Are small groups expected utility?

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Are small groups Expected Utility?[♣]

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Abstract: In this paper we analyse the empirical performance of several preference functionals using individual and group data. Our investigation aims to address two fundamental questions that have, until now, not been addressed in literature. Specifically, we intend to assess if there exists a risky choice theory that statistically fits group decisions significantly better than alternative theories, and if there are significant differences between individual and group choices. Experimental findings reported in this paper provide answers to both questions showing that when risky choices are undertaken by small groups (dyads in our case), disappointment aversion outperforms several alternative preference functionals, including expected utility. Since expected utility typically emerged as the dominant model in individual risky choices, this finding suggests that differences between individual and group choices exist, showing that the preference aggregation process drives out EU.

Keywords: group decision, expected utility, risk and uncertainty.

JEL codes: C91, C92, D81, D70

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1. Introduction

Since its axiomatization by von Neumann and Morgenstern (1944), the expected utility theory (EUT) has been the dominant framework for analysing individual decision problems under risk and uncertainty. Starting with the well-known paradox of Allais (1953), however, a large body of experimental evidence, indicating that individuals systematically tend to violate the assumptions underlying EUT, was produced. This experimental evidence motivated researchers to develop alternative theories of choice under risk and uncertainty that were able to accommodate the observed patterns of behaviour. Nowadays a large number of alternative theories exist (e.g. regret theory, disappoint aversion, prospect theory, rank-dependent theory, etc.).[1] Naturally, the question arises: Which theory can best explain observed choice behaviours? To address this question many experimentalists studied and compared the empirical performance of single alternatives. Most notable, this line of research was significantly advanced by Harless and Camerer (1994) and Hey and Orme (1994).

All of the existing studies, we are aware of, use individual choice data in order to evaluate the alternatives.[2] However, decision processes are not always individual, there are many circumstances where individuals make their decisions in groups. It is striking that neither the validity of expected utility[3] nor the comparative performances of the single alternative theories of choice under risk and uncertainty have been systematically investigated with group decision. This paper therefore aims to fill this gap, presenting results of an experiment designed to address the following research questions: Is there a risky choice theory fits group decisions significantly better (in a statistical sense)? And, are there significant differences (in an economic sense) between individual and group choices?

The remainder of the paper proceeds as follows: Section 2 briefly presents the relevant literature on group decision and risk. Experimental design is discussed in section 3. Section 4 explains the estimation procedure. Section 5 presents our experimental results and section 6 concludes.

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[1] See Starmer, 2000; Sugden, 2004 and Schmidt, 2004 for a comprehensive survey.

[2] See, among others, Carbone and Hey (1994, 1995), Morone (2008), Hey et al. (2009).

[3] Perhaps, it should be noted here that there are exceptions to this void in the literature. We will provide an account of this in the following section.

2. Risk and group decisions

Recently, growing experimental literature has explored differences between individuals and groups (or between groups of different size) in various decision contexts involving strategic behaviours.[4]

However, experimental investigations on non-strategic group risky choices are more scant. In fact, there is only limited evidence of group, as opposed to individual, behaviour. Earlier studies by Bone (1998) and Bone et al. (1999) provided some interesting results, suggesting that the common effects observed in the literature regarding EUT (the common ratio and preference reversal effects) are observable also in groups.

More recently, Bateman and Munro (2005) provided results of an experiment designed to investigate to what extent decisions made by couples and decisions made separately by individuals (who are part of a couple) conform to EUT. The authors used established couples and presented them individually and jointly with decisions involving monetary payoffs, finding that joint choices are more risk averse than those made by individuals. Moreover, experimental findings showed that couples display the same anomalous patterns in their risky choices as are regularly recorded in individual choice experiments.

Along this line of investigation, Shupp and Williams (2008) evaluate risk aversion using price data elicited by a willingness to pay mechanism for risky prospects. They find that the variance of risk preferences is generally smaller for groups than individuals and the average group is more risk averse than the average individual in high-risk situations, but groups tend to exhibit lower risk aversion than individuals in low-risk situations.

Subsequently, commenting on the paper by Charness et al. (2007) that shows how salient group membership has a strong effect on individual decisions in coordination and prisoner's dilemma games, Sutter (2009) demonstrated that their findings also apply to non-strategic decisions. By performing an investment experiment the author showed that individual decisions with salient group membership are largely the same as team decisions; a finding that helps bridge the literature on team decision-making and on group membership effects.

Finally, Masclet et al. (2009) conducted a field experiment (recruiting salaried and self-employed workers) and explored individual and group decisions under risk and uncertainty. The authors found that groups are more likely than individuals to choose safe lotteries and

[4] Beauty-contest games (Kocher and Sutter, 2005; Kocher et al., 2007; Sutter, 2005), centipede games (Bornstein et al., 2004), ultimatum games (Bornstein and Yaniv, 1998), dictator games (Cason and Mui, 1997), signalling games (Cooper and Kagel, 2005), policy decisions (Blinder and Morgan, 2005), location and pricing (Barreda et al., 2002), and auctions (Cox and Hayne, 2006; Sutter et al., 2009).

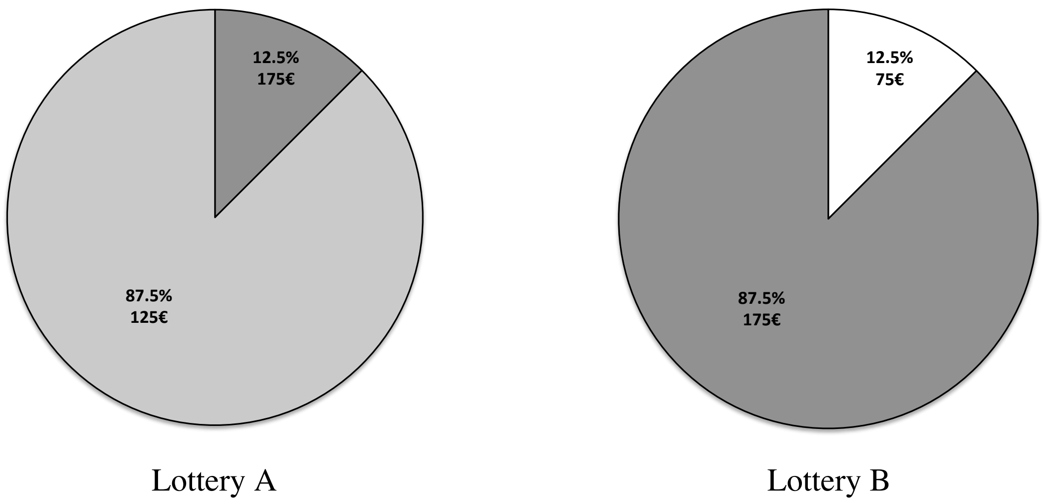
that individuals risk attitude is correlated with the socio-demographic characteristics of the participant to the experiment (namely, the type and the sector of employment).

Although very relevant, none of these studies attempts to compare EU and non-EU theories of risky choices. In fact, the field of risky choice has extensively investigated individual decision processes under risk and uncertainty, expending much effort to scrutinize EUT and proposing many alternatives that should, in principle better accommodate individual choice anomalies typically observed in empirical assessments. However, as mentioned in the introduction, there is a void in the literature in assessing alternative theories when it comes to group choices. Moving on from this, we report hereafter on the first economic experiment that attempts to fit EU preference functional and a number of its generalizations to group decisions and compare their relative performance.

3. Experimental Design

The experiment presented here closely follows that of Hey and Orme's (1994). We recruited students from the University of Bari via a mailing-list system. They were presented with a set of pairwise choice questions; each pairwise choice is composed of two lotteries, labelled "Lottery A" and "Lottery B", of the kind depicted in Figure 1. Each subject has to report his/her preference between the two lotteries.[5]

Figure 1: The Presentation of Lotteries



[5] Note that we are deliberately not allowing subjects to express indifference between lotteries. This simplifies our data analysis since, if subjects are given the opportunity to express indifference and take advantage of this opportunity, it is not obvious how one should treat such responses (see Hey, 2001). Moreover, this choice does not affect the value of the experiment to the subjects, since if subjects are truly indifferent it does not matter how they respond, given the adopted incentive mechanism.

The experiment was conducted at the ESSE laboratory of experimental economics at the University of Bari in November 2008 with 38 participants. Each participant attended two separate and subsequent sessions: in Session 1 subjects played individually, in Session 2 they played in randomly created groups of two[6].

In each session participants were presented with the same 100 pairwise choice lotteries (reported in Table A1, in Appendix 1). The time taken to complete each session varied between the two sessions and also across subjects, since participants were explicitly encouraged to proceed at their own pace.[7] The incentive mechanism was that the chosen lottery would be played for real. Specifically, whenever a group completed Session 2, one question was randomly selected for each subject (from both sessions) and played out for real. The average payment made to the 38 subjects over these two sessions was €97.50; the maximum payment to any subject was €175 and the minimum €25. Consequently, the average payment was around €83.6 per hour spent doing the experiments. This is considerably above the marginal wage rate of the subjects performing the experiment.

4. Estimation procedure and preference functionals

As mentioned earlier, our study closely follows that of Hey and Orme's (1994), whose analysis is grounded on two fundamental observations. First, there is not necessarily one best preference functional for all subjects, but the behaviour of different subjects may be explained best by different functionals. Second, subjects make errors from time to time in their responses, which demand a stochastic specification of preference functionals for our empirical test. To take into account the first observation, we estimated each model subject by subject. To take into account the second observation, we added an error term to each preference functional assuming that errors are identically and independently distributed among subjects and questions.

4.1 Some notes on estimation techniques

Let's indicate the two lotteries in the pairwise choice by A and B; then, assuming that there is no noise or error in the subject's responses, she/he will report a preference for A, if and only if $\mathrm{EU}(A) > \mathrm{EU}(B)$ – that is, if and only if $\mathrm{E}[u(A) - u(B)] > 0$. However, as we know from the existing literature, subjects' responses are typically affected by noise. If we denote this noise or

[6] We are aware that there are many factors that can affect group decisions (e.g. gender, age, placement of group members). Additionally, the social interaction between a man and a woman can be quite different than between two men or two women. For instance, "beauty" and other stereotypes can have huge impact on the outcomes of group decisions (Andreoni and Petrie, 2008). To minimise the impact of such problems, we kept the pairs identity confidential so that each group member maintained anonymity with subjects communicating through the computer interface.

[7] The required time to complete one session was between 85 and 55 minutes.

measurement error by ϵ, then the subject will report a preference for A if, and only if, E[u(A) - u(B)] + $\epsilon >$ 0, that is, if and only if $\epsilon >$ E[u(B) - u(A)]. Following this line of reasoning, we can now write the probability that the subject reports a preference for A as: Prob{ϵ > E[u(B) - u(A)]}.[8]

Having determined the actual reported preferences, we then proceed to the estimation of the parameters using maximum likelihood methods. To do so, we need to specify the distribution of the measurement error, which we shall assume to be normally distributed with mean 0 and variance s. As noted by Hey and Orme (1994), the magnitude of s measures the noisiness of the subject's responses: if s = 0, then the subject makes no mistakes. As s increases, the noise also increases. As s approaches infinity, there is no information content in the subject's responses. Note that when estimating an utility function from an experiment, there are two usual approaches: (a) to assume a particular functional form and estimate the parameters of that form; (b) to estimate the utility at the various outcome values used in the experiment. In our estimation we follow the latter technique.

4.2 The preference functionals

In the experiment reported here there were four outcome values (€25, €75, €125, and €175), which we denote by x_1, x_2, x_3 and x_4.[9] Let $\mathbf{x} = \{x_1, x_2, x_3, x_4\}$ be the vector of outcomes. Since we used a pairwise choice gamble to derive preference statements, our data involved two lotteries represented by two probability vectors denoted by $\mathbf{p} = \{p_1, p_2, p_3, p_4\}$ and $\mathbf{q} = \{q_1, q_2, q_3, q_4\}$. Let W denote the subject's preference functional and $V(\mathbf{p}, \mathbf{q}) = W(\mathbf{p})$-$W(\mathbf{q})$ the relative evaluation or net preference functional. All those subjects who exhibit a positive net preference functional (i.e. $V(\mathbf{p}, \mathbf{q}) > 0$) strictly prefer lottery A over lottery B. Conversely, all those subjects who exhibit a negative net preference functional (i.e. $V(\mathbf{p}, \mathbf{q}) < 0$) strictly prefer lottery B over lottery A. Finally, if $V(\mathbf{p}, \mathbf{q}) = 0$, then subjects are indifferent between the two lotteries.

As mentioned earlier, subjects state their preferences with some error; hence have: $V^*(\boldsymbol{p}, \boldsymbol{q}) = V(\boldsymbol{p}, \boldsymbol{q}) + \epsilon$, where ϵ is the error term. As mentioned above, ϵ is normally distributed with mean 0 and variance s; introducing a further normalization we can put $s = 1$ hence obtaining ϵ is $N(0, s)$.[10]

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[8] Note that the probability that the subject reports a preference for B can be derived accordingly.

[9] Note that for the estimation of parameters we follow Hey and Orme (1994). The theoretical foundation of the employed estimation technique can be found in Orme (1995).

[10] As observed by Hey and Orme (1994: 1301), an alternative procedure would be, in addition to $u(x_1) = 0$, to put $u(x_4) = 1$ and then specify the error variance to be σ^2; in this case one should estimate σ in addition to $u(x_2)$ and $u(x_3)$. Choosing instead to put the error variance equal to unity we will estimate $u(x_2)$, $u(x_3)$, and $u(x_4)$. The two procedures are highly comparable, the main difference being in interpreting the results: other things being equal, under our procedure, a subject who makes relatively small errors will have relatively large values for $u(x_2)$, $u(x_3)$,

The first model we estimate is *risk neutrality*, given by **RN**: $V^*(\boldsymbol{p},\boldsymbol{q}) = k\sum_{i=1}^{4}(p_i - q_i)x_i + \epsilon$. In this model we have to estimate only the parameter k, which is the relative magnitude of subjects' errors.

The second model we estimate is *expected utility*, given by **EU**: $V^*(\boldsymbol{p},\boldsymbol{q}) = \sum_{i=2}^{4}(p_i - q_i)\,u(x_i) + \epsilon$. We normalized $u(x_1)$ to zero, and the variance of the error term to unity. We did the same also for the alternative theories presented below.

The third model is the theory of *disappointment aversion* introduced by Gul (1991). The main psychological motivation of this theory is the hypothesis that choice behaviour tries to avoid the disappointment that would result if the actual outcome of the lottery were lower than the certainty equivalent. In our framework, disappointment aversion is characterized as follows

$$\textbf{DA}: V^*(\mathbf{p},\mathbf{q}) = min_{j=0}^{2}\left(\frac{(1+\beta)\sum_{i=2}^{3-j}p_i u(x_i)+\sum_{i=4-j}^{4}p_i u(x_i)}{1+\beta\sum_{i=1}^{3-j}p_i} - \frac{(1+\beta)\sum_{i=2}^{3-j}q_i u(x_i)+\sum_{i=4-j}^{4}q_i u(x_i)}{1+\beta\sum_{i=1}^{3-j}q_i}\right) + \epsilon.$$

Note that β is an additional parameter, which determines the degree of disappointment aversion. If $\beta = 0$, then DA reduces to EU. Our characterization initially appears different from that of Hey and Orme's (1994), but it can be shown that they are identical (see Appendix 2).

The fourth model is *rank-dependent* expected utility theory, which is nowadays the most prominent alternative to EU. We estimate two variants of rank-dependent utility, one with a power weighting function and one with the weighting function proposed by Quiggin (1982).

For rank-dependence with power function the weighting function w is given by $w(r) = r^\gamma$ and we have **RP**: $V^*(\mathbf{p},\mathbf{q}) = \sum_{j=2}^{4}u(x_j)\{[(\sum_{i=j}^{4}p_i)^\gamma - (\sum_{i=j+1}^{4}p_i)^\gamma][(\sum_{i=j}^{4}q_i)^\gamma - (\sum_{i=j+1}^{4}q_i)^\gamma]\} + \epsilon$. Note that if $\gamma = 1$, then RP reduces to EU.

For rank-dependence with "Quiggin" weighting function (Quiggin, 1982), the weighting function is given by $w(r) = r^\gamma / [r^\gamma + (1-r)^\gamma]^{1/\gamma}$, which yields

$$\textbf{RQ}: V^*(\mathbf{p},\mathbf{q}) = \sum_{j=2}^{4}u(x_j)\left\{\left[\frac{\left(\sum_{i=j}^{4}p_i\right)^\gamma}{\left[\left(\sum_{i=j}^{4}p_i\right)^\gamma+\left(1-\sum_{i=j}^{4}p_i\right)^\gamma\right]^{1/\gamma}} - \frac{\left(\sum_{i=j+1}^{4}p_i\right)^\gamma}{\left[\left(\sum_{i=j+1}^{4}p_i\right)^\gamma+\left(1-\sum_{i=j+1}^{4}p_i\right)^\gamma\right]^{1/\gamma}}\right] - \left[\frac{\left(\sum_{i=j}^{4}q_i\right)^\gamma}{\left[\left(\sum_{i=j}^{4}q_i\right)^\gamma+\left(1-\sum_{i=j}^{4}q_i\right)^\gamma\right]^{1/\gamma}} - \frac{\left(\sum_{i=j+1}^{4}q_i\right)^\gamma}{\left[\left(\sum_{i=j+1}^{4}q_i\right)^\gamma+\left(1-\sum_{i=j+1}^{4}q_i\right)^\gamma\right]^{1/\gamma}}\right]\right\} + \epsilon.$$

Note that RQ reduces to EU if $\gamma = 1$.[11]

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and $u(x_4)$, while a subject who makes relatively large errors will have relatively small values for $u(x_2)$, $u(x_3)$, and $u(x_4)$. Under the alternative procedure, the relatively careful subject would have a relatively small value for σ.

[11] We also estimated Prospective Reference Theory and Weighted Utility Theory. Consistent with existing literature, we found that they fit the experimental data very poorly. Therefore we decided not to include them in this paper; results are available upon request.

5. Results

As we stated in the introduction, what we are trying to understand here is if there is a theory of risky choice that fits group decisions significantly better than the alternatives, and if there are significant differences among individual and group choice. In order to address the first of these two questions, we used the Akaike information criterion to provide a ranking of the various functionals.

Following Hey and Orme (1994), and provided that we always have the same number of observations across all models, the corrected-log-likelihood Akaike information criterion ($CAIC$) can be written as $CAIC = logL(\hat{\alpha}) - k$; where $L(\hat{\alpha})$ is the maximized likelihood for a particular estimated preference functional and k is the number of estimated parameters in that functional. The smaller CAIC is, the better the model will be.

We report rankings for individual and group treatments in Table 1 and Table 2, respectively. In the last column of these two tables we also report the average rankings, averaged over all subjects (of course, the smaller this value is, the better the model will be).

Table 1: Performance (%) of the five preference functionals based on individual data

		Rank					**Average Rank**
		1st	2nd	3rd	4th	5th	
Preference Functional	RN	0.237	0.026	0.053	0.000	**0.684**	**3.868**
	EU	0.211	0.184	0.368	0.211	0.026	**2.657**
	DA	**0.263**	0.237	0.132	0.289	0.079	**2.684**
	RP	0.131	0.316	0.210	0.211	0.132	**2.897**
	RQ	0.158	0.237	0.237	0.289	0.079	**2.894**

Table 1 suggests that EU is, overall, the best performing model on this criterion and that **DA** is a reasonably close second best. Moreover, rank-dependent models (both with the Quiggin weighting function and with the power weighting function) do fairly well; conversely, **RN** is the worst performing model. The reader should be cautioned that average values hide a considerable variation across subjects,[12] which can be partially unveiled by looking at the percentage values of each rank position. Specifically, we can observe that **DA** ranks first with 26.3% of the cases and either first or second in half of the cases. This makes **DA** the winner on this criterion. Consistent with earlier findings obtained by Hey and Orme (1994), we can conclude that, when looking at risky choices undertaken individually, expected utility theory also emerges "fairly intact" in our analysis.

[12] As pointed out by Hey and Orme (1994), when interpreting such rankings one should keep in mind that average results counter the idea that subjects are different and have different preference functionals.

When looking at group data (see Table 2), the emerging picture is partially different. Now, the best performing model is disappointment aversion, **RQ** ranks second and expected utility ranks only third. Decomposing the average rank as we did above, we can observe that **DA** ranks first with 36.8% of the cases and either first or second in almost 70% of the cases. This makes **DA** the absolute winner in the group treatment. This finding answers our first question: Disappointment aversion fits group data significantly better than any other theory, including expected utility.

Table 2: Performance (%) of the five preference functionals based on group data

		Rank					**Average Rank**
		1st	2nd	3rd	4th	5th	
Preference Functional	RN	0.053	0.053	0.053	0.105	**0.737**	**4.423**
	EU	0.211	0.158	0.316	0.211	0.105	**2.844**
	DA	**0.368**	0.316	0.158	0.158	0.000	**2.106**
	RP	0.211	0.105	0.211	0.316	0.158	**3.108**
	RQ	0.158	0.368	0.263	0.211	0.000	**2.527**

Hence, when it comes to group decisions, **DA** outperforms **EU**; a result that did not occur with individual decision data. Consequently, this also contributes towards answering our second question, suggesting that there are significant differences between individual and group choice. To further validate these finding, we shall perform two other tests. First, we will compare the performance of alternative models with **EU** (Table 3) using again the CAIC; then we will perform a likelihood ratio test to test the superiority of alternatives with respect to **EU** (Table 4).

Table 3: Performance (%) of alternative models w.r.t. the EU model

	Individuals	Groups
EU vs. DA	0.500	0.260
EU vs. RP	0.550	0.530
EU vs. RQ	0.550	0.470

Table 3 reports pair comparisons and shows that **EU** outperforms alternative models in half or more of the cases when referring to individuals' treatment. This percentage is quite stable when comparing **EU** with **RP** and **RQ** in groups' treatment, but it drops to 26% when we compare **EU** with **DA**. This result corroborates our earlier finding regarding the superiority of the DA model when it comes to group risky decisions.

Recall now that **DA**, **RP** and **RQ** are all generalizations of **EU**, in the sense that the latter is a special case of each of the former. Hence, we refer to them as higher-level models when compared to EU. Moving down from higher levels to lower levels involves parameter restrictions. In the context of this experiment, going from **DA**, **RP** and **RQ** to **EU** always involves one parameter restriction. Accordingly, we can use standard likelihood ratio tests to investigate whether the higher level functionals fit significantly better than the lower level functionals, by which we mean that the parameter restrictions that reduce the higher-level functional to the lower-level functional are rejected at the appropriate significance level.

Table 4: Likelihood ratio tests for the superiority of higher-level models

Alternative Functionals vs. Expected Utility				
Percentage of subjects for whom test significant at				
	5%		1%	
	Individuals	Groups	Individuals	Groups
DA	0.316	0.474	0.158	0.053
RP	0.237	0.263	0.132	0.105
RQ	0.237	0.316	0.105	0.000

Table 4 reports the results of carrying out such tests at two levels of significance (i.e. 5% and 1%). Most notably, this test shows that, at the 5% level, **EU** is rejected in favour of **DA** for considerably more subjects on the group treatment than on individual treatment. Moreover, the percentage of times **EU** is rejected in favour of one of the alternatives always grows as we move from individuals to groups. This suggests that the preference aggregation process drives out **EU**.[13]

6. Conclusions

In this paper we analysed the empirical performance of several preference functionals using individual and group data. Our investigation aimed at addressing two fundamental questions never addressed before in the literature. Specifically, we intended to assess if there exists a risky choice theory fits group decisions significantly better (in a statistical sense) than alternative theories, and if there are significant differences (in an economic sense) between individual and group choices. As we believe, we succeeded to provide answers to both questions showing that when risky choices are undertaken by small groups (dyads in our case), disappointment aversion outperformed several alternative preference functionals. Most notably, this handful of alternatives included expected utility, which typically emerged as the dominant model in individual risky choices. This latter finding suggests that differences exist between individual

[13] Noteworthy, at the 1% level of significance we are not able to reject EU in favour of one of the top-level functionals in the majority of the cases.

and group choices, showing that the preference aggregation process drives out **EU**. Hence, we can conclude that even if subjects are EU, small groups are not.

As a concluding remark, we would like to caution the reader on a critical point: Although relevant, these aggregate findings hide a considerable variation across subjects as well as groups, suggesting that groups are different as much as people are different. Therefore it is hard to find a preference functional that clearly wins all alternatives. More likely, we can find (as we indeed found) a functional that better fits group data, always bearing in mind the underlying heterogeneities.

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Appendix 1

Table A1: The 100 Pairwise Choice Questions

Question Number	Lottery A				Lottery B			
	p_1	p_2	p_3	p_4	q_1	q_2	q_3	q_4
1	.000	.000	.875	.125	.000	.125	.000	.875
2	.000	.000	.875	.125	.000	.125	.000	.875
3	.000	.000	.875	.125	.000	.125	.500	.375
4	.000	.000	.875	.125	.000	.375	.000	.625
5	.000	.000	.875	.125	.000	.375	.125	.500
6	.000	.000	.875	.125	.000	.375	.250	.375
7	.000	.000	.875	.125	.000	.625	.000	.375
8	.000	.125	.500	.375	.000	.375	.000	.625
9	.000	.125	.500	.375	.000	.375	.125	.500
10	.000	.125	.875	.000	.000	.375	.000	.625
11	.000	.125	.875	.000	.000	.375	.125	.500
12	.000	.125	.875	.000	.000	.375	.250	.375
13	.000	.125	.875	.000	.000	.375	.500	.125
14	.000	.125	.875	.000	.000	.625	.000	.375
15	.000	.125	.875	.000	.000	.875	.000	.125
16	.000	.250	.750	.000	.000	.375	.000	.625
17	.000	.250	.750	.000	.000	.375	.125	.500
18	.000	.250	.750	.000	.000	.375	.250	.375
19	.000	.250	.750	.000	.000	.375	.500	.125
20	.000	.250	.750	.000	.000	.375	.500	.125
21	.000	.250	.750	.000	.000	.625	.000	.375
22	.000	.250	.750	.000	.000	.875	.000	.125
23	.000	.375	.500	.125	.000	.625	.000	.375
24	.000	.125	.875	.000	.000	.250	.750	.000
25	.000	.375	.125	.500	.000	.375	.250	.375
26	.000	.000	.500	.500	.125	.000	.250	.625
27	.000	.000	.500	.500	.125	.000	.250	.625
28	.000	.000	.875	.125	.125	.000	.250	.625
29	.000	.000	.875	.125	.125	.000	.625	.250
30	.000	.000	.875	.125	.375	.000	.375	.250
31	.000	.000	.875	.125	.500	.000	.000	.500
32	.000	.000	.875	.125	.750	.000	.000	.250
33	.000	.000	.100	.000	.125	.000	.250	.625
34	.000	.000	.100	.000	.125	.000	.625	.250
35	.000	.000	.100	.000	.375	.000	.375	.250
36	.000	.000	.100	.000	.500	.000	.000	.500
37	.000	.000	.100	.000	.750	.000	.000	.250
38	.000	.000	.100	.000	.750	.000	.000	.250
39	.000	.000	.100	.000	.750	.000	.125	.125
40	.125	.000	.625	.250	.500	.000	.000	.500
41	.250	.000	.750	.000	.375	.000	.375	.250
42	.250	.000	.750	.000	.500	.000	.000	.500
43	.250	.000	.750	.000	.750	.000	.000	.250
44	.250	.000	.750	.000	.750	.000	.125	.125
45	.375	.000	.375	.250	.500	.000	.000	.500
46	.375	.000	.625	.000	.500	.000	.000	.500
47	.375	.000	.625	.000	.750	.000	.000	.250
48	.375	.000	.625	.000	.750	.000	.125	.125
49	.250	.000	.750	.000	.375	.000	.625	.000
50	.750	.000	.000	.250	.750	.000	.125	.125
51	.000	.750	.000	.250	.250	.375	.000	.375
52	.000	.750	.000	.250	.375	.125	.000	.500
53	.000	.750	.000	.250	.625	.000	.000	.375
54	.000	.875	.000	.125	.250	.375	.000	.375
55	.000	.875	.000	.125	.375	.125	.000	.500

56	.000	.875	.000	.125	.500	.250	.000	.250
57	.000	.875	.000	.125	.625	.000	.000	.375
58	.000	.875	.000	.125	.625	.125	.000	.250
59	.125	.750	.000	.125	.250	.375	.000	.375
60	.125	.750	.000	.125	.375	.125	.000	.500
61	.125	.750	.000	.125	.500	.250	.000	.250
62	.125	.750	.000	.125	.625	.000	.000	.375
63	.125	.750	.000	.125	.625	.125	.000	250
64	.125	.875	.000	.000	.250	.375	.000	.375
65	.125	.875	.000	.000	.375	.125	.000	.500
66	.125	.875	.000	.000	.500	.250	.000	.250
67	.125	.875	.000	.000	.625	.000	.000	.375
68	.125	.875	.000	.000	.625	.125	.000	.250
69	.125	.875	.000	.000	.750	.125	.000	.125
70	.125	.875	.000	.000	.875	.000	.000	.125
71	.125	.875	.000	.000	.875	.000	.000	.125
72	.250	.375	.000	.375	.375	.125	.000	.500
73	.500	.250	.000	.250	.625	.000	.000	.375
74	.500	.250	.000	.250	.625	.000	.000	.375
75	.000	.750	.000	.250	.125	.750	.000	.125
76	.000	.750	.250	.000	.125	.000	.875	.000
77	.000	.750	.250	.000	.125	.375	.500	.000
78	.000	.750	.250	.000	.375	.125	.500	.000
79	.000	.750	.250	.000	.375	.250	.375	.000
80	.000	.750	.250	.000	.500	.000	.500	.000
81	.000	.750	.250	.000	.500	.125	.375	.000
82	.000	.100	.000	.000	.125	.000	.875	.000
83	.000	.100	.000	.000	.125	.375	.500	.000
84	.000	.100	.000	.000	.250	.625	.125	.000
85	.000	.100	.000	.000	.375	.125	.500	.000
86	.000	.100	.000	.000	.375	.250	.375	.000
87	.000	.100	.000	.000	.500	.000	.500	.000
88	.000	.100	.000	.000	.500	.000	.500	.000
89	.000	.100	.000	.000	.500	.125	.375	.000
90	.000	.100	.000	.000	.750	.125	.125	.000
91	.250	.625	.125	.000	.375	.125	.500	.000
92	.250	.625	.125	.000	.375	.250	.375	.000
93	.250	.625	.125	.000	.500	.000	500	.000
94	.250	.625	.125	.000	.500	.125	.375	.000
95	.375	.250	.375	.000	.500	.000	.500	.000
96	.375	.250	.375	.000	.500	.000	.500	.000
97	.375	.625	.000	.000	.500	.000	.500	.000
98	.375	.625	.000	.000	.500	.125	.375	.000
99	.375	.625	.000	.000	.750	.125	.125	.000
100	.375	.125	.500	.000	.500	.125	.375	.000

Note: Lottery A takes the values x_1, x_2, x_3 and x_4 with respective probabilities p_1, p_2, p_3 and p_4 and Lottery B takes the values x_1, x_2, x_3 and x_4 with respective probabilities q_1, q_2, q_3 and q_4. The **x** vector takes the value (€25, €75, €125, €175).

Appendix 2

Derivation of Disappoint Aversion specification.

Let start with our formulation of Disappointment Aversion Theory, as reported in the paper

DA: $V^*(\mathbf{p},\mathbf{q})$

$$= \ min_{j=0}^{2}\left(\frac{(1+\beta)\sum_{i=2}^{3-j} p_i u(x_i) + \sum_{i=4-j}^{4} p_i u(x_i)}{1+\beta\sum_{i=1}^{3-j} p_i}\right.$$

$$\left. - \frac{(1+\beta)\sum_{i=2}^{3-j} q_i u(x_i) + \sum_{i=4-j}^{4} q_i u(x_i)}{1+\beta\sum_{i=1}^{n-1-j} q_i}\right) + \epsilon$$

if $j = 0 \ \Rightarrow V^*(\mathbf{p},\mathbf{q}) \ = \ \left(\frac{(1+\beta)\sum_{i=2}^{3} p_i u(x_i)+p_4}{1+\beta\sum_{i=1}^{3} p_i} - \frac{(1+\beta)\sum_{i=2}^{3} q_i u(x_i)+q_4}{1+\beta\sum_{i=1}^{3} q_i}\right) + \epsilon$

if $j = 1 \ \Rightarrow V^*(\mathbf{p},\mathbf{q}) \ = \ \left(\frac{(1+\beta)p_2+\sum_{i=3}^{4} p_i u(x_i)}{1+\beta\sum_{i=1}^{2} p_i} - \frac{(1+\beta)q_2+\sum_{i=3}^{4} q_i u(x_i)}{1+\beta\sum_{i=1}^{2} q_i}\right) + \epsilon$

If $j = 2 \ \Rightarrow V^*(\mathbf{p},\mathbf{q}) \ = \ \left(\frac{\sum_{i=2}^{4} p_i u(x_i)}{1+\beta p_1} - \frac{\sum_{i=2}^{4} q_i u(x_i)}{1+\beta q_1}\right) + \epsilon$

Now, taking the minimum we obtain exactly the same formulation proposed by Hey and Orme (1994: 1297).