Fairness Motivations and Procedures of Choice between Lotteries as Revealed through Eye Movements

Amos Arieli
Department of Neurobiology, the Weizmann Institute of Science

Yaniv Ben-Ami
School of Economics, Tel Aviv University

Ariel Rubinstein
University of Tel Aviv Cafés,
School of Economics, Tel Aviv University and
Department of Economics, New York University

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Abstract:
Eye tracking is used to investigate decision makers' motivations and procedures in choice problems. Patterns of eye movements in problems where the deliberation process is easily discernable are used to understand the deliberation in other problems. We find that in problems which involve the distribution of income between the participant and another individual, participants who behave selfishly nevertheless take into consideration the size of the payment to the other person. In problems that involve choice between two simple lotteries, eye movements indicate that many participants based their decision on a comparison of prizes and probabilities rather than making an expected utility calculation.

Key-words: Neuroeconomics, Eye-tracking, Decision Making, Similarity.

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1. Introduction

Neuroeconomics is a relatively new field in which researchers utilize information created non-intentionally by decision makers in order to learn about the decision-making process in economic problems. The types of information used in Neuroeconomics include neural activity in the brain (as manifested in hemodynamic response and measured by fMRI), eye movements (as recorded by an eye tracker) and response time. The deliberation process and motivations of decision makers are of interest in and of themselves. Neuroeconomics aims that its experimental results will be the base for formalization of reasonable assumptions for models that involve procedural and behavioral elements of decision making. Whether research in Neuroeconomics is indeed capable of making a fundamental contribution to Economics is currently a subject of intense debate which will not be discussed here (see the articles in Caplin and Schotter (2008) and the special issue of Economics and Philosophy (2008)).

In this study, we chose to focus exclusively on eye tracking since it provides information that is relatively easy to interpret, even without knowledge about the structure and function of the brain. Previous work that used eye movements to study decision making was carried out already in the 70s[1] and also in recent years.[2] Other methods of tracking decision makers' deliberations are also available. For example, in MouseLab information is hidden behind boxes on the computer screen and the participant accesses the information by moving the cursor over the boxes (see Payne et al. (1993) and http://www.mouselabweb.org). The two methods are compared in the conclusion section.

The research strategy is as follows: In the first stage, we analyse the eye movements of decision makers in "base cases", in which the deliberation process is straightforward. The base

[1] Early studies include Russo and Rosen (1975), which studied multi-alternative choice, and Russo and Dosher (1983), which investigated multi-attribute binary choice and concluded that feature-by-feature comparisons make up much of the decision procedure.

[2] Recent papers include Wang et al. (2006), which found that senders in a sender-receiver game look much more on their own payoff and that their pupils tend to dilate when sending false messages, and Reutskaja et al. (2008) which found that when selecting among snack foods under extreme time pressure and option overload participants execute a relatively efficient search procedure.

cases are used to verify that the eye movements reflect the deliberation procedure in the way that we assume. The second stage involves "test cases", in which the choice process is difficult to discern. In this stage, we compare the participants' eye movements in the test cases to those in the base cases. When the pattern of eye movements in the test case resembles what was observed in one of the base cases, we conclude that the choice procedure used was similar to that used in the base case.

This strategy is applied to two research questions. The first involves choice between two payment schemes, each of which specifies two amounts of money -- one to be paid to the participant and the other to an anonymous individual. We are interested in investigating whether people who make the "selfish" choice, i.e. the scheme in which they receive the higher payment, are being purely selfish or have arrived at the selfish decision after considering the effect of their choice on the size of the payment to the other individual.

The second research question involves choice between simple lotteries, each described by an amount of money and a probability of obtaining it. We attempt to determine whether decision makers evaluate each of the alternatives separately -- a choice strategy that is likely to be consistent with expected utility maximization -- or whether the decision is reached by comparing prizes and probabilities separately.

Note that we are not interested here in the participants' final decisions, per se. Gathering data on behavior and judgment can be done more effectively by using standard experimental techniques with a much larger and diverse sample. Our focus is on using information on choice and eye movements to understand processes that are difficult to track using other methods.

2. Method

Participants were asked to respond to a sequence of simple virtual choice problems. In each problem, a participant was asked to choose between pairs of alternatives labeled Left (L) and Right (R). Each decision problem was presented on a unique screen (Figure 1), in which the two parameters that describe the L alternative, a and b, appear in the upper and lower left-hand parts of the screen and the two parameters that characterize the *R* alternative, *c* and *d*, appear in the upper and lower right-hand parts of the screen. A solid line separates the two sides of the screen.

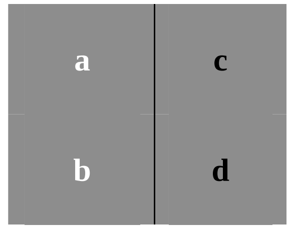

Figure 1: Schematic representation of the screen shown to the participants.

The problems used in the study (numbered here according to their order of appearance) were of the following types:

(1) Sums: The parameters are integers. The question is "Which is the larger sum: *a*+*b* or *c*+*d*?".

(2) Differences: The parameters are integers. The question is "Which difference is larger: *a*–*b* or *c*–*d*?".

(3) Risk preferences: The parameters *a* and *c* are dollar amounts while *b* and *d* are probabilities. The question is "Which lottery would you choose: $*a* with probability *b* or $*c* with probability *d*?".

(4) Time preferences: The parameters *a* and *c* are dollar amounts and *b* and *d* are dates. The question is "Which would you prefer: to receive $*a* at time *b* or $*c* at time *d*?".

(5) Social preferences: The participant was asked to imagine that he and another hypothetical student had completed a task together, with equal effort invested by each of them, and that he is to choose between two compensation schemes.[3] The parameters are dollar amounts. The question is "Which scheme would you choose: $*a* for you and $*b* for the other student or $*c* for you and $*d* for the other student?".

The choice was made by clicking on either the left or the right mouse buttons. No time restrictions were imposed on the participants. A typical median response time was eight seconds.

[3] The participant was told that he does not know the other student, that he will never meet him again and that the other student will never know what the participant's compensation was or that he had chosen between two schemes.

The 47 participants[4] were paid a show-up fee which was equivalent to about $12; there were no further rewards during the experiment.

We continuously recorded the point of gaze (i.e. where the person is looking).[5] Figure 2 provides examples of the eye movement paths for four participants who were comparing differences (251–222 vs. 187–153).

Analyzing the huge amount of recorded data was not straightforward. Our first approach was to transform the data into movies showing the path of eye movement on the screen. Our hope was that the choice procedure would be evident from the movies. However, there were only a few such cases (an example can be watched at http://arielrubinstein.tau.ac.il/ABR09/).[6] Rather, a diversity of transition sequences was observed and in general it was difficult to interpret the eye movements on the level of the individual. Therefore, we turned to analyzing the aggregated data.

Our analysis was based on the path of the participant's gaze between the different parts of the screen. The screen was divided into four sections: Top Left, Top Right, Bottom Left and Bottom Right. Eye movements between two sections were classified into one of six categories: Left-Vertical, Right-Vertical, Top-Horizontal, Bottom-Horizontal, Descending-Diagonal and Ascending-Diagonal.

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[4] The participants (24 males and 23 females; average age of 27) all had normal or corrected-to-normal vision and were students (in fields other than economics) at the Weizmann Institute and the Faculty of Agriculture of the Hebrew University, which are both in Rehovot, Israel. An informed consent form was obtained from all the participants, in accordance with the approved Declaration of Helsinki for this project.

[5] We used a high-speed eye-tracking system (iView) made by SensoMotoric Instruments (SMI). The iView system is based on an infrared light camera (thus enabling recordings to be made in complete darkness). It captures (at a sampling frequency of 240Hz or one sample every 4.2 milliseconds) a high-resolution image of the pupil and corneal reflection. The recorded data is used to compute the absolute gaze position in terms of screen coordinates. The few observations in which the absolute gaze position was not identified by the eye tracker for more than 20% of the total time until the participant responded were omitted from the analysis.

[6] The participant in this case was asked to compare $a+b$ to $c+d$. It is clear that at first he tried to calculate $d–b$ and $a–c$ using horizontal eye movements; at some point he realized that the answer can be derived more easily by comparing $d–a$ to $b–c$, which requires diagonal eye movements.

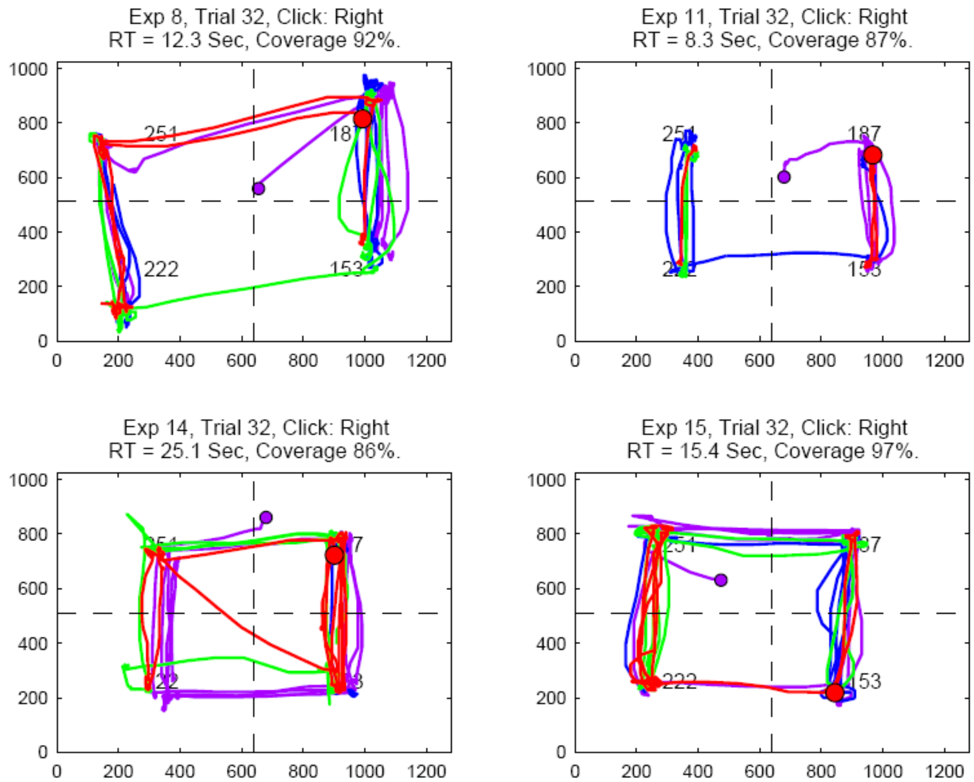

Figure 2: Eye movements of four participants while solving problem #32, in which they compared differences (251–222 vs. 187–153). The time sequence is divided into four equal segments and the order indicated by color: purple → blue → green → red. The purple and red dots indicate eye position at the beginning and end of the process, respectively.

For each problem and each participant, we calculated the proportion of time spent in each of the six types of eye movements. We noticed that participants tend to gaze at the option they chose just before they click on the mouse and therefore we omitted the last half-second of every observation. We also omitted any period for which the eye tracker did not identify the eye position, which was usually the result of blinking. Finally, in order to enable identification of diagonal movements, which always pass briefly through another section of the screen, we omitted any period in which the participant's gaze did not stay in a particular section for at least 50 msec.[7]

[7] 50 msec was found to be effective in distinguishing between eye fixation and an eye movement passing through a section of the screen without stopping.

We calculated the proportion of time spent by a participant in responding to a certain problem in each of the six eye movements as follows:

(i) Let *0* be the point in time at which the problem is first presented and *T* be the point in time at which the participant clicked on the mouse.

(ii) Denote the transition times between sections of the screen by: $t_1, t_2, \ldots, t_k, \ldots, t_n$.

(iii) The segment of time $[0,T\text{-}0.5]$ is divided into *n* intervals:

$[0, (t_1 + t_2)/2]$, $[(t_1 + t_2)/2, (t_2 + t_3)/2]$, ……,$[(t_{n-1} + t_n)/2,T\text{-}0.5]$. The duration of the *k*'th interval (k=1,..,n) is credited to the total for the eye movement that occurred at time t_k.

(iv) By dividing the time credited to each category of eye movement by the total of all the eye movements, we obtain the MTP (Movement-Time-Proportion) vector consisting of six numbers representing the proportion of time spent in each movement.

(v) We averaged the MTPs over all participants for each problem and denoted this vector of averages as α.

We also produced a similar vector for the number of transitions. In this case, each transition contributes a value of 1 to the corresponding eye movement total. Dividing by the total number of transitions, we obtain the MTC (Movement-Count-Proportion) vector and averaging over all participants we obtain a statistic we denote as β.[8] The two measures gave almost identical results, thus reducing the concern that the results were spurious.

In this approach, high α-values for the two vertical movements imply that participants' choices were based on holistic operations, which relate to each alternative as a separate entity. High α-values for the horizontal movements indicate that participants based their decisions on comparing each of the features of the alternatives separately.[9]

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[8] We added the β measure as a response to a potential criticism that α is sensitive to variation in the level of difficulty in understanding the question's parameters (e.g., if one of the parameters takes a long time to read, this will lengthen the duration of the movement into and out of that section of the screen).

[9] Russo and Rosen (1975) and Russo and Dosher (1983) based their analysis on counting movements from one section of the screen, X, to another, Y, and back to X. In contrast, we base our analysis on counting movements from X to Y even if there is no return to X. In problems where the response time is relatively long, the two …

3. Choice involving Social Preferences

The first part of the study consisted of problems involving social preference, in which the participant was asked to choose between two compensation schemes -- one appearing on the left of the screen and the other on the right. For each scheme the payment to the participant was shown in the Top section of the screen and the other student's payment was shown in the Bottom section.

Following are some considerations that might guide a decision maker's choice in such a problem:

"*Selfishness*": The participant cares only about his own compensation. This is likely to be manifested in mostly Top-Horizontal movements.

"*Fairness*": The participant cares about the distribution of income between him and the other student and prefers a more egalitarian distribution. This consideration will lead to vertical eye movements.

"Aversion to Getting Less": The participant is averse to getting less than the other student. This consideration should also lead to vertical eye movements.

"*Utilitarianism*": The participant wishes to maximize the combined income of the two students (or perhaps a weighted sum). This procedure can involve either vertical movements (when computing the sums) or horizontal movements (in determining whether his gain is greater than the other student's loss). A particular case of the Utilitarianism motivation is "*Domination"*, in which the participant prefers a scheme that provides more income for both him and the other student. Domination is expected to yield horizontal movements.

approaches yield the same qualitative results. In problems where the response time is relatively short, the former method does not yield sufficient data to make significant inferences.

Step 1: The base case

The base case for this part of the study is #77:

\$224 for you **\$224 for the other student**	**\$271 for you** **\$226 for the other student**

The only possible motivation for the choice of *L* in this problem is egalitarianism. The 36 participants who answered this problem were split evenly in their choices. Such preferences for an egalitarian outcome may seem unlikely but are in fact in line with recent findings on inequality aversion among non-economists (see Fehr et al. (2006)).

Figure 3 presents the eye movements for eight participants (four who chose *L* and four who chose *R*) for whom eye movements could be clearly interpreted. Such cases were however not common.

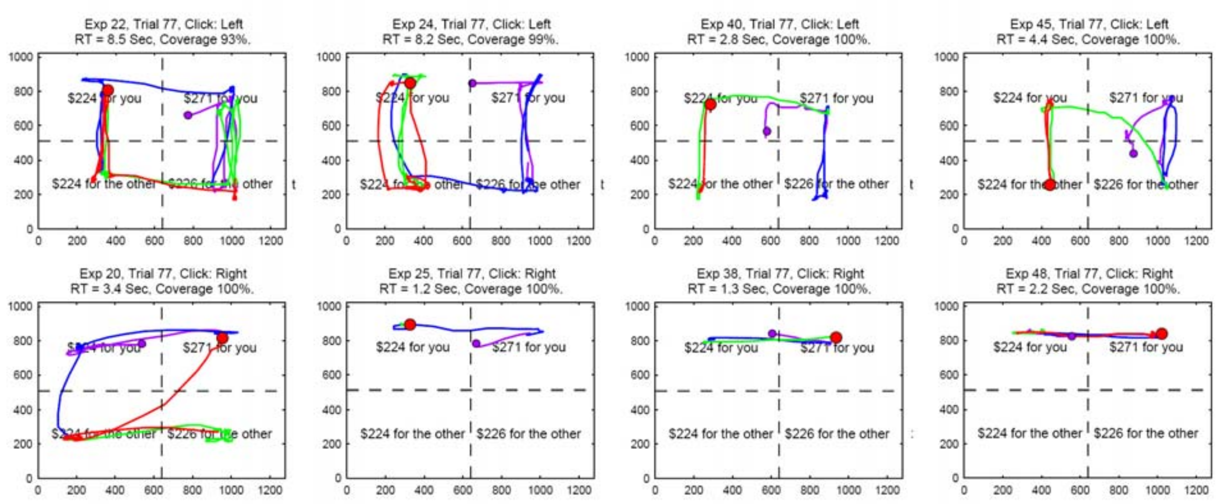


Figure 3: Eye movements for eight participants while responding to problem #77 (choosing between the compensation schemes \$224,\$224 and \$271,\$226): Top row: four participants who chose the "fair" option (*L*). Bottom row: four participants who chose the "selfish" option (*R*).

Table 1 presents the α-values (and in parenthesis the β-values) for the participants who chose *L* and for those who chose *R*. The information on diagonal movements was omitted since their proportion of the total was negligible.

Participants who chose *L* in #77			Participants who chose *R* in #77		
$224	19% (21%)	**$271**	**$224**	43% (42%)	**$271**
34% (34%) ↕	↔	↕ 34% (32%)	15% (16%) ↕	↔	↕ 26% (23%)
$224	7% (8%)	**$226**	**$224**	14% (15%)	**$226**

Table 1: α's (and β's) for participants who chose *L* and *R* in #77. Location within the cell corresponds to type of movement. Arrows are drawn such that their thickness is proportional to the α-values.

The α-values for the participants who chose *L* and for those who chose *R* are dramatically different.[10] The former spent 68% of their time in vertical movements. The latter spent 57% in horizontal movements, with most of that in Top-Horizontal movements, which is consistent with their choice of the selfish alternative.

Step 2: The test case

In the following two problems, the choice procedure is not easily determined.

In #73, 87% of the 38 participants chose *L* when presented with the following screen:

$91 for you	**$87 for you**
$82 for the other student	**$110 for the other student**

In #74, 76% of the 38 participants chose *L* when presented with the following screen:

$117 for you	**$89 for you**
$94 for the other student	**$98 for the other student**

The choice of *L* in #73 could be the result of selfish considerations, but could also be the result of fairness considerations. In #74, the fairer scheme is *R*. The choice of *L* could be the result of selfishness alone or of deliberation that also takes into account the other student's

[10] $P < 0.01$ on a Wilcoxon test.

compensation. Eye movements can provide a hint as to the participants' motivations in this case. Tables 2a and 2b present the α's for the participants who chose *L* in #73 and #74:

Participants who chose *L* in #73		
$91	24% (25%) ↔	**$87**
31% (32%) ↕		↕ 28% (27%)
$82	↔ 10% (11%)	**$110**

Table 2a: α's (β's in parentheses) for those who chose *L* in #73.

Participants who chose *L* in #74		
$117	23% (23%) ↔	**$89**
29% (30%) ↕		↕ 33% (31%)
$94	↔ 7% (8%)	**$98**

Table 2b: α's (β's in parentheses) for those who chose *L* in #74.

Step 3: Comparing the test case to the base case

There is a striking similarity between the eye movement patterns of those who chose *L* in #73 and #74 and those who chose *L* in #77. Therefore, one could infer that the considerations of those who chose *L* in both problems were not purely selfish.

Those who chose *L* in #73 may be exhibiting a preference for Fairness or Aversion to Getting Less. Those who chose *L* in #74 may be exhibiting Aversion to Getting Less or Utilitarianism. However, given the high proportion of vertical movements among those who chose *L* in #74, it seems unlikely that a large proportion of the participants were guided by Utilitarianism since they would have quickly noticed the horizontal differences and would not have needed to compute the vertical sums.

Step 4: More about the significance of the base case

Our analysis is based on the partition of the participants between those who chose *L* in #77 (denoted #77*L*) and those who chose *R* (denoted *#77R*). These two groups appear to have responded differently in other problems of this type. The time devoted to vertical movements by participants who chose *L* in #77 was consistently longer -- by 10%-25% -- than for those who chose *R* in *#77* (see Table 3).

Figure 4 clearly shows the difference in eye movements between the #77*L* and #77*R* groups. Each data point represents a participant and its color indicates his choice in #77 (blue for *L* and red for *R*). The position on the diagram indicates the proportion of time spent by the participant on horizontal and vertical movements. It is evident that members of #77*L* display patterns of deliberation that are systematically distinct from the patterns of members of #77*R* (i.e. the blue points tend to be above the red points).

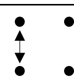
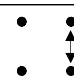
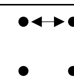
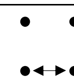
Types of Eye-Movements:										
#	*L*	*R*	#77*L*	#77*R*	#77*L*	#77*R*	#77*L*	#77*R*	#77*L*	#77*R*
73	\$91 \$82	\$87 \$110	34%	27%	30%	27%	22%	29%	8%	11%
74	\$117 ,\$94	\$89 \$98	31%	25%	37%	31%	19%	27%	7%	10%
75	\$231 \$231	\$234 \$278	32%	17%	41%	32%	13%	33%	7%	11%
76	\$85 \$170	\$93 \$141	21%	11%	34%	21%	24%	46%	13%	19%
77	\$224 \$224	\$271 \$226	34%	15%	34%	26%	19%	43%	7%	14%
78	\$155 \$60	\$136 \$78	23%	13%	29%	20%	31%	46%	12%	15%

Table 3: α's in all social preferences problems (#73-#78) for participants who chose *L* or *R* in #77.

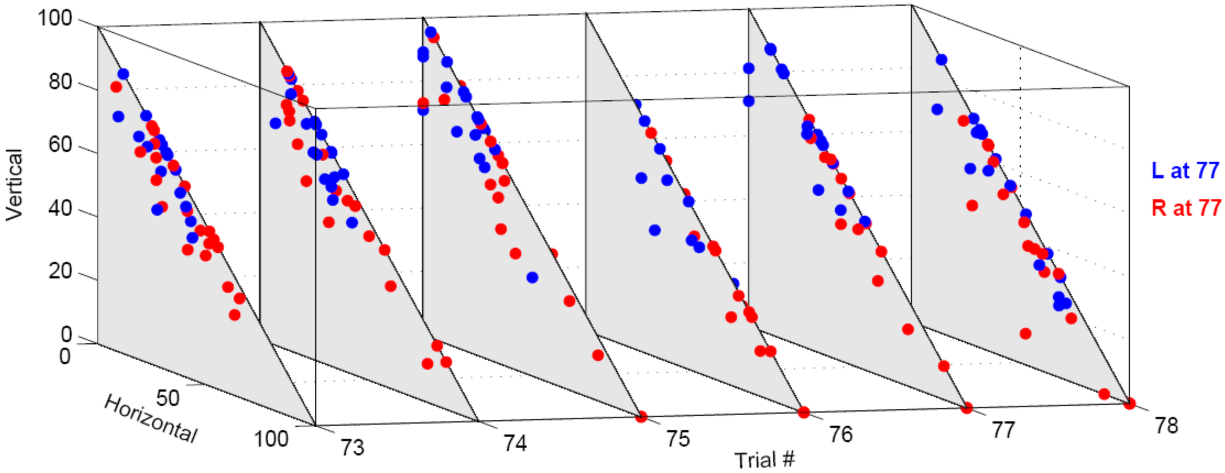


Figure 4: Proportions of horizontal and vertical movements in problems #73-#78

The two populations also differ in terms of behavior. Participants who chose *R* in #74 appear to give greater consideration to fairness. This alternative was chosen by 44% of the #77*L* group but by only 5% of the #77*R* group. The choice of *L* in #75 is also associated with fairness and was chosen by all of the #77*L* group but by only 38% of the #77*R* group. Similarly, in #78 all of the #77*L* group chose *R* vs. only 40% of the #77*R* group.

4. Choice Under Uncertainty

The second part of the study involves problems in which the participants were asked to choose between two simple lotteries:

$\$X_1$	**$\$X_2$**
With probability p_1	**With probability p_2**

Experiments involving such decision problems constitute the basis for much of the literature on decision making under uncertainty. One can postulate two main procedures used by decision makers who confront such a choice problem:

a) Computing the expected payoff (or the expectation of a transformation of the payoff) for each of the lotteries and then choosing the lottery with the higher expectation.[11] Applying such a procedure involves vertical eye movements.

b) Comparing the prizes and the probabilities separately. In the case that there is a conflict between the probability and prize dimensions, the choice is made according to which difference is perceived as more significant by the decision maker. In particular, if the decision maker detects similarity between the parameters in one dimension but not in the other, he will base his decision on the dimension lacking similarity (for a formal presentation of this procedure, see Rubinstein (1988)). Applying such a procedure involves horizontal eye movements.

A high proportion of vertical eye movements will be considered evidence that an expected payoff was calculated. A high proportion of horizontal eye movements will be taken to mean that prizes and probabilities were compared separately. In order to get some idea of the amount of time invested in each of these two main procedures, two base cases were analyzed:

Step 1: Base Case I

The first base case consisted of problems that involve the comparison of the difference between two numbers on the left side of the screen to the difference between two numbers on the right side (see Table 4).

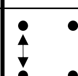
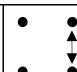
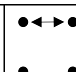
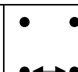
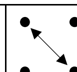
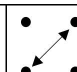
#	The differences		% of choices		α - values					
	$L = x_1 - y_1$	$R = x_2 - y_2$	%*L*	%*R*						
32	251 222	187 153	24%	76%	38%	44%	12%	4%	1%	0%
33	6132 4874	5793 4528	68%	32%	35%	37%	15%	10%	1%	2%
34	983462 718509	983501 718499	22%	78%	19%	21%	36%	19%	3%	2%

Table 4: α-values for #32-34.

[11] Some of the studies in the Neuroeconomics literature claim to have found evidence of such expected utility calculations in fMRI data (Glimcher et al. (2008)).

In #32, the most straightforward procedure involves actually computing the differences using vertical movements. Indeed, vertical movements accounted for 82% of the time spent on this problem. Problem #33 is not as simple and 68% of the participants chose the wrong answer (this is the only case in the experiment in which the majority of participants chose the wrong answer). The α of vertical movements declined to 72% since many participants used horizontal comparisons in an attempt to simplify the problem (though this computational route is not much easier). In #34, it is easier to answer the question by calculating the horizontal differences and as a result the share of vertical movements declined to 40%.

Figure 5 presents examples of two typical participants. Note that in #32 they used vertical movements almost exclusively while in #34 horizontal movements dominate. In #33, we observe a mixture of horizontal and vertical movements.

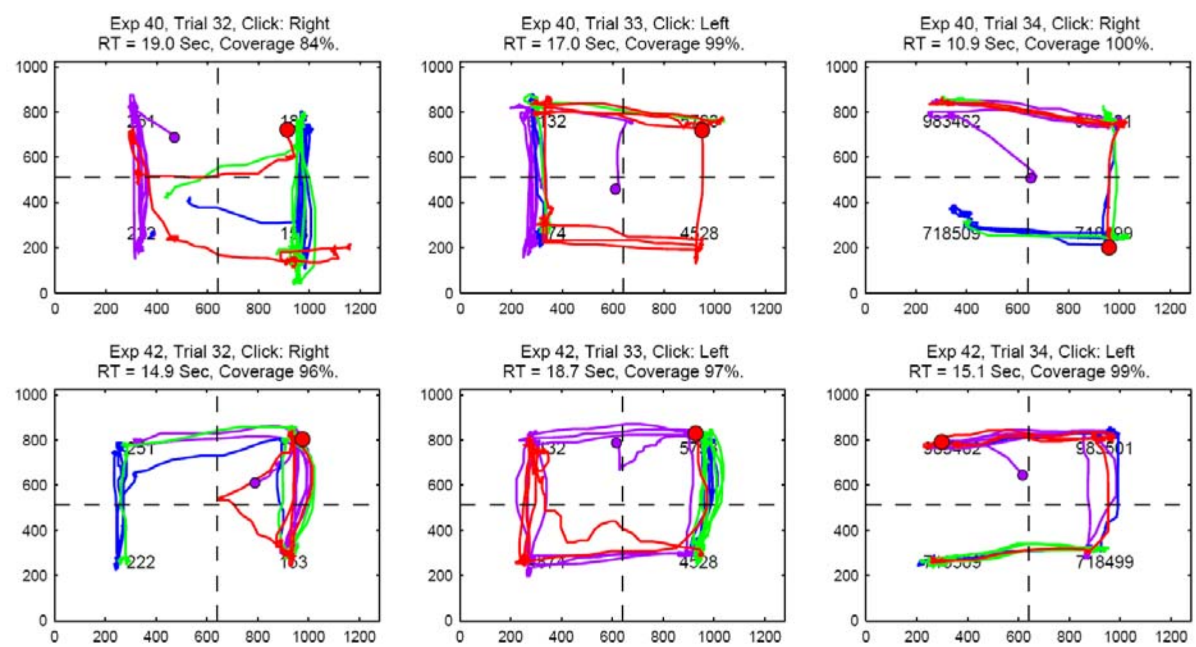


Figure 5: Eye movements for two participants (each row represents one participant) while responding to #32, #33 and #34.

Step 2: Base case II

The second base case consisted of problems that involve time preference. The participants were asked to choose between receiving a particular sum of money on a certain date and a different sum of money on a different date. Table 5 summarizes the data for three such problems.

In this case, it is hard to imagine that any of the participants were making "present-value-like" computations that require vertical movements. It seems clear that they based their decisions on the separate comparison of sums of money and delivery dates. Indeed, we find that 2/3 of eye movements were horizontal in these problems.

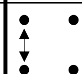
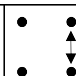
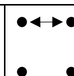
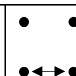
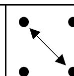
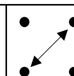
	The alternatives		% of choices		α - values					
#	***L* = (x_1,t_1)**	***R* = (x_2,t_2)**	%*L*	%*R*						
54	\$351.02 On 20-Jun-2009	\$348.23 On 12-Jul-2009	92%	8%	15%	16%	23%	40%	2%	4%
55	\$467.39 On 17-Dec-2009	\$467.00 On 16-Dec-2009	58%	42%	13%	13%	37%	30%	5%	2%
56	\$500.00 On 13-Jan-2009	\$508.00 On 13-Apr-2009	74%	26%	12%	15%	25%	44%	2%	2%

Table 5: α's for time preference problems. Experiments took place during June-September 2008.

Step 3: The test case

The test case involved problems of choice under uncertainty. The data is summarized in Table 6, where the shaded background indicates problems for which the α-values were relatively high.

Note that in problems where the calculation of the expectation appears to be relatively simple, the proportion of vertical movements was higher by about 10% than in problems where it was relatively difficult.

	The lotteries		% of choices		AMTPs					
#	***L* = (*x*₁,*p*₁)**	***R* = (*x*₂,*p*₂)**	%*L*	%*R*	↕	↕	↔	↔	↘	↙
36	($3000, 0.15)	($4000, 0.11)	60%	40%	**24%**	**22%**	19%	28%	4%	2%
37	($1700,0.4)	($1300,0.5)	51%	49%	**19%**	**26%**	25%	24%	4%	2%
38	($637,0.649)	($549,0.732)	41%	59%	16%	17%	**30%**	**30%**	2%	4%
39	($3000,0.9)	($4000,0.66)	97%	3%	18%	15%	**28%**	**31%**	4%	4%
40	($3100,1/5)	($1740,1/3)	51%	49%	17%	20%	26%	31%	3%	2%
41	($5283,0.27)	($5279,0.269)	92%	8%	13%	13%	**39%**	**31%**	2%	2%
42	($735,on a roll of 6)	($280,on a roll of even)	11%	89%	**21%**	**26%**	24%	22%	5%	2%
43	($5100,0.6)	($5825,0.8)	3%	97%	13%	24%	32%	22%	4%	4%
44	($13600,0.3)	($15500,0.2)	37%	63%	17%	18%	**34%**	**26%**	3%	2%
45	($6666,0.6)	($4444,0.8)	28%	72%	18%	23%	27%	26%	3%	3%

Table 6: α's for all participants in each lottery choice problem.

Step 4: Comparing the test case to the base cases

We now compare the eye-tracking data for the choice between lotteries (the test case) with data from Base Case I (comparison of differences) and Base Case II (time preference). The main features of the data can be seen in Tables 7a and 7b which present the eye-movement transition diagrams for problem #36 (choice between lotteries), #32 (comparison of differences) and #56 (time preference).

Participants who chose *L* in #36			Participants who chose *R* in #36		
$3000	20% (25%) ↔	**$4000**	**$3000**	17% (22%) ↔	**$4000**
28% (29%) ↕		↕ 19% (17%)	19% (19%) ↕		↕ 28% (27%)
P 0.15	↔ 26% (23%)	**P 0.11**	**P 0.15**	↔ 31% (26%)	**P 0.11**

Table 7a: AMTPs and AMTCs for participants who chose *L* and *R* in #36.

All participants in #32			All participants in #56		
251	12% (13%) ↔	**187**	**$500.00**	25% (32%) ↔	**$508.00**
38% (37%) ↕		↕ 44% (42%)	12% (13%) ↕		↕ 15% (16%)
222	↔ 4% (5%)	**153**	**On 13-Jan**	↔ 44% (34%)	**On 13-Apr**

Table 7b: AMTPs and AMTCs for all participants in #32 and #56.

Eye movements in the test case were not similar to those in either of the base cases and fell somewhere in between them. More generally, the average proportion of vertical movements in all of the problems in the test case ranged from 26-47% which is well below the proportions in #32 and #33.

The α-values in the choice of lotteries are most similar to those in #34 in which the participants made a complicated comparison of differences. However, the problem was structured in such a way that the answer is easily obtained by horizontal calculations (*a* is smaller than *c* and *b* is greater than *d*).

The fact that the eye movements in the choice of lotteries are most similar to those in #34 seem to indicate that when choosing between simple lotteries the participants usually relied on comparing prizes and probabilities separately. However, the proportion of time spent in horizontal movements in the lottery problems is less than in the problems of Base Case II, where it is clear that participants used a similarity-based procedure. It appears that although in lottery problems participants focus heavily on the comparison of prizes and probabilities, they do not employ a procedure that is purely similarity-based.

If account is also taken of the variation between the different problems of the test case, it appears that when the expectation calculation is relatively difficult participants use a similarity-based comparison; otherwise they use a mixture of the two procedures.

Step 5: Further evidence

Further evidence for the intensive use of the similarity-based procedure in the choice between lotteries was found through a separate group of problems in which participants again chose between two simple lotteries but in which the locations of the probability and dollar amount on the right side of the screen (*R*) were switched:

$\$X_1$	**With probability p_2**
With probability p_1	**$\$X_2$**

In all the problems presented up to this point, the α's of the diagonal movements were negligible (see Tables 4, 5 and 6). Diagonal movements are not normally characteristic of the stage in which a participant is simply absorbing the data and therefore, they appear only if they have some computational role. They did not have any such role in the test and base case problems and therefore are not observed. In contrast, diagonal movements were used, sometimes heavily, in the current set of problems (see Table 8), which indicates that the participants compared prizes to prizes and probabilities to probabilities.[12] Figure 6 presents typical eye movements for two participants responding to #49.

[12] We avoid comparing the intensity of the diagonal movements to that of the vertical or horizontal movements since this would require setting up a specially designed calibration which we did not do.

	The lotteries		% of choices		AMTPs					
#	***L* = (*x*₁,*p*₁)**	***R* = (*p*₂,*x*₂)**	%L	%R	↕ (left)	↕ (right)	↔ (top)	↔ (bottom)	↘	↙
47	$1400 0.6	0.8 $1000	28%	72%	24%	25%	23%	11%	**7%**	**5%**
48	$5000 0.96	0.66 $7000	94%	6%	26%	22%	20%	14%	**7%**	**11%**
49	$4947 0.640	0.638 $4952	61%	39%	16%	17%	12%	7%	**23%**	**25%**
50	$5000 0.16	0.11 $7000	57%	43%	21%	21%	14%	10%	**10%**	**24%**
51	$2468 0.26	0.53 $1234	6%	94%	19%	22%	16%	9%	**14%**	**20%**
52	$621 0.87	0.82 $652	68%	32%	17%	20%	13%	10%	**18%**	**22%**

Table 8: α's for all participants in the lottery choice problems with diagonal layout.

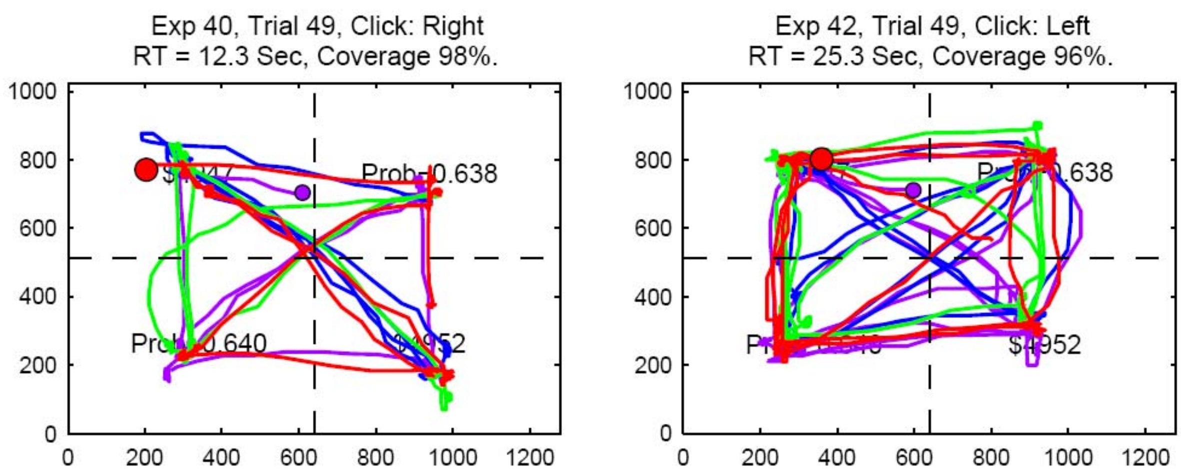


Figure 6: Eye movements of two participants (40 and 42) while solving problem #49.

5. Discussion

Our main findings can be summarized as follows: In social preference problems, when behavior can be interpreted as being motivated by either selfishness or social considerations, eye movements provided evidence that participants were not motivated solely by selfishness. In choice under uncertainty, evidence was found that participants make their choices based on comparing the prizes and the probabilities separately and that a greater degree of difficulty in computing the expectation of the lotteries reinforces this tendency.

There are three main alternative methods to approach the research question: 1) Observation of behavior: One could confront the participants with additional choice problems with the aim of exposing the motives behind their choices. There is an inherent difficulty with this approach in the context of the issues discussed in this paper. The social preferences part of our study was designed to determine whether participants who behave selfishly decide to do so after considering the social consequences or whether they care only about themselves. Obviously, behavior cannot shed light on this question. Similarly, the risk preference part of the study aims to determine whether subjects utilize an expected-utility-like calculation or a procedure based on similarity concepts. As shown in Rubinstein (1988), behavior that is consistent with a preference relation cannot distinguish between these two theories of choice.

2) MouseLab: This method has the advantage of being able to gather data on a large number of participants. Although MouseLab has some attractive features, it requires that the participant make a conscious decision at each stage with regard to the order in which he looks into the information boxes; in contrast, eye tracking is able to follow movements that are non-intentional. In addition, the need to move the mouse in MouseLab prolongs the decision making process and induces an unnaturally systematic information acquisition behavior (Lohse and Johnson, 1996).

3) Asking the subjects: A straightforward way of obtaining information is to simply ask participants what was going on in their mind during the decision-making process. However, it is well known that participants' answers are based on a subjective reconstruction of the experience that may or may not correlate with the actual process that took place (Nisbett and Wilson, 1977).

Overall, we find eye tracking to be an intuitive and relatively simple tool that can be used to study decision-making processes. Whether findings from studies such as ours will influence

Economic Theory remains to be seen, but in our opinion there are many problems on which the current method of research can shed light. One such an example has to do with a regularity we spotted in the data: Participants' eye movements were quite consistent in the various social preference problems, whereas in the risk preference problems we noticed a shift from vertical to horizontal movements when the calculation of the expectations became more difficult. Do people use a more consistent procedure when making decisions that have a moral component? Future eye-tracking research could perhaps help answer this question and others like it.

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