double the time of actions *C* and *D*.

In this case, I would identify the instinctive responses as *C* and *D* – the action *D* because it contains '9' which is the highest payoff in the matrix and the action *C* because the average payoff for the row is the highest in the matrix. The weakly dominated action *A* seems to be reasonless. Some reasoning is needed to choose *B* which is the only survivor of successive elimination of strongly dominated strategies (the elimination order is $2A$, $1A + D$, $2D$, $1C$, $2C$). Thus, the action *B* appears to be the one which requires the most cognitive reasoning.

Note that *C* was chosen in somewhat less time than *D*. This casts doubt on the assumption made in the literature that subjects follow only a few steps of the successive elimination process. The action *D* is eliminated before *C* and thus one expects the RT for *D* to be below that of *C* which in fact was not the case.

2. The Traveller's Dilemma, the Beauty Contest and the Centipede Game

The six examples presented in Sections 2–4 are of a slightly different nature than the above two examples and involve a certain amount of 'reverse engineering'. In these examples, the classification into cognitive and instinctive is not *a priori* as self-evident as in examples 1 and 2. Given that cognitive actions involve longer response times, one interpretation of the results enables us to classify actions as cognitive or instinctive based on the observed response times.

In this Section, I discuss the results of three problems which are often used to demonstrate the tension between clear-cut game theoretic analysis based on serial inductive thinking and the vagaries of actual behaviour.

Example 3. The Traveller's Dilemma (No.53 on the website)

Imagine you are one of the players in the following two-player game:

- *Each of the players chooses an amount between $180 and $300.*
- *Both players are paid the lower of the two chosen amounts.*
- *Five dollars are transferred from the player who chose the larger amount to the player who chose the smaller one.*
- *In the case that both players choose the same amount, they both receive that amount and no transfer is made.*

What is your choice?

This game was suggested in Basu (1994). Assuming that the players care only about their final dollar payoff, the only equilibrium strategy in this game is 180. Table 3 and Figure 3 summarise the choices of 2,985 individuals who attended the Nash lectures and 1,573 students in various courses. Note that the distribution of answers is similar to that of the 50 answers reported in Goeree and Holt (2001) for experiments with real payoffs.

Table 3

Example 3: Results

	Goeheree and Holt	*Nash Lectures*	*MRT*	*Courses*	*MRT*
n	50	2985	77 *sec*	1,573	88 *sec*
180	8%	13%	87 *sec*	20%	99 *sec*
181–294	18%	14%	70 *sec*	17%	79 *sec*
295–299	24%	17%	96 *sec*	16%	118 *sec*
300	50%	55%	72 *sec*	46%	80 *sec*

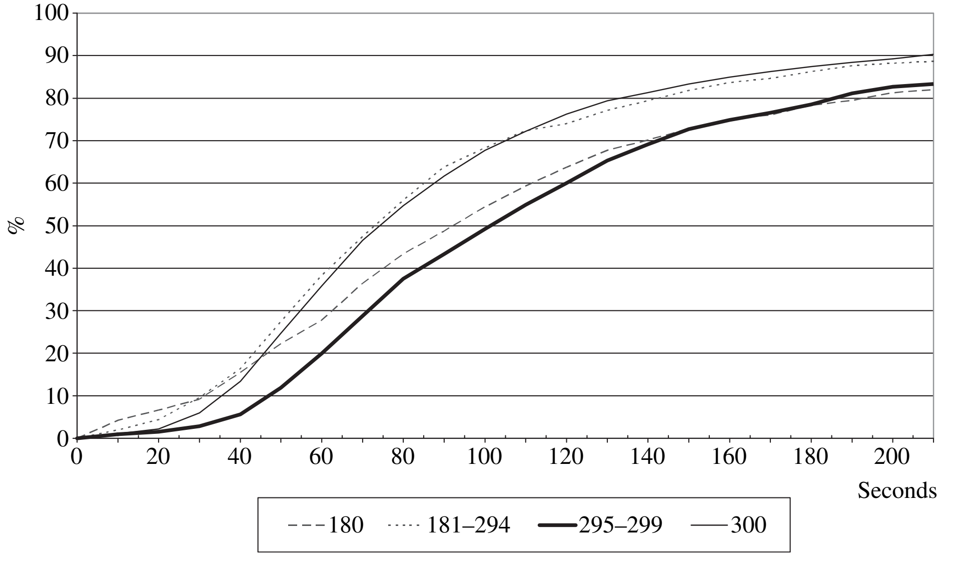

Fig. 3. *Example 3: Response Time Frequencies*

Strikingly, the response time for the range 295–299 is the longest while the response times for 300 and the range 181–294 were the shortest.

The response 300 seems to be the instinctive action while the choices involving more cognitive reasoning are in the range 295–299 (following an argument of the type 'he will choose 300 and therefore I will choose 299' or 'he will choose 299 and therefore I will choose 298' etc.). The answers 181–294 appear to be arbitrary and are probably the result of a random 'pick a number' algorithm. The classification of the Nash equilibrium action, i.e. 180, is more difficult. For some it might have been the outcome of a non-trivial reasoning process while for others it might have been the result of prior knowledge of the game.

Note that the results for the Nash lecture audiences differ from those of the students. Students tended to choose the 'game theoretic solution' more often. Furthermore, distributions of the response time differ between the two groups. However, what is relevant for our purposes is the relative magnitudes of the time responses which are in fact similar in both populations. Thus, the actions which seem to require the most cognitive reasoning, i.e. those in the range 295–299, clearly have the longest RT. The instinctive response of 300 has a similar time response distribution to that of responses in the range 181–194 which appears to be the result of 'pick a number'. The Nash equilibrium response of 180 lies between the cognitive response and the instinctive response. This is probably because some of the respondents calculated the equilibrium while others acted according to what they remembered from a course on game theory.

Example 4: The Beauty Contest Game (No. 1 on the website)

Each of the students in your class must choose an integer between 0 and 100 in order to guess '2/3 of the average of the responses given by all students in the class'.

Each student who guesses 2/3 of the average of all responses rounded up to the nearest integer, will receive a prize to be announced by your teacher (or alternatively will have the satisfaction of being right!).

What is your guess?

The Beauty Contest Game is another in which the depth of reasoning is thought to be the source of differences in behaviour. Successive elimination of dominated strategies eliminates all actions other than 0 or 1 and combinations of these two actions are consistent with the game's Nash equilibria. The game has been heavily experimented; see, for example, Nagel (1995). The average guess of 2,423 subjects in 66 courses was 36.2 which is very close to the number Nagel obtained.

I divide the results into three categories: Category *A* consists of the responses 33–34 and 22 (which is close to $2/3 \times 2/3 \times 50$) which seem to be the result of a clear process of reasoning such as: 'The average will be 50 and therefore I will choose a number close to $2/3 \times 50 = 33.3$' or an iteration of this argument. Category *C* consists of responses of 50 or more which seem to indicate a misunderstanding of the game. Category *B* consists of the 'victims of Game Theory' who chose the Nash equilibrium and the subjects whose strategy was to give the best response to a wild guess.

The results are summarised in Table 4 and Figure 4. Clearly those who chose an action in Category *A* thought for a longer time than the others. Those who made choices in Category *C* thought for a much shorter time.

Table 4

Example 4: Results

		n = 2,423	0–1	2–13	14–15	16–21	22	23–32	33–34	35–49	50	51–100
		86 *sec*	11% 269	9% 213	2% 47	6% 137	4% 99	10% 249	11% 262	11% 267	16% 393	20% 487
A	15%	126 *sec*					157 *sec*		113 *sec*			
B	49%	89 *sec*	91 *sec*	89 *sec*	84 *sec*	82 *sec*		84 *sec*		94 *sec*		
C	36%	70 *sec*									70 *sec*	70 *sec*

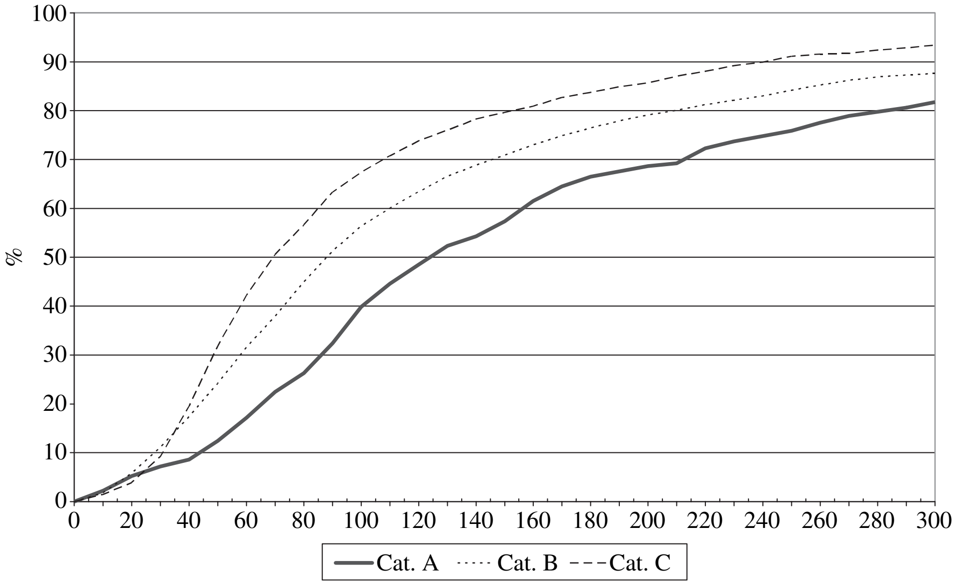

Fig. 4. *Example 4: Response Time Frequencies*

The results cast doubt on the classification used by Nagel and others whereby the whole range of 20–25 is classified as one group. In my data, the MRT of the 4% who chose 22 was 157 seconds while the MRT among the 8% who chose 20, 21, 23, 24 or 25 was only 80 seconds. This must mean that there is little in common between the choice of 22 and the rest of the category which Nagel called 'Step 2'.

Example 5: The Centipede Game (No.33 on the website)

You are playing the following 'game' with an anonymous person. Each of the players has 'an account' with an initial balance of $0. At each stage, one of the players (in alternating order – you start) has the right to stop the game.

If it is your turn to stop the game and you choose not to, your account is debited by $1 and your opponent's is credited by $3.

Each time your opponent has the opportunity to stop the game and chooses not to, your account is credited by $3 and his is debited by $1.

If both players choose not to stop the game for 100 turns, the game ends and each player receives the balance in his account (which is $200; check this in order to verify that you understand the game).

At which turn (between 1 and 100) do you plan to stop the game? (If you plan not to stop the game at any point write 101).

The Centipede Game is another prime example of the tension between Nash equilibrium and the way in which games are actually played. Assuming that the players care only about the amount in their own account, the only Nash equilibrium strategy for player 1 is to stop the game at turn 1. However, this is a highly unintuitive action. The response 101 seems to be the instinctive one. The cognitive actions are in the upper range of the responses (98, 99, 100). A choice in the range 2–97 seems to be a reasonless one.

The results in Table 5 and Figure 5 once again appear to demonstrate a correlation between time response and whether a choice is cognitive, instinctive or reasonless.

3. The Ultimatum Game

Following Guth *et al.* (1982), a great deal of experimental work in game theory has been done on the Ultimatum Game:

Example 6. The Ultimatum Game – the Proposer (No. 23 on the website)

Imagine that you and a person you do not know are to share $100.

You must make an offer as to how to split the $100 between the two of you and he must either accept or reject your offer. In the case that he rejects the offer, neither of you will get anything.

What is your offer?

I offer the following amount to the other person (if he agrees I will get the rest):____

It is customary to assume that each player is only interested in attaining as much money as possible. Applying the Subgame Perfect Equilibrium concept, game theory 'predicts' that the proposer will offer either $1 or nothing to the responder who will accept the offer. Of course, this is unrealistic. In real life, the proposer often cares about the amount of money he offers to the other player, perhaps due to feelings of guilt for exploiting his preferred status or perhaps out of fear that the responder might be insulted by too low an offer and prefer to get nothing rather than agreeing to an 'insultingly low offer'.

The distribution of responses across the nine Nash lecture audiences was quite uniform (and demonstrated some systematic gender differences according to which females made higher offers on average). The results for 3,202 subjects in six Nash

Table 5

Example 5: Results

$n = 1{,}361$	1	2–97	98–100	101
%	12	11	20	57
median	132 *sec*	80 *sec*	163 *sec*	123 *sec*

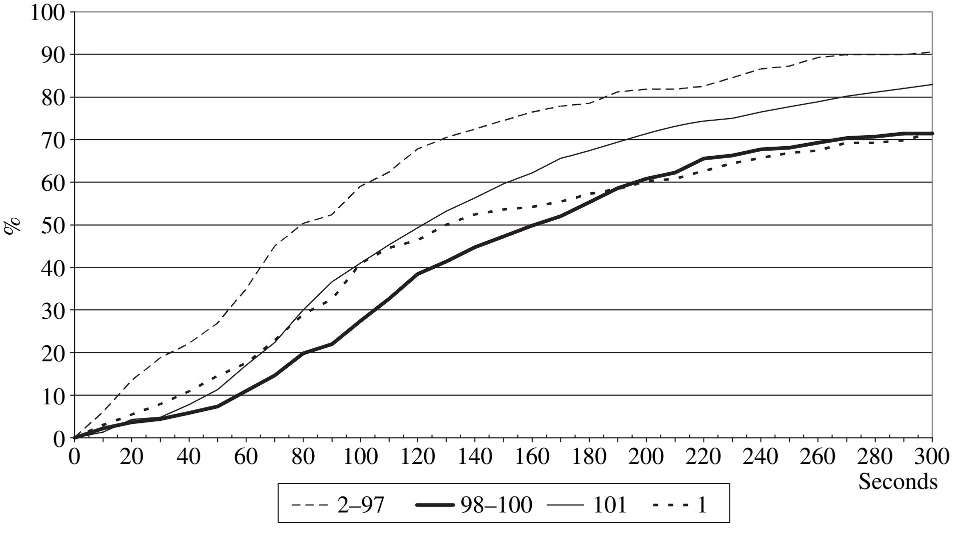

Fig. 5. *Example 5: Response Time Frequencies*

lectures are presented in Table 6 and Figure 6 alongside the statistics for the responses of 1,426 students in 46 courses:

In this case, distinguishing between the different actions is not straightforward. In particular, it is unclear whether the instinctive action in this case is the 50:50 split or the one in which the proposer demands almost the entire sum. We can look to response time for further clues. The MRT of those who offered less than $50 was 25% higher than of those who offered an equal split, thus supporting the hypothesis that the equal split is the instinctive action for many of the subjects.

There is a group of significant size within the Nash lecture audiences who offered the other player more than $50. The low MRT of those who offered 61 or more supports the view that these choices were the outcome of a misunderstanding of the question. However, the MRT of responses in the range 51–60 (55 seconds) was even higher than that of responses in the range 40–49 (51 seconds) and thus it is not clear whether these responses were intentional or an outcome of error.

Table 6
Example 6: Results

Answer	Nash Lectures	MRT	Courses	MRT
Total	$n = 3{,}202$	49 *sec*	$n = 1{,}426$	41 *sec*
0–1	15%	55 *sec*	15%	53 *sec*
2–25	9%	56 *sec*	8%	48 *sec*
26–49	11%	52 *sec*	16%	45 *sec*
50	47%	43 *sec*	44%	36 *sec*
51–60	11%	55 *sec*	8%	42 *sec*
61–100	8%	46 *sec*	9%	39 *sec*

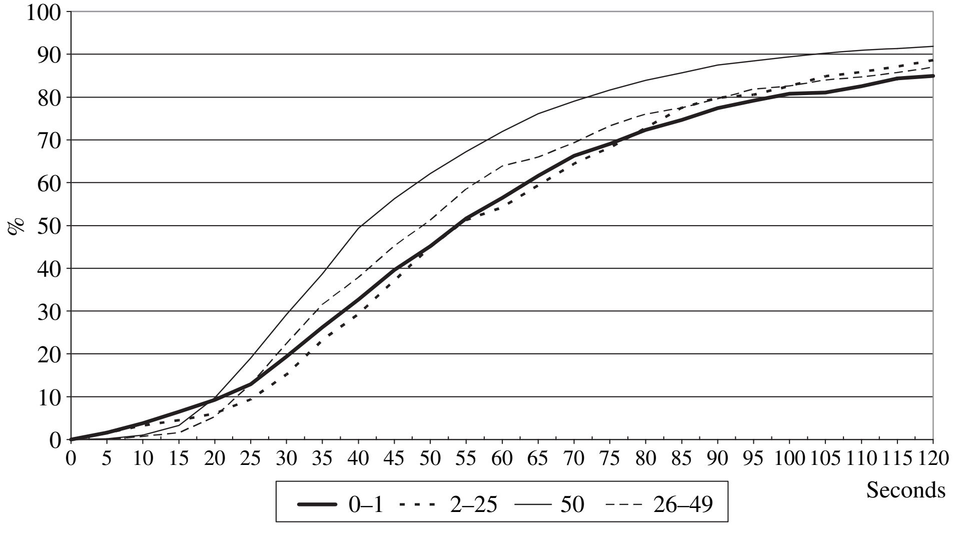

Fig. 6. *Example 6: Response Time Frequencies*

After responding to this question, Nash lecture audiences were asked to imagine that they are the responder in the Ultimatum Game who has been offered \$10 out of the \$100. Almost all the teachers also assigned the responder version following the proposer version.

Example 7. The Ultimatum Game: The Responder (No. 25 on the website)

You and someone you do not know are to share \$100. He makes you an offer and you can either accept it or reject it.

If you reject it, neither of you will get anything. He offers you \$10 (if you accept, he will get \$90). Do you accept the offer? Yes/No

A surprisingly high proportion of subjects, 63%, 'accepted' the offer. Remarkably, 95% of those who offered 0–10 in the previous question accepted the \$10 as opposed to only 53% of those who offered an equal split.

Is there a difference in response time between those who accepted and those who rejected the \$10? The RTs of 2,620 members of the audiences at the Technion, Tilburg, LSE, Georgetown, UBC and Sabanci universities were recorded in addition to those of 1,080 students in 33 courses. Remarkably, not only was the median of the two groups identical but, as Figure 7 shows, the RT distributions of those who accepted and those who rejected the offer were almost identical.

This result appears to conflict somewhat with the results reported by the fMRI experiments. Sanfey *et al.* (2003) attributed acceptance of the lower offer to the cognitive side of the brain while rejection was attributed to the emotional part of the brain. One would expect that the response time of those who accepted the low offer would therefore be higher; however, the distributions of those who accepted and those who rejected the offer are amazingly similar, which casts doubt on the conclusion reached from the fMRI results.

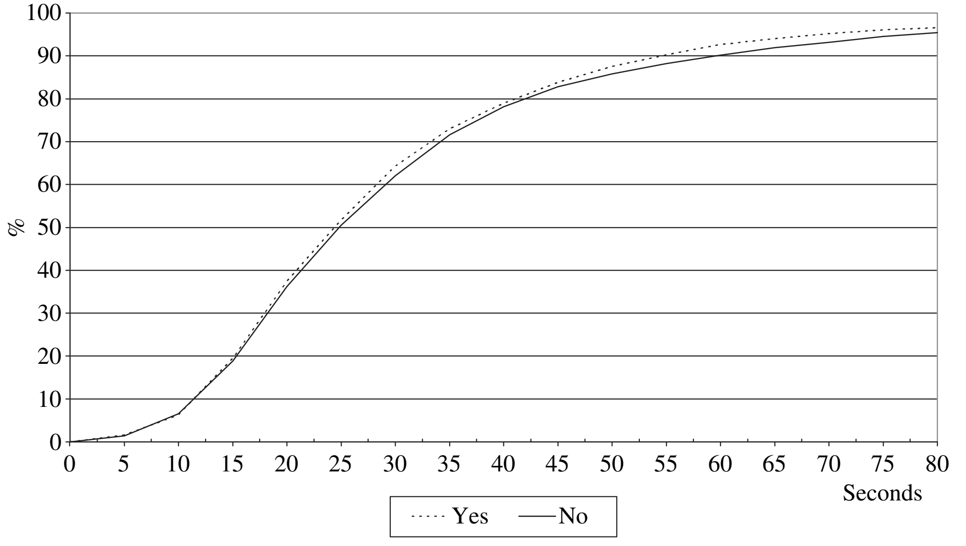

Fig. 7. *Example 7: Response Time Frequencies*

Table 7
Example 7: Results

Answer	Nash Lectures	MRT	Courses	MRT
	2,620	27	1,080	20
Yes	63%	27	62%	20
No	37%	27	38%	20

4. The Allais Paradox

The final example is a variant of the Allais Paradox taken from Kahneman and Tversky (1979). Subjects were asked to respond to two problems:

Example 8: The Allais Paradox (No. 39 and No. 40 on the website)
I

Imagine you have to choose one of the following two lotteries:
Lottery A yields \$4,000 *with probability* 0.2 *and* \$0 *with probability* 0.8.
Lottery B yields \$3,000 *with probability* 0.25 and \$0 *with probability* 0.75.
Which lottery would you choose?

II

Imagine you have to choose one of the following two lotteries:
Lottery C yields \$4,000 *with probability* 0.8 *and* \$0 *with probability* 0.2.
Lottery D yields \$3,000 *with probability 1.*
Which lottery would you choose?

Students in 31 courses responded to these problems and it was recommended that teachers present Problem I first and Problem II second. Participants in the Nash

Table 8

Example 8: Results

	Kahneman + Tversky	*Lecture Audience and Classes*	*MRT*
I	$n = 95$	$n = 1{,}258$	44 *sec*
$A = 0.2[4000] + 0.8[0]$	65%	62%	50 *sec*
$B = 0.25[3000] + 0.75[0]$	35%	38%	36 *sec*
II	$n = 95$	$n = 1{,}168$	23 *sec*
$C = 0.8[4000] + 0.2[0]$	20%	26%	32 *sec*
$D = [3000]$	80%	74%	20 *sec*

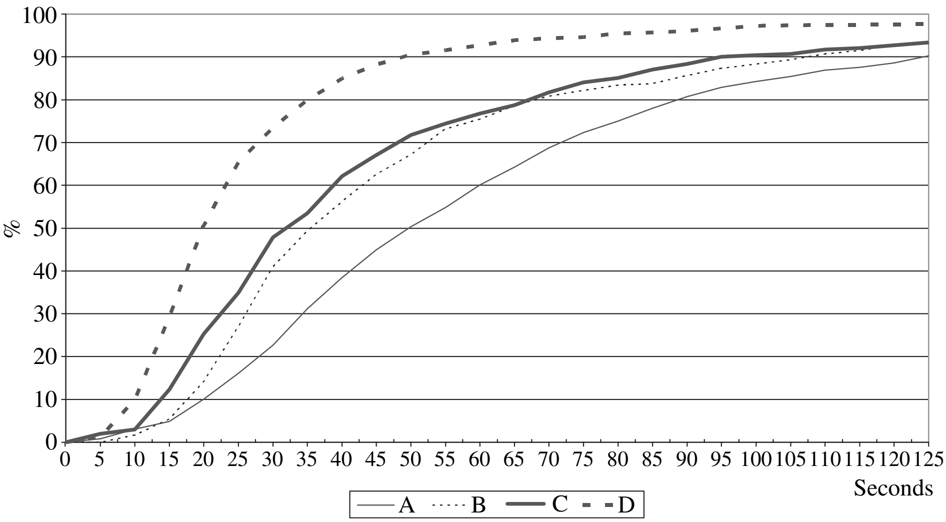

Fig. 8. *Example 8: Response Time Frequencies*

lecture in York University were also asked to respond to the two problems in this order but with several problems in between. The results for the Nash lecture audience and those for the students in the classes are presented together in Table 8 and in Figure 8. The results are very similar to the original results of Kahneman and Tversky (1979).

The choice of lottery *A* clearly requires more time than the choice of *B* as does the choice of *C* relative to *D*. The fact that the RTs of *C* and *D* are lower than those of *A* and *B* must be an outcome of the fact that Problem II was presented after Problem I so that the subjects were already familiar with the problem.

In Problem II, the sure prize of 3000 seems to be the instinctive response while the choice of the risky lottery 0.8[4000] + 0.8[0] requires calculation and deliberation. Thus, the distinction between instinctive and cognitive choices can explain the large differences in RT between the two choices.

In Problem I, the choice of 0.2[4000] + 0.2[0] is usually explained either by the comparison of the expectations or by the procedure – described in Rubinstein (1988) – in which the decision maker finds the probabilities to be similar and makes the choice according to the decisive difference in the size of the prizes. The choice of

0.25[3000] + 0.75[0] is more difficult to interpret. The differences in response time seem to indicate that the choice of 0.25[3000] + 0.75[0] was for many an outcome of reasonless choice.

5. Conclusion

I conclude by replying to potential criticisms of the approach suggested in this article.

(a) The method of data collection

The data are indeed very noisy and are blurred by the behaviour of subjects who 'choose' without serious deliberation. There are also differences in server speed. Furthermore, subjects differ in how fast they read and think. Indeed, this is the reason I do not advise conducting this kind of research using a sample of less than several thousand. Here, the magic of a large sample gives us a clear picture of the relative time responses.

A standard criticism of survey experiments is that in the absence of monetary rewards behaviour is less realistic. However, in my experience there is no significant difference between survey results and results in experiments with monetary rewards; see also Camerer and Hogarth (1999). In any case, we are not interested here in the absolute distribution of responses in real life problems (and note that even with real payments the experiment is still far from a real life situation), but only in the relative response times of the different choices. Thus, the absence of real rewards should not have any significant impact.

(b) Statistical tests

I believe that the results presented here are sufficiently persuasive that the performance of statistical tests would not have any value beyond paying taxes to the orthodoxy. It is true that for certain problems (not presented here) in which the results exhibited only slight differences in response time, statistical tests are needed. However, I doubt that the results of such tests would be of much interest unless the differences were large enough to make the tests redundant in any case.

With that said, I yielded to the pressure of readers of earlier drafts and conducted the standard Wilcoxon Two-Sample Test.

Experiment	*Pair*	*p*−*value*
Zero Sum Game (No. 15)	*T,B*	3.6×10^{-11}
Successive Elimination of Strategies (No. 4)	*B,C*	8×10^{-39}
The Traveller's Dilemma (No. 53)	295–9,300	1.3×10^{-23}
Guess 2/3 of the Average (No. 1)	*A,B*	2.8×10^{-9}
	B,C	2.6×10^{-8}
Centipede Game (No. 33)	101,98–100	6.1×10^{-5}
	98–100,2–97	3.9×10^{-12}
The Ultimatum game (No. 23)	50,0−1	4.3×10^{-16}
The Ultimatum Game: A Responder (No. 25)	*Y,N*	2.9×10^{-2}
The Allais Paradox (No. 39 and No. 40)	*A,B*	4.4×10^{-10}
	C,D	6.3×10^{-20}

(c) The distinction between intuitive and cognitive choices

As mentioned earlier, the classification of choices was done intuitively. An alternative and more formal approach would be to base classification on other sources of information such as the results of a survey in which subjects were asked whether they consider a choice to be instinctive or not. Of course, such an approach would have its own deficiencies. In any case, the distinction between intuitive and cognitive responses was used here only as a suggestive explanation for the huge differences in time response between actions.

Overall, I believe that the methodology used in this article is a cheap and incisive tool for understanding the process of reasoning involved in classical economic decision problems. Furthermore, the results appear to be more clear-cut and less speculative than those obtained recently by fMRI studies.

Tel Aviv University and New York University

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