Risk aversion and embedding bias,

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ABSTRACT

In Selten (1967) "Strategy Method," the second mover in the game submits a complete strategy. This basic idea has been exported to nonstrategic experiments, where a participant reports a complete list of contingent decisions, one for each situation or state in a given sequence, out of which one and only one state, randomly selected, will be implemented.

In general, the method raises the following concern. If S^0 and S^1 are two different sequences of states, and state $\bar{s}$ is in both S^0 and S^1, would the participant make the same decision in state $\bar{s}$ when confronted with S^0 as when confronted with S^1? If not, the experimental results are suspect of suffering from an "embedding bias."

We check for embedding biases in elicitation methods of Charles Holt and Susan Laury (Laury and Holt, 2000, and Holt and Laury, 2002), and of the present authors (Bosch-Domènech and Silvestre, 1999, 2002, 2006a, b) by appropriately chosen replications of the original experiments. We find no evidence of embedding bias in our work. But in Holt and Laury's method participants tend to switch earlier to the riskier option when later pairs of lotteries are eliminated from the sequence, suggesting the presence of some embedding bias.

Keywords: Embedding bias, strategy method, Holt, Laury, Risk Attraction, Risk Aversion, Experiments.

JEL Classification Numbers: C91, D81

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1. Introduction

Selten (1967) introduced "The Strategy Method" in experimental two-person, sequential games. In the strategy method, the second mover submits a complete list of contingent actions out of which only one will be implemented in the game. This basic idea has been exported to nonstrategic experiments, where a participant (or "subject") reports a complete list of contingent decisions, one for each situation or state *s* in a determined sequence *S*, out of which one and only one, randomly selected, will be implemented. Because the method generates a relatively large amount of individual data at a low cost, it has been widely used in experimental economics.[1]

Note that, in Selten's (1967) strategy method the second mover makes her (i. e., his or her) contingent decisions in a situation of *uncertainty*, because she does not know which *s* will occur, and the uncertainty is *strategic* in the sense that it is a player, namely the first mover, who decides on *s*. But in the nonstrategic context the uncertainty is *nonstrategic*, because it is a random device that selects *s*.

In general, the method raises the following concern. If S^0 and S^1 are two different sequences of states, and state $\bar{s}$ is a term in both S^0 and S^1, would the participant make the same decision in state $\bar{s}$ when confronted with S^0 as when confronted with S^1? An affirmative answer means that the decision taken in state $\bar{s}$ is does not depend on whether $\bar{s}$ is embedded in sequence S^0 or in sequence S^1: the decision is then embedding-invariant. But a negative answer would question the validity of the data obtained, particularly when the sequence of states is chosen by the experimenter for convenience in the absence of a natural grouping of possible states in real life, and hence arbitrarily framing the experiment. It that case, we shall refer to an "embedding bias."

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[1] The advantage of the strategy method does not lie only on the quantity of data provided but on the type of data. It shows the participants' complete strategies, thus helping the experimenter to better understand their motivations and beliefs (see Michael Mitzkevitz and Rosemarie Nagel, 1993).

We check for embedding biases in elicitation methods that have been recently used to study risk attitudes (attraction or aversion) while paying participants in real money and according to their decisions. In particular, we focus on two groups of papers, one by Charles Holt and Susan Laury (Laury and Holt, 2000, and Holt and Laury, 2002), and another one by the present authors (Bosch-Domènech and Silvestre, 1999, 2002, 2006a, b). We replicate the original experiments in these groups with appropriately chosen subsequences of the original sequences of states. In a nutshell, we find no evidence of embedding bias in our work. In Holt and Laury's method, on the contrary, participants tend to switch earlier to the riskier option when later pairs of lotteries are eliminated from the sequence, suggesting the presence of some embedding bias.[2]

2. Holt and Laury's method

2.1. Description

Participants in Laury and Holt (2000) and Holt and Laury (2002) face a sequence of ten pairs of binary lotteries, numbered one to ten in Table 1 below, each pair involving a safer lottery (*S*) and a riskier one (*R*). The last column in the table indicates the difference "expected dollar value of lottery *S* (denoted EV^S) minus expected dollar value of lottery *R* (denoted EV^R):" this difference decreases and becomes increasingly negative along the ten-pair sequence, and a risk-neutral individual would choose the pattern *SSSS*/*RRRRRR*. Thus, a participant choosing *SSSSSSS/RRR* displays risk aversion. [3]

This experimental design has been tested for possible order biases by Glenn Harrison *et al*. (2005) and Holt and Laury (2005). We address here a different sort of possible bias, what we call *embedding bias*. Suppose that a participant selects the pattern *SSSSSSS/RRR* when facing the 10-lottery-pair sequence of Table 1: in particular, she chooses the safe option in the lottery pair appearing in the seventh row of Table 1. Would she still choose the safe lottery in that pair if, instead of facing Table 1, she faced Table 2, obtained from Table 1 by deleting its last three rows? Note that, in Table 2, that lottery pair is embedded in a 7-pair sequence, and becomes the last one, whereas in Table 1 the very same pair is embedded in a 10-pair sequence, and has three other pairs placed after it. A switch from *S* to *R* would be a manifestation of embedding bias.

[2] The tendency to switch earlier in the shorter lists brings to mind the phenomenon, discussed in Steffen Andersen *et al*. (2005), that in multiple-price lists subjects may be inclined to pick a response in the middle of the list, independent of true valuations. Incidentally, Andersen *et al*. believe that the Holt and Laury elicitation method is less likely to suffer from this framing effect because "the values are bounded by the laws of probability between 0 and 1,…" From this perspective, our work here can be interpreted as the removal of the zero and one anchors.

[3] Laury and Holt (2000) also run similar experiments with losses. But we have not attempted to check for embedding biases there, because of the added complexity of replicating this type of experiments (see Bosch-Domènech and Silvestre, 2006b).

Lottery Pair #	Safe Lottery (*S*)				Risky Lottery (*R*)						
	Prob.	Payoff	Prob.	Payoff	Prob.	Payoff	Prob.	Payoff	EV^A	EV^B	Difference
1	0.1	$2	0.9	$1.60	0.1	$3.85	0.9	$0.10	$1.64	$0.48	$1.17
2	0.2	$2	0.8	$1.60	0.2	$3.85	0.8	$0.10	$1.68	$0.85	$0.83
3	0.3	$2	0.7	$1.60	0.3	$3.85	0.7	$0.10	$1.72	$1.23	$0.49
4	0.4	$2	0.6	$1.60	0.4	$3.85	0.6	$0.10	$1.76	$1.60	$0.16
5	0.5	$2	0.5	$1.60	0.5	$3.85	0.5	$0.10	$1.80	$1.98	−$0.17
6	0.6	$2	0.4	$1.60	0.6	$3.85	0.4	$0.10	$1.84	$2.35	−$0.51
7	0.7	$2	0.3	$1.60	0.7	$3.85	0.3	$0.10	$1.88	$2.73	−$0.84
8	0.8	$2	0.2	$1.60	0.8	$3.85	0.2	$0.10	$1.92	$3.10	−$1.18
9	0.9	$2	0.1	$1.60	0.9	$3.85	0.1	$0.10	$1.96	$3.48	−$1.52
10	1	$2	0	$1.60	1	$3.85	0	$0.10	$2.00	$3.85	−$1.85

Table 1. Design of the Holt and Laury experiments (adapted from Glenn Harrison *et al*., 2005)

Lottery Pair #	Safe Lottery (*S*)				Risky Lottery (*R*)						
	Prob.	Payoff	Prob.	Payoff	Prob.	Payoff	Prob.	Payoff	EV^S	EV^R	Difference
1	0.1	$2	0.9	$1.60	0.1	$3.85	0.9	$0.10	$1.64	$0.48	$1.17
2	0.2	$2	0.8	$1.60	0.2	$3.85	0.8	$0.10	$1.68	$0.85	$0.83
3	0.3	$2	0.7	$1.60	0.3	$3.85	0.7	$0.10	$1.72	$1.23	$0.49
4	0.4	$2	0.6	$1.60	0.4	$3.85	0.6	$0.10	$1.76	$1.60	$0.16
5	0.5	$2	0.5	$1.60	0.5	$3.85	0.5	$0.10	$1.80	$1.98	−$0.17
6	0.6	$2	0.4	$1.60	0.6	$3.85	0.4	$0.10	$1.84	$2.35	−$0.51
7	0.7	$2	0.3	$1.60	0.7	$3.85	0.3	$0.10	$1.88	$2.73	−$0.84
~~**8**~~	~~0.8~~	~~$2~~	~~0.2~~	~~$1.60~~	~~0.8~~	~~$3.85~~	~~0.2~~	~~$0.10~~	~~$1.92~~	~~$3.10~~	~~−$1.18~~
~~**9**~~	~~0.9~~	~~$2~~	~~0.1~~	~~$1.60~~	~~0.9~~	~~$3.85~~	~~0.1~~	~~$0.10~~	~~$1.96~~	~~$3.48~~	~~−$1.52~~
~~**10**~~	~~1~~	~~$2~~	~~0~~	~~$1.60~~	~~1~~	~~$3.85~~	~~0~~	~~$0.10~~	~~$2.00~~	~~$3.85~~	~~−$1.85~~

Table 2. The deletion of the last three rows of Table 1

2.2. Our test for embedding bias in Holt and Laury's method

To test for embedding bias we ran an experiment with four sessions, labelled *A* to *D* and designed five treatments, numbered one to five.

Treatment 1 was an exact replication of Holt and Laury's, i. e., each participant faced the choice sequence of Table 1.

In Treatment 2 each participant faced the seven-pair sequence described in Table 2, i. e., obtained by deleting the last three rows from Table 1.

In Treatment 3 each participant faced the seven-pair sequence obtained by deleting rows 1, 2 and 10 of Table 1.

In Treatment 4 each participant faced the seven-pair sequence obtained by deleting rows 1, to 3 of Table 1.

Finally, in Treatment 5 each participant faced the seven-pair sequence obtained by deleting rows 1, 9 and 10 of Table 1.

Participants in the experiment were students from the Universitat Pompeu Fabra who volunteered. In each session, with a different group of participants, we run four of the five treatments in various orders, repeating one of them. Session *A*, with 28 participants, implemented Treatments 2, 3, 4, 1, 2. Session *B*, with 24 participants, Treatments 4, 5, 2, 1, 4. Session *C* with 21 participants, Treatments 1, 2, 3, 4, 1. And Session *D*, with 24 participants, Treatments 3, 2, 4, 1, 3.

The results of the four sessions appear in Tables A1 to A4 in the Appendix. Table 3 displays the ratios of safe choices per lottery-pair number and treatment, i. e., the entry for Lottery Pair # j (j = 1,…, 10) and Treatment i (i = 1,…, 5) is the quotient

$$\frac{\text{Aggregate number of } \textit{safe} \text{ choices in Lottery Pair \# } j \text{ and Treatment } i}{\text{Aggregate number of choices (safe and risky) in Lottery Pair \# } j \text{ and Treatment } i}.$$

Lottery Pair #	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
1	0.99	0.99	-	-	-
2	0.99	0.98	-	-	1.00
3	0.99	0.97	0.97	-	1.00
4	**0.98**	**0.94**	**0.96**	**0.96**	**1.00**
5	**0.91**	**0.78**	**0.84**	**0.88**	**0.83**
6	**0.74**	**0.53**	**0.58**	**0.75**	**0.50**
7	**0.35**	**0.18**	**0.33**	**0.32**	**0.04**
8	0.09	-	0.06	0.09	0.04
9	0.02	-	0.03	0.03	-
10	0.01	-	-	0.03	-
Number of Observations per Treatment	118	125	97	131	24

Table 3. Ratio of safe choices per lottery pair number and treatment (in bold the lottery pairs common to all treatments).

The inspection of Table 3 shows that, in Treatments 2 and 5, which are precisely the ones where at least two lottery pairs have been deleted at the end of the complete sequence, the percentage of safe choices for Lottery Pairs 5, 6 and 7 is remarkably smaller than in the three remaining treatments. It appears that, if the sequence ends earlier, then subjects tend to switch earlier from the safe to the risky lottery.

In particular, while for Treatments 1, 3 and 4 about one third (35%, 33% and 32%) of the participants display risk aversion in Lottery Pair 7, the percentage plummets to 18% and 4% in Treatments 2 and 5. Although less spectacularly, the percentages also appear to differ markedly for Lottery Pair 6, where the percentage of safe-choosing participants falls by as much as one third when going from Treatments 1, 3 and 4 to Treatments 2 and 5.

Figure 1 graphically compares the ratios of safe choices in Treatment 1 (our baseline) with those in Treatment 2 (the one with the largest number of lottery pairs removed at the end of the sequence) for Lottery Pairs 1 to 7. It shows a marked decrease in risk aversion when going from Treatment 1 to Treatment 2.

As noted by Harrison *et al*. (2004, p. 1), within-subjects analysis respects “the individual heterogeneity that one would expect from risk aversion, which is after all a subjective preference.” Our design allows for such analysis. In particular, we can focus on the individual decisions for Lottery Pairs 4 to 7 (the only ones common to all five treatments). It can be checked from the data in the Appendix that, when going from Treatment 1 to Treatment 2, the majority (53%) of the 97 participants shift to a *lower* number of safe choices, while 13% move to a higher number of safe choices, and 34 % maintain the same number of safe choices.

These comparisons suggest that when deciding on a particular lottery pair, its position in the list of pairs in which it is embedded matters. As observed above, it appears as if participants feel a pressure to switch to a risky choice before the end of the sequence lottery pairs. If so, this pressure is totally justified in the complete sequence of 10 lottery pairs (because anybody who likes money must choose lottery *R* in Lottery Pair 10), but may be due to an embedding bias in the sequences where a few of the last terms have been removed.

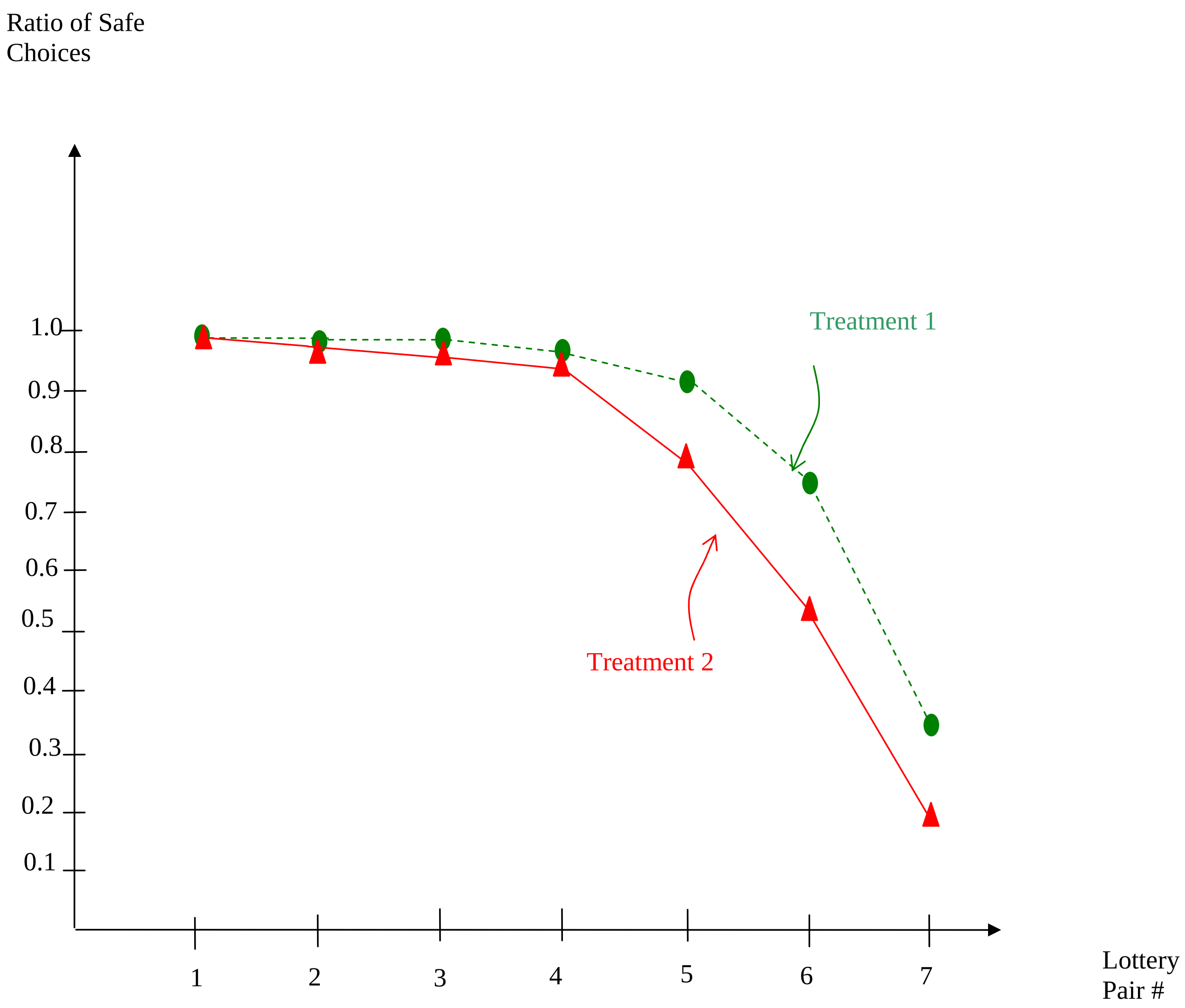

Figure 1. The Ratios of Safe Choices in Treatments 1 and 2 for the Lottery Pairs 1 to 7.

3. Our method

3.1. Our elicitation method

Our experimental elicitation method (Bosch-Domènech and Silvestre 1999, 2002, 2006a, b) also aims at analyzing risk attitudes, but differs from the one in the work of Holt and Laury.
In our experiments, a state is an amount s of potential gain. When facing state s, a participant may take one of two actions: either choosing the certain amount of money ps, or playing a lottery that gives the amount of money s with probability p (and nothing with probability $1 – p$). We ask a participant to state her action for each of the possible amounts of money gains s in a given sequence S.

In our previous work, we adopted a treatment where the sequence of possible money amounts to be gained is

$$S^* = \{€3, €6, €12, €30, €45, €60, €90\}.$$

A participant was told that she would be randomly assigned, without replacement, to one of the seven different money amounts in the treatment, and was asked to choose, for each of the different money amounts and before knowing to which of them she would actually be assigned, between the certain gain of 0.8 times the money amount and the uncertain prospect that gives the money amount with probability 0.8 and nothing with probability 0.2. We say that a participant displays *risk attraction* (resp. *risk aversion*) in a particular choice if she chooses the uncertain (resp. certain) alternative.

The participants, student volunteers from Universitat Pompeu Fabra, were given a folder to record their decisions, which contained one page for each money amount in the treatment. Every page had five boxes arranged vertically. The certain gain was printed in the first box, and the amount of money of the uncertain prospect in the second one, with the statement that the probability of winning was 0.8. The third box contained two check cells, one for choosing the certain gain, and another one for choosing the uncertain prospect.[4] Below a separating horizontal line, two more boxes were later used to record the random outcome and the take-home amount. In order to facilitate decisions, a matrix on the back of the page showed all the amounts of money involved. The participants received this information as written instructions (available on request), which were read aloud by the experimenter. The treatment began after all questions were privately answered. Once all participants had registered their decisions (under no time constraint: nobody used more than 15 minutes), their pages were collected. Participants were then called one by one to an office with an urn that initially contained a number of pieces of paper: each piece

[4] Note that there is no default, i.e., “doing nothing” is not an option.

indicated one money amount, and each of the different amounts occurred the same number of times. A piece of paper was randomly drawn (without replacement): the experimenter and the participant then checked her choice for that particular money amount. If her choice was the certain gain, she would take home 0.8 times the amount of money of her class. If, on the contrary, she chose the uncertain prospect, then a number from one to five was randomly drawn from another urn. If the number one was drawn, then the participant would take nothing home. Otherwise, she would take home the total amount of money. The participant was then paid and dismissed, and the next participant was escorted into the office.

3.2. Our test for embedding bias in our elicitation method

To test for embedding bias in our elicitation method just described, we conducted an experiment where, in addition to Treatment S^*, we implemented three new treatments, each characterized by one of the following sequences of amounts to be gained:

S^1 = {€3, €6, €12, €30, €45, €60},

S^2 = {€3, €6, €12, €30, €45}, and

S^3 = {€3, €6, €12, €30}.

The notation indicates that sequence S^t is obtained by deleting the last t terms of sequence S^* (t = 1, 2, 3). Notice that treatments S^1, S^2, S^3 and S^* share the first four amounts of money.

A participant in the experiment faced a single sequence, i.e., participated only in one treatment. We had 28 participants in Treatment S^1, 27 in Treatment S^2, 24 in Treatment S^3 , and a total of 108 corresponding to four sessions of Treatment S^*.[5]

The experimental results are presented in Tables A5-A8 in the Appendix. For each treatment we compute the frequency of choices favoring the certain gain for each amount of money at risk, see Table 4.

[5] In addition to a new session of Treatment S^*, we use also data from previous experiments reported in Bosch-Domènech and Silvestre (1999, 2002, 2006a).

In the experiments that we had previously performed involving the seven amounts of money of Treatment *S**, we had systematically verified that the frequency of *risk aversion increases* with the amount of money at stake along the sequence of money amounts. We have interpreted this pattern as being determined by the absolute amounts of money involved. But, in principle, it could also be driven by the confounding effect of how close an amount of money is to the end of the sequence presented to the participants, manifesting an embedding bias. If this were the case, we would expect that, for a given amount of money at stake, risk aversion would be more frequent when that amount appears at or near the end of the sequence. In terms of Table 4, the frequency of risk aversion for the higher amounts of money would then decrease as we move down the corresponding columns.

The inspection of Table 4 does not indicate this to be the case. The numbers are reasonable close across treatments, with a few exceptions (marked in boldface) which do not seem to have much bearing with the issue that concerns us here. In the case of the highest amount (€30) covered by all four treatments, the frequencies of risk aversion are indistinguishable and, therefore, independent on where "€30" is located in the sequence of amounts to be gained. The same is true of the highest amount of money covered by more than one treatment (€60), and for two of the three frequencies in the intermediate case of €45. In any event, there is no indication whatsoever of a decreasing frequency of risk aversion as we move down the columns.[6]

	€3	€6	€12	€30	€45	€60	€90
Treatment S^1	**0.39**	0.50	**0.65**	0.82			
Treatment S^2	0.52	0.52	0.78	0.85	0.81		
Treatment S^3	0.50	0.50	0.79	0.83	0.79	0.875	
Treatment S^*	0.45	**0.59**	0.75	0.85	0.88	0.91	0.93

Table 4. Frequency of choices favoring the certain gain (and thus displaying risk aversion).

4. Relation to the literature

The two elicitation methods tested in this paper share the following three features.

(a) Participants face lists of states, and report decisions contingent to every state.

[6] A cursory inspection of the data on risk attitude when confronting *losses* found in Bosch-Domènech and Silvestre (2006b), obtained by the same elicitation procedure, does not show evidence of embedding bias in that case either, but the sample size for each treatment is substantially smaller than here, hindering inference.

(b) The state is randomly selected, instead of being strategically chosen by a player, as in Selten's (1967) strategy method.

(c) The participant makes her decisions before knowing which state occurs. We say that the decisions (or the corresponding treatment) are "cold" if this is the case, and "hot" otherwise.

Note that the treatment is likely to be cold if participants face lists of states, but features (a) and (c) are logically independent.[7]

As we will see next, the literature offers different combinations of features (a)-(c), testing for forms of contamination similar to what we call embedding bias, but sometimes mixing embedding with temperature (hot or cold). Psychological effects of the vividness, immediacy and salience of an actual situation may generate differences between hot and cold treatments.[8] Perhaps the anticipated response (a cold response) of a person to a situation that may or may not occur differs from the actual response (hot) when the situation actually occurs, and one may conjecture that temperature potentially creates a source of bias beyond any embedding effect.

Yet our previous work shows no temperature effect for our design: In Bosch-Domènech and Silvestre (1999, 2006a) we asked the participants whether they wanted to reconsider their choice after being randomly assigned to a money amount: in fact, the same participant faced an embedded, cold decision first, and a single, hot decision later. Out of a combined total of 63 participants, only two did change their mind, which indicates that temperature, in general, played no significant role.

As in the procedure followed in the two groups of experiments that we have tested, the selection of the state is nonstrategic in Starmer and Sugden (1991). The experiment was designed to test the reduction principle in compound lotteries and the common consequence effect, rather than embedding or temperature biases. But some of the information that they obtained is germane to, if not strictly to embedding, certainly to temperature. They refer to a weak "contamination effect," defined as a tendency for the "random-lottery" responses to differ slightly from "real-choice" responses. They do not statistically test for a contamination effect, but they conclude the paper with the following words.

> "All we can say is that for the choice problems used in our experiment, subjects' responses did not differ much between the random-lottery and the real-choice designs. If there are any 'contamination effects' at work in the experiment, they seem to be fairly weak." (Starmer and Sugden, 1991, page 978.)

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[7] The following two examples illustrate the independence. Participants in Groups *A* and *D* of the experiment reported in Chris Starmer and Robert Sugden (1991) faced a list of two states, yet they knew which of the states occurred: thus the treatment was hot. Conversely, a Second Mover in Treatment 1*H* of Andrew Schotter *et al*. (1994) had to decide for only one possible state (i.e., when First Mover had chosen *R*), but her decision was cold because there was no guarantee that the state would occur.

[8] See, e.g., Richard Nisbett and Lee Ross (1980).

John Hey and Jinkwon Lee (2005) set up an experiment with two parts, “Pairwise Choice” and “Complete Ranking.” In the Pairwise Choice, subjects are faced with a list of 30 binary choices, and they are paid according to their choice in a randomly selected pair. Hence, the design is similar to Holt and Laury’s and to ours. The Complete Ranking part asks for the ranking of eleven gambles in order of preference. The design is intended to test whether subjects respond to the list as a whole or question by question. They find that the hypothesis that subjects answer question by question is strongly supported against the alternative, a result which is in line with our findings here concerning our elicitation method.

Much of the relevant literature for the case where the state is chosen by a player compares the strategy method with the ordinary-play method (that only uses date gathered at junctures of the actual play of the game), and, thus, tests for *combined* embedding-temperature effects. In Jordi Brandts and Gary Charness (2000), the hot treatment corresponds to the ordinary-play method, while their cold treatment follows the strategy method. In their words (page 228): “One might expect that some actions would trigger stronger emotional responses in this *hot* environment, where only effective actions are recorded.” Nevertheless, they conclude that there is little difference between the responses obtained by the strategy method versus the ordinary-play method. Other papers point in the opposite direction. Jeannette Brosig *et al*. (2003) find differences between the two methods for “punishment” games.[9]

Werner Güth *et al*. (2001) consider three versions of a “mini ultimatum game.” They find that some differences among the three versions which appear in the ordinary-play method disappear when the strategy method is follows, although the differences are not significant at a 5% significance level (Brandts and Charness, 2000, page 233). The “mini” in the mini-ultimamum game refers to the fact that the proposer can make only two proposals, whereas in a conventional ultimatum game proposers can propose any division, perhaps subject to step constraints. Robert Oxoby and Kendra McLeish (2004) conduct ultimatum game experiments (dividing $10 at $1 steps) under both the strategy and the ordinary-play methods, and report similar results in them.[10] Timothy Cason and Vai-Lam Mui (1998) report on experiments for the Dictator Game, where the first mover decides how to divide $40 constrained to $2 steps (a total of 21 possible divisions, (40, 0), (38, 2) and so on), whereas the second mover, contrary to the

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[9] But they presented the information in a matrix rather than a tree, and we know from Schotter *et al*. (1996) that this may not be innocuous.

[10] As in Brandts and Charness (2000), in the strategy method participants have to report their strategies for both the contingency where they play first mover and for that where they play second mover, but they actually play either first or second mover, the alternative being selected at random. Hence, the selection of the state has both strategic and random components.

ultimatum game, has no choice. In order to study social influence, they designed an experiment where a first mover plays twice (with two different second movers, who never are first movers), and her second proposal can be made contingent to the first proposal of another first mover to whom she has been randomly paired. In the hot treatment, a first mover makes her second proposal after knowing the first proposal of the first mover to which she has been paired, whereas in the cold treatment she has to submit a list of 21 second proposals contingent to each of the 21 possible states, each state being defined by a first proposal of the other first mover. Note that there is no real strategic interaction between a first mover and the other first mover to which she has been randomly paired, because a first mover's payoff does not depend on another first mover, but the (payoff irrelevant) state is decided by another player. Cason and Mui (1998) find no significant different between the two methods.

4. Conclusions

The possibility of biases due to embedding or temperature cannot be ignored. While some elicitation designs in the literature appear to be free from these biases, others are not. Here we have checked for embedding biases in the elicitation methods of Holt and Laury and our own by replicating the original experiments while varying the lists where the various decisions are embedded.

We find no evidence of embedding bias in our work. But we discover a degree of embedding bias in Holt and Laury elicitation method: participants tend to switch earlier to the riskier option when later pairs of lotteries are eliminated from the sequence, indicating that their original work may overestimate the extent of risk aversion. Yet the bias is purely quantitative, without casting doubts on the validity of their qualitative results.

APPENDIX: DATA

Treatment 2	Treatment 3	Treatment 4	Treatment 1	Treatment 2
SSSSSS/R	SSSSS/RR	SSSS/RRR	SSSSSS/RRRR	SSSSS/RR
SSSSSSS	SSSSS/RR	SSSS/RRR	SSSSSSS/RRR	SSSSSSS
SSSSS/RR	SSSS/RRR	SSSS/RRR	SSSSSSS/RRR	SSSSSS/R
SSSSSS/R	SSSS/RRR	SSSS/RRR	SSSSSSS/RRR	SSSSSS/R
SSSSSSS	SSSSSS/R	SSSSSS/R	SSSSSSSSS/R	SSS/RR/SS
SSSSS/RR	SSSS/RRR	SSSS/RRR	SSSSSSS/RRR	SSSSSS/R
SSSSSSS	SSSSS/RR	SSSS/RRR	SSSSSSS/RRR	SSSSS/RR
SSSSS/RR	SSS/RRRR	SS/RRRRR	SSSSS/RRRRR	SSSS/RRR
SSSSSS/R	SSSS/RRR	SSSSS/RR	SSSSSSS/RRR	SSSSSS/R
SSSSSS/R	SSSS/RRR	SSSSS/RR	SSSSSSS/RRR	SSSSSS/R
SSSSSSS	SSSSS/RR	SSSSS/RR	SSSS/RRRRRR	S/RRRRRR
SSSSSS/R	SSSS/RRR	SSS/RRRR	SSSSSS/RRRR	SSSSSS/R
SSSSSS/R	SSSSS/RR	SSSS/RRR	SSSSSSSS/RR	SSSSSSS
SSSSS/RR	SSSS/RRR	S/R/SS/RRR	SSSSSSSS/RR	SSSSS/RR
SSSS/RRR	SS/RRRRR	S/RRRRRR	SSSSS/RRRRR	SSSS/RRR
SSSS/RRR	SS/RRRRR	S/RRRRRR	SSSSS/RRRRR	SSSSS/RR
SSSSS/R/S	S/RR/SS/RR	SSS/RRR/S	SSSSSS/R/S/RR	S/RR/SSSS
SSSSSS/R	SSSSSS/R	SSSS/RRR	SSSSSS/RRRR	SSSSS/RR
SSSSSS/R	SSSS/RRR	SSS/RRRR	SSSSSS/RRRR	SSSSSS/R
SSSSSS/R	SSSSS/RR	SSSS/RRR	SSSSSSSS/RR	SSSSSSS
SSSS/RRR	SS/RRRRR	SSS/RRRR	SSSSS/RRRRR	SSSS/RRR
SSSSSS/R	SSS/RRRR	SSS/RRRR	SSSSS/RRRRR	SSSSSS/R
SSSSSS/R	SSSS/RRR	SSSS/RRR	SSSSSS/RRRR	SSSSSSS
SSSSS/RR	SSSS/RRR	SS/RRRRR	SSSSS/RRRRR	SSSSS/RR
SSSSS/RR	SSS/RRRR	SS/RRRRR	SSSS/RRRRRR	SSSSS/RR
SSSS/RRR	SS/RRRRR	S/RRRRRR	SSSS/RRRRRR	SSSSSSS
SSS/RRRR	SSS/RRRR	S/RRRRRR	SSSSS/RRRRR	SSSSSSS
SSSSS/RR	SSSSS/RR	SSS/RRRR	SSSSSS/RRRR	SSSSSS/R

Table A1. Choices of participants in Session *A* on Holt and Laury’s elicitation method.

Treatment 4	Treatment 5	Treatment 2	Treatment 1	Treatment 4
SSS/RRRR	SSSS/RRR	SSSSS/RR	SSSS/RRRRRR	SS/RRRRR
SSS/RRRR	SSSSS/RR	SSSSSS/R	SSSSSS/RRRR	SSS/RRRR
SSS/RRRR	SSSSS/RR	SSSSSS/R	SSSSSS/RRRR	SSS/RRRR
SSS/RRRR	SSSS/RRR	SSSSS/RR	SSSSS/RRRRR	SSS/RRRR
SSS/RRRR	SSSSS/RR	SSSSSS/R	SSSSSS/RRRR	SSS/RRRR
SSS/RRRR	SSSSS/RR	SSSSSS/R	SSSSSS/RRRR	SSS/RRRR
SSS/RRRR	SSSSS/RR	SSSSSS/R	SSSSSS/RRRR	SSS/RRRR
SSS/RRRR	SSSS/RRR	SSSSS/RR	SSSSSS/RRRR	SSS/RRRR
SSS/RRRR	SSSSS/RR	SSSSS/RR	SSSSSS/RRRR	SSS/RRRR
SSSSS/RR	SSSSS/RR	SSSSSS/R	SSSSSSS/RRR	SSSSS/RR
SS/RRRRR	SSSS/RRR	SSS/RRRR	SSSS/RRRRRR	S/RRRRRR
SSS/RRRR	SSSSS/RR	SSSSSS/R	SSSSS/RRRRR	SSS/RRRR
S/RRRRRR	SSS/RRRR	SSSS/RRR	SSSSSS/RRRR	S/RRRRRR
SS/RRRRR	SSSS/RRR	SSSSS/RR	SSSSS/RRRRR	SS/RRRRR
SS/RRRRR	SSS/RRRR	SSSSS/RR	SSSSS/RRRRR	SSS/RRRR
SSS/RRRR	SSSSS/RR	SSSSSS/R	SSSSSS/RRRR	SSS/RRRR
SS/R/S/RRR	SSSS/RRR	SS/R/S/RRR	SSSSS/RRRRR	SSS/RRRR
SSS/RRR/S	SSS/RRR/S	SSS/RRR/S	SSSSSSSSSS	RRR/SSSS
SSSS/RRR	SSSSS/RR	SSSSSS/R	SSSSSSS/RRR	SSSS/RRR
SSSS/RRR	SSSSS/RR	SSSSSSS	SSSSSSS/RRR	SSSS/RRR
S/RRRRRR	SSS/RR/S/R	SS/R/S/RRR	SSS/RRR/S/RRR	SSS/RRRR
SSSS/RRR	SSSSS/RR	SSSSSS/R	SSSSSSS/RRR	SSSS/RRR
SS/RRRRR	SSSS/RRR	SSSSSS/R	SSSSS/RRRRR	SS/RRRRR
SS/RRRRR	SSSS/RRR	SSSSS/RR	SSSSSS/RRRR	SS/RRRRR

Table A2. Choices of participants in Session *B* on Holt and Laury’s elicitation method.

Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 1
SSSSSSS/RRR	SSSSS/RR	SSSSS/RR	SSSS/RRR	SSSSSS/RRRR
SSSSSS/RRRR	SSSSSS/R	SSSSS/RR	SSS/RRRR	SSSSSS/RRRR
SSSSSS/RRRR	SSSSS/RR	SSSS/RRR	SSS/RRRR	SSSSSS/RRRR
SSSSSSS/RRR	SSSSSSS	SSSSS/RR	SSSS/RRR	SSSSSSS/RRR
SSSSSS/RRRR	SSSSSSS	SSSS/RRR	SSS/RRRR	SSSSSS/RRRR
SSSSSS/RRRR	SSSSSS/R	SSS/RRRR	SS/RRRRR	SSSSSS/RRRR
SSSSSS/RRRR	SSSSSS/R	SSSS/RRR	SSSSS/RR	SSSSSSSS/RR
SSSSSSS/RRR	SSSSSS/R	SSSSS/RR	SSSS/RRR	SSSSSSS/RRR
SSSSSS/RRRR	SSSSS/RR	SSSS/RRR	SSS/RRRR	SSSSSS/RRRR
SSSSSS/RRRR	SSSSSS/R	SSSS/RRR	SSS/RRRR	SSSSSS/RRRR
SSSSS/RRRRR	SSSSS/RR	SSSS/RRR	SSS/RRRR	SSSSS/RRRRR
SSSSSSSS/RR	SSSSSS/R	SSSSS/RR	SSS/RRRR	SSSSSS/RRRR
SSSSSS/RRRR	SSSSSS/R	SSSS/RRR	SSS/RRRR	SSSSSS/RRRR
SSSSSSS/RRR	SSSSSS/R	SSSS/RRR	SSSS/RRR	SSSSSSS/RRR
SSSSSS/RRRR	SSSSSS/R	SSSS/RRR	SSSS/RRR	SSSSSSS/RRR
SSSSS/RRRRR	SSSSS/RR	SSSS/RRR	SSSS/RRR	SSSSSS/RRRR
SSSSSSS/RRR	SSSSS/RR	SSSS/RRR	SSSS/RRR	SSSSSSS/RRR
SS/R/SS/RRRRR	SSSS/RRR	SSS/RRRR	SSSS/RRR	SSSSSS/RRRR
SSSSSS/RRRR	SSSS/RRR	SSS/RRRR	SS/RRRRR	SSSSSS/RRRR
SSSSSSS/RRR	SSSSSS/R	SSSS/RRR	SSS/RRRR	SSSSSSS/RRR
SSSS/RRRRRR	SSSSSSS	SSSS/RRR	SSSS/RRR	SSSSSSS/RRR

Table A3. Choices of participants in Session *C* on Holt and Laury's elicitation method.

Treatment 3	Treatment 2	Treatment 4	Treatment 1	Treatment 3
SSS/RRRR	SSSS/RRR	SSS/RRRR	SSSSS/RRRRR	SSS/RRRR
SSS/RRRR	SSSS/RRR	SS/RRRRR	SSSS/RRRRRR	SS/RRRRR
SSS/RRRR	SSSSS/RR	SSS/RRRR	SSSSSS/RRRR	SSSS/RRR
SSSSS/RR	SSSSSSS	SSSS/RRR	SSSSSSS/RRR	SSSSS/RR
SS/RRRRR	SSS/RRRR	RRRRRRR	SSS/R/S/RRRRR	SS/RRRRR
SSS/RRRR	SSSSS/RR	SSS/RRRR	SSSS/RRRRRR	SSS/RRRR
SSSS/RRR	SSSSS/RR	SSS/RRRR	SSSSSS/RRRR	SSSS/RRR
SSS/RRRR	SSSS/RRR	S/RRRRRR	SSSSSS/RRRR	SSSS/RRR
SSS/RRRR	SSSS/RRR	SS/RRRRR	SSSSS/RRRRR	SSS/RRRR
SS/RRRRR	SSSS/RRR	SS/RRRRR	SSSSS/RRRRR	SS/RRRRR
SSSSS/RR	SSSSSS/R	SSSS/RRR	SSSSSSS/RRR	SSSSS/RR
SSSSS/RR	SSSSSS/R	SSS/RRRR	SSSSSS/RRRR	SSSS/RRR
SSSSS/RR	RR/S/R/SSS	RR/S/R/SSS	RR/S/R/SSSS/RR	RR/S/R/SSS
SS/R/S/RRR	SSSSSSS	SSSSS/RR	SSSSSSS/RRR	SSSSS/RR
SSSSS/RR	SSSSSS/R	SSS/RRRR	SSSSSSS/RRR	SSSSS/RR
SSSSS/RR	SSSSSSS	SSSS/RRR	SSSSSSS/RRR	SSSSS/RR
SS/RRRRR	SSS/RRRR	RRRRRRR	SSSSS/RRRRR	SSS/RRRR
SSSSS/RR	SSSSSS/R	SSS/RRRR	SSSSSS/RRRR	SSSS/RRR
SSSS/R/S/R	SSSSS/RR	SSS/RRRR	SSSSSSSS/RR	SSSSS/RR
RRRRRRR	SSSSSS/R	SSS/RRRR	SSSSSS/RRRR	SSSS/RRR
RRRRRRR	SSSS/RRR	RRRRRRR	SSSS/RRRRRR	SS/RRRRR
SSSSS/RR	SSSS/RRR	SSSS/RRR	SSSSSSS/RRR	SSSSS/RR
SS/RRRRR	SSSS/RRR	SSS/RRRR	SSSS/RRRRRR	SSS/RRRR
SSSSSSS	SSSSSSS	SSSSSS/R	SSSSSSSSS/R	SSSSSSS

Table A4. Choices of participants in Session *D* on Holt and Laury’s elicitation method.

€3	€6	€12	€30
u	c	u	c
c	c	c	c
c	c	c	c
c	c	c	c
u	u	u	u
u	u	c	c
u	u	c	c
c	c	c	c
c	c	c	c
c	c	u	c
u	u	c	c
c	c	c	c
u	u	u	u
u	u	c	c
u	u	u	c
c	c	c	c
u	u	u	u
u	u	u	u
c	c	c	c
u	c	c	c
u	u	u	c
u	u	u	u
c	c	c	c
u	u	c	c
u	c	c	c
c	c	c	c
u	u	u	c
u	u	u	c

Table A5. Treatment S^1. A letter *c* indicates choosing the certain gain (thus displaying risk aversion), while a letter *u* indicates choosing the uncertain gain (thus displaying risk attraction). Each line corresponds to the decisions of one participant.

€3	€6	€12	€30	€45
c	c	c	c	c
c	c	c	c	c
c	c	u	c	u
c	c	c	c	c
u	u	u	u	u
u	u	c	c	c
c	c	c	c	c
c	c	c	c	c
u	c	c	c	c
u	u	u	c	c
u	u	c	c	c
c	c	c	c	c
c	c	c	c	c
c	c	c	c	c
c	c	c	c	c
c	c	c	c	c
u	u	c	c	c
u	u	c	c	c
u	u	u	c	c
c	u	c	u	u
u	u	u	u	u
c	c	c	c	c
u	u	u	c	c
u	u	c	c	c
u	u	u	u	u
u	u	c	c	c
c	c	c	c	c

Table A6. Treatment S^2. A letter *c* indicates choosing the certain gain (thus displaying risk aversion), while a letter *u* indicates choosing the uncertain gain (thus displaying risk attraction). Each line corresponds to the decisions of one participant.

€3	€6	€12	€30	€45	€60
u	u	u	c	u	c
u	u	c	c	c	c
u	u	c	c	c	c
c	c	c	c	c	c
u	u	u	u	u	u
u	u	u	c	c	u
u	u	u	u	u	u
c	c	c	c	c	c
c	u	c	c	c	c
c	c	c	c	c	c
u	c	c	c	c	c
c	c	c	c	c	c
u	c	c	c	c	c
u	u	u	u	u	c
c	c	c	c	c	c
c	c	c	c	c	c
u	u	c	c	c	c
c	u	c	c	u	c
c	c	c	c	c	c
c	c	c	c	c	c
u	u	c	u	c	c
c	c	c	c	c	c
c	c	c	c	c	c
u	u	c	c	c	c

Table A7. Treatment S^3. A letter *c* indicates choosing the certain gain (thus displaying risk aversion), while a letter *u* indicates choosing the uncertain gain (thus displaying risk attraction). Each line corresponds to the decisions of one participant.

€3	€6	€12	€30	€45	€60	€90
Data from Bosch-Domènech and Silvestre (1999)						
c	c	c	c	c	c	c
u	u	u	c	c	c	c
c	c	c	c	c	c	c
u	u	u	c	c	c	c
u	c	c	u	c	c	c
u	u	c	c	c	c	c
u	u	u	u	c	c	c
c	c	c	c	c	u	c
c	c	c	c	c	c	c
u	u	u	c	c	c	c
c	c	c	c	c	c	c
u	c	u	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
u	c	c	c	c	c	c
c	c	c	c	c	c	c
u	u	u	c	u	u	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
u	c	c	c	c	c	c
Data from Bosch-Domènech and Silvestre (2006a)						
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
u	c	c	c	c	c	c
u	c	c	c	c	c	c
u	c	c	c	c	c	c
u	c	c	c	c	c	c
u	u	c	c	c	c	c
u	u	c	c	c	c	c
u	u	c	c	c	c	c
u	u	u	u	c	c	c
u	u	u	u	u	c	c
u	u	u	u	u	u	u
c	c	c	u	u	c	u
c	c	c	c	u	u	u
u	u	c	c	u	c	u
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
u	c	c	c	c	c	c
u	c	c	c	c	c	c

u	c	c	c	c	c	c
u	c	c	c	c	c	c
u	c	c	c	c	c	c
u	c	c	c	c	c	c
u	u	c	c	c	c	c
u	u	c	c	c	c	c
u	u	c	c	c	c	c
u	u	c	c	c	c	c
u	u	u	c	c	c	c
u	u	u	c	c	c	c
u	u	u	u	c	c	c
u	u	u	u	c	c	c
u	u	u	u	u	u	c
u	c	c	c	c	c	u
u	u	c	u	c	c	c
u	u	u	u	c	c	u

Data from Bosch-Domènech and Silvestre (2002)

c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
u	c	c	c	c	c	c
u	u	c	c	c	c	c
u	u	c	c	c	c	c
u	u	c	c	c	c	c
u	u	c	c	c	c	c
u	u	c	c	c	c	c
u	u	u	c	c	c	c
u	u	u	c	c	c	c
u	u	u	c	c	c	c
u	u	u	u	u	c	c
c	u	u	c	c	c	c
u	u	u	c	c	u	c
u	u	c	c	u	u	u

New data

c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
c	c	c	c	c	c	c
u	c	c	c	c	c	c
u	u	c	c	c	c	c

u	u	c	c	c	c	c
u	u	u	c	c	c	c
u	u	u	u	c	c	c
u	u	u	u	c	c	c
u	u	u	u	u	u	c
u	u	u	u	u	u	u
c	u	u	c	c	c	c
c	c	c	c	u	c	c
c	c	c	c	u	u	c

Table A8. Treatment *S**. A letter *c* indicates choosing the certain gain (thus displaying risk aversion), while a letter *u* indicates choosing the uncertain gain (thus displaying risk attraction). Each line corresponds to the decisions of one participant.

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