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Random Lottery Incentive Mechanism in Dynamic Choice Experiments

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Abstract

Cubitt, Starmer and Sugden [*TheEconomic Journal*, 108, 1362-80, (1998)] pose a dynamic choice argument against the random lottery incentive (RLIS) mechanism. To wit, the RLIS relies on principles of dynamic choice. Thus, experimental research on the dynamic choice principles should be conducted ina single choice design. This study attempts to evaluate the empirical validity of their argument by quasi-replicating their single choice experiment in a RLIS design. Results suggest that one may use the RLISin dynamic choice experiments.

JEL classification: B49**,** C91, D11, D81

PsycINFO classification: 2360**,** 3920

Keywords: experiments, payment approaches,non-expected utility and risk, dynamic choice principles

***** I am indebted to Chris Starmer and Robin Cubitt for very insightful discussions.

1. Introduction

Cubitt et al. (1998) embodied the first experimental investigation of the theoretical correspondence[1] between EUT independence axiom[2] and the dynamic choice principles of *timing independence*, *separability*, *frame independence* and *reduction of compound lotteries*[3]. Theirstudy sets out the three sequential choice problems that connected the two typical common ratio effect (CRE) choice problems, namelythe prior risk, precommitment and two-stage lottery problems. The experimental design was characterised by a single choice incentive system and a text presentation of the problems to subjects. The main result is a failure of timing independence: the resolution of a prior risk increases risk aversion -*post resolution increased aversion* (PRIA) *behaviour*-.

The replicability of Cubitt et al. (1998) findings is of interest partly because their findings on the (novel) dynamic choice problems are striking, but also because their findings on the (traditional) static choice problems were not aligned with the existing theoretical correspondence. Thus, one wants to know whether both sets of findings could have been influenced by unusual features of their experiment. In addition, their theoretical argument against the use of the RLIS to experimentally investigate the dynamic choice principles (discussed below)provokesa crucial methodological question.

The present studyreports an experiment that attempts to both replicate and extend Cubitt et al. (1998). The replication part aims to assess the robustness of their findings under a different subject pool and some distinct design features. One of them is the use of the random lottery incentive system (RLIS). This design difference also extends Cubitt et al. (1998) findings by allowing for within subjects tests. The next section describes the main features in their study, including their criticism of the RLIS in dynamic choice experiments. Section 3 develops the motivation of the current study and the main design features that arise from it. Other procedural and design features are described in Section 4. Section 5 presents and discusses the results. Section 6 concludes.

2. Cubitt, Starmer and Sugden (1998): reviewed

The summary below briefly describes Cubitt et al.'s (1998) theoretical background. The starting point is the scaled-up and the scaled-down choice problems involved in a particular violation of EUT independence, the common ratio effect (CRE). In the scaled-up problem the individual chooses between the lotteries: S=(10,1) and R=(16,0.8;0,0.2); in the scaled-down problem, between the lotteries: S'=(10,0.25;0,0.75) and R'=(16,0.20;0,0.8). Figure 1 depicts the location of both pairs of lotteries in the Marshack and Machinaunit probability triangle.

[Insert Figure 1: Cubitt et al.'s (1998) CRE choice problems in the probability triangle]

[1] Burks (1977); Hammond(1988);McClennen(1990); Cubbit (1996);Sarin and Wakker(1998), and Etchart(2002).
[2] Intuitively, risk preferences between lotteries only depend on the distinguishing elements between them.
[3] On a dynamic choice problem -a sequence of decisions: some are made by the individual and some by chance-, the principles, respectively and intuitively, require that risk preferences do not depend on: the timing of the resolution of intermediate risks;choice or risk history; the presentation of the choice problem, nor the specific number of stages as long as the overall probability is constant.

EUT independence axiom requires individuals to choose either the S-type (safer) lottery or the R-type (riskier) lottery in both choice problems[4]. The typical CRE (or fanning-out in CRE) is the tendency for individuals to choose the safe lottery in the scaled-up problem, whilst the risky lottery in the scaled-down problem; that is, a behavioural tendency towards risk seeking as the lotteries become riskier.

The theoretical correspondence between EUT independence axiom and the sequential choice principles suggests the empirical failure of, at least one of, these principles. Cubitt et al. (1998) conducts the first experiment designed to investigate the empirical link between the CRE and the descriptive status of the sequential choice principles. To this aim, the study sets out the prior risk, precommitment and two-stage lottery choice problems. These problems make the CRE pair of choice problems behaviourally equivalent by jointly assuming the dynamic choice principles of separability, timing independence, frame independence and reduction of compound lotteries. Table 1 below shows the text presentation of the problems in the order required by the application of the dynamic choice principles, whose spirit is summarized next. In the original study (p.1379-1380), the problems are respectively labelled by number: "Problem 1", "Problem 2" and so on up to "Problem 5".

[Insert Table 1 here]

The scaled-up and the prior risk problems face the individual with a choice between Option A, the risky choice, and Option B, the safe choice. But whilst the prior risk problem has a past, i.e. a risk history (the subject has to survive a prior risk), the scaled-up one does not. If the principle of separability holds, both problems are equivalent. The precommitment problem requires the individual to precommit to one of the options in the event that he is entitled to choose, but before knowing if he will be entitled to (i.e., before the resolution of the prior risk). Timing independence –testable analogue of dynamic consistency- demands the individual to choose the same option in the precommitment and in the prior risk problem, i.e., before and after the resolution of the prior risk.The precommitment and the two-stage lottery choice problems only differ in presentation: the two-stage lottery one incorporates explicitly the prior risk as the first-stage of the lottery options. Frame independence entails that this different presentation should not affect individual behaviour. The scaled-down problem results from multiplying out probabilities applying probability rules in the two-stage lottery problem;reduction of compound lotteries demands the individual to choose equally in both problems. EUT independence axiom implies the equivalence between the scaled-down problem and the scaled-up problem. And, according to traditional individual choice theory under risk, all of the fiveproblems are behaviourally equivalent.

Cubitt et al. (1998) identify and describe the set of theories that follow the “just one principle is eliminated strategy”[5] to bring together the CRE failure of EUT independence and standard sequential choice theory. The strategy consists, as its name prescribes, of rejecting one, and only one, of the sequential choice principles whilst maintaining the others. Separability is rejected by Machina's (1989) backtracking procedure to reconcile a typical CRE

[4]In the unit probability triangle, EUT's independence axiom implies that individual's indifference curves are parallel-upward sloping straight-lines.

[5]The strategy name appears in Cubitt, Stamer and Sugden (2004).

individual with dynamic consistency; timing independence is rejected by Karni and Safra's (1989, 1990) model of behaviourally consistent choice; frame independence is rejected by Kahneman and Tversky's (1979) editing stage in prospect theory; and reduction of compound lotteries is rejected by Segal's (1987, 1989, 1990) procedure to deal with two-stage lotteries.

A key feature of their experiment is the use of a single choice design. Cubitt et al. (1998, p. 1371-72) posit the following theoretical argument against the RLIS in dynamic choice experiments. "This incentive system is valid, if and only if, the response given by the subject reflects her true preferences with respect to the task, i.e. if it coincides with the response which she would give to that task if she faced it by itself and definitely for real. Whether this is the case hinges on principles of dynamic choice." (p. 1371).They clarify the argument in footnote 8, page 1372, as follows. Any choice in a RLIS implies the precommitment to a choice before the RLIS mechanism -prior risk- is resolved. Timing independence requires the before-resolution choice to equalthe choice the subject would make after the resolution of the RLIS, i.e. the post-resolution choice. Separability requires the post-resolution choice to equal the isolated choicethe individual would makein a single choice design. Hence if both principles hold, the RLIS is valid. More concretely, "timing independence and separability are jointly sufficient for the validity of the" RLIS (footnote 8, p.1372). The question is: are they empirically necessary?

The current study attempts to shed some light on the question above by quasi-replicating their experiment within a RLIS design.In a RLIS experimental design, the scaled-up and the precommitment choice problems are equivalent by means of timing independence and separability. But also and following their reasoning in footnote 8, facing each one of themina RLISis equivalent, by timing independence and separability, to facing the corresponding one in a single choice design. A possibility is that whatever the difference is, if there is, between the preferences elicited ina *RLIS*design and the preferences elicited in a*single* choice design due to(the failure of)timing independence and separability, this difference might (should?) be common for both problems. If that were the case, one could still test the dynamic choice principles ina RLIS design.

Their experiment is "pen & paper" and operationalises risks by a physical device consisting of a bag and one hundred numbered chips. The resolution of risks was individually done for each participant by the controller picking up a chip from the bag. There are no practices before each individual faced its one and only choice problem for real. The 400 subjects that took part on the experiment were randomly allocated to each one of the five problems above.

Table 2 and Table 3 below summarise, respectively, the findings and tests of hypotheses inCubitt et al. (1998). Special mention requires Table 3 distinction between the classic test and the timing variation test in the typical CRE. The classic test of the typical CRE compares the risky choices in the scaled-up and the scaled-down problems. The timing variation strategy-typical CRE compares the pooled risky choices in the scaled-up and prior risk choice problems, on the one hand, to the pooled risky choices in the precommitment, two-stage lottery and scaled-down choice problems.

[Insert Table 2 here]

[Insert Table 3 here]

The chi-square test value of 16.89 rejects the standard choice theory assumption that all of the 5 problems are behaviourally equivalent. In addition, the principle of timing independence fails at the 1% significance level, and the failure is in the direction of more risk aversion in the prior risk problem than in the precommitment problem, i.e., a PRIA behavior. The PRIA behaviour goes in consonance with the behavior in the typical CRE, though Cubitt et al. (1998)only observe this phenomenon in the timing variation strategy test. Neither separability, frame independence nor reduction of compound lotteries fails. However, there is a considerable difference, though statistically insignificant[6], in the choice percentages (Table 2) of the two-stage lottery and the scaled-down choice problems -equivalent by the reduction principle-.

Because the Cubitt et al. (1998) is a single choice design, there is no possibility of considering whether timing independence violators also display the typical CRE or, if so, whether the CRE and the failure of timing independence go in the same direction. The current RLIS study extends their study allowing for within subject analysis.

The next section describes the experimental framework under which Cubitt et al. (1998) is exposed to a robustness test.

3. Motivation and design

First, as advanced in the introduction, the interest to replicate Cubitt et al.'s (1998) findings arises from their being, simultaneously, striking in terms of the dynamic choice principles and unexpected in terms of the static choice principle (EUT independence). This combination is puzzling because there is a well-stated theoretic correspondence among the two choice domains. Then, one might wonder if the two sets of contrasting findings could have been influenced by unusual features of their experiment.

In the replication part of the study, I am interested in whether their main findings recur in a study with a different subject pool and certain distinguishing design features. The most important of these are: (i) the use of state-dependent trees; (ii) the public draw for prior risks; (iii) the RLIS.

The use of state-dependent trees and the public draw for prior risks are intended to enhance, respectively, the visibility of the dynamic structure of the problems to subjects, relative to Cubitt et al.'s (1998) text displays, and the saliency of the prior risks. Investigation of the robustness of their findings to this type of enhancement is my second motivation. The first part requires decision trees, so I need to impose the principle of frame independence which, in turn, abolishes their distinction between the precommitment and the two-stage lottery problems. The second part was achieved by the "theatre" of the public draw. In their study, any risk was individually resolved by the controller picking up a chip from a bag. In this experiment, whilst post decision risks were privately resolved by each individual subject

[6]The z-statistic value is just 8 hundredth below the critical value.

picking a chip from the black box; each prior risk was publicly played per session by one of the participants.

My third motivation, requiring (iii), is to see whether the timing independence violation (or other dynamic choice effects) can be replicated using a RLIS. This is of interest because, notwithstandingCubitt et al.'s (1998)theoretical argument for single choice designs, the RLIS has two important practical advantages. One is that it economises on subjects, an especially important consideration when there are prior risk problems. The other is that it permits within-subject tests, so allowing the investigation to be extended. The first such test entails the comparison of individual behaviour in the pair of problems involved in the CRE (scaled-up versus scaled-down) with his behaviour in the pair of problems involved in the timing independence principle (prior risk versus two-stage). For any such pair of problems, the individual can exhibit a constant preference for the risky option, a constant preference for the safe option, a switch from the risky to the safe option or a switch from the safe option to the risky option. Are the preferences over both pairs of choice problems independent?

The Cubitt et al. (1998)quasi-replica is embodied in a comprehensive dynamic choice study that investigates also the common consequence effect. Hence, this dynamic choice experiment involves a total of 13 choice problems, 9 of which correspond to the dynamic choice framework of the common consequence effectdescribed in Ruiz-Martos (2017). Figure 2 depicts the decision tree representations of Cubitt et al. (1998)scaled-up, prior risk, two-stage lottery and scaled-down problems.

[Insert Figure 2: Cubitt et al.'s(1998) decision trees]

The scaled-up choice problem is a straightforward choice between the certainty and the lottery. The prior risk choice problem faces the individual to the choice between the certainty and the lottery but after a prior risk has been resolved. Thus, the separability principle requires the individual to choose the same option in both choice problems. The two-stage choice problem calls upon the individual to choose a particular option before the resolution of the prior risk. Conditioned on frame independence, timing independence makes the prior risk and the two-stage lottery problems equivalent. The scaled-down choice problem is the probability equivalent single-stage version of the two-stage lottery problem; consequently the reduction of compound lotteries principle demands the individual to choose equally in both problems. EUT independence axiom requires the individual to exhibit the same attitude towards risk in the scaled-up and the scaled-down problems. Finally, traditional individual choice theory makes the four problems behaviourally equivalent.

Let *f(·)* represent the percentage of risky choices in any choice problem. Within the above framework, the analogs of Cubitt et al.'s (1998)hypotheses are formulated below.

The standard individual choice theory under risk implies the null hypothesis $H1_0$:

H1 (Standard choice theory):

$H1_0$:*f(Scaled-up)=f(Prior Risk)=f(Two-stage)=f(Scaled-down)*.

$H1_A$: not [·].

The null hypothesis for the separability principle faces two constrasting alternative hypotheses. Machina (1989) argues that if the typical CRE individual uses a back-tracking procedure, so that he identifies the options available at the prior risk choice problem as the lotteries implied by the tree as a whole, he will choose the risky option in the prior risk problem but the safe one in the scaled-up problem. Isen (1999) reports evidence that subjects who had been induced positive affect are more risk averse than those on a neutral affective state; so if surviving a prior risk that entitles the subject to make a choice induces positive affect, the individual will exhibit the opposite behaviour to the one prescribed by Machina (1989). Formally:

H2 (Separability):

$H2_0$:*f(Scaled-Up)=f(Prior Risk)*;

$H2_{A_1}$ (Machina89): *f(Scaled-Up)*<f(Prior Risk);

$H2_{A_2}$ (Isen99): *f(Scaled-Up)>f(Prior Risk)*.

With respect to the alternative hypothesis to timing independence, the Cubitt et al. (1998)finding of an increase in risk aversion from before to after the resolution of the prior risk constitutes the post resolution increased aversion to risk -PRIA-behaviour:

H3 (Timing Independence):

$H3_0$:*f(Prior Risk)=f(Two-stage)*;

$H3_A$ (PRIA): *f(Prior Risk)<f(Two-stage)*.

Segal's (1987, 1989, 1990) procedure to deal with two-stage lotteries gives the alternative hypothesis of the reduction of compound lotteries axiom (RCLA):

H4 (RCLA):

$H4_0$:*f(Two-stage)=f(Scaled-down)*;

$H4_A$: not [·].

And the alternative hypothesis of the EUT independence axiom is the typical CRE behaviour:

H5 (EUT independence):

$H4_0$:*f(Scaled-up)=f(Scaled-down)*;

$H4_A$(typical CRE): *f(Scaled-up)<f(Scaled-down)*.

4. Other procedural and design features

Figure 3 captures the state-wise dependent decision tree representation of the prior risk choice problem in the experiment. The other three choice problems were represented by the corresponding modification of this decision tree diagram.

Note that, unlike the original study, risks are operationalised by one hundred poker chips -of three distinct colours- in a black box. In particular, there were 75 blue, 20 green and 5 red poker chips. This colourful representation of the states of the world pursued to simplify the decision tree diagram and the understanding of probabilities to individual subjects; and conditioned the decision tree diagram to be state-dependent.

The letter "K" on the top-right corner did not convey any more information to participants other than a code -an alphabet letter ranging from A to M- that would randomly determine the one and only risk choice that each subject would play out for real at the end of the experiment.

[Insert Figure 3 here]

After each risk task, subjects had to answer three general knowledge questions. Knowledge tasks (available upon request) served as fillers and were incentivised at 10 pence per each correct answer. Thus each subject faced a total of 13 risk tasks and 36 knowledge tasks and the average payoff was of £7 for an experiment that lasted no more than one hour.

Like Cubitt et al. (1998), the current study is a "*pen&paper*" design. A novel feature of this "*pen&paper*" RLIS experiment is that it is not instrumented by a booklet, as many others "*pen&paper*" RLIS designs, but by the following procedure. Any task, either risk or the three knowledge ones, was presented in a decision sheet that was handed in to subjects only at the moment they had to make a choice or to answer the knowledge questions. After completing each task, subjects were instructed to put the corresponding decision sheet inside an A4-size manilla envelope. This procedure ensured that (i) when answering a risk choice problem, subjects did not know what other problems would follow; (ii) subjects were not allowed to alter their choices in earlier risk problems when late ones were revealed. A standard booklet format guarantees neither (i) nor (ii), if subjects can leaf freely through the booklet.

Instructions were supported by a Power Point presentation that helped to illustrate the decision tree diagram and the knowledge tasks. The decision tree diagram in figure 3 was explained by some examples of risk choice problems[7]with different monetary consequences than Cubitt et al. (1998); and knowledge tasks, by an example. The instructions finished with a summary of the earnings subjects could have in each task; but the Powerpoint presentation continued until the end of the experiment displaying the corresponding task at each time of the session.

5. Results

5.1. Replication

The experiment was conducted at the University of Nottingham during the 2006-2007 winter across a total of 15 sessions where 78 participants took part. A by-product of the unique and public resolution of the prior risks per session is that only 32 subjects survived to

[7]Specifically: a medium common consequence effect, a two-stage lottery and a prior risk choice problem.

make a choice in the prior risk problem; a number which, though small, is still acceptable to test the separability principle in this part of the study.

[Insert Table 4 here]

Table 4 above summarises the percentage of risky choices for any choice problem. The very clear tendency to risk seeking in the scaled-down problem in comparison with the scaled-up problem indicates the presence of a typical CRE (see below). In terms of the dynamic choice problems, the most noticeable discrepancy in the percentage of risky choices appears between the prior risk and the two-stage lottery choice problems, and in the direction of the PRIA behaviour as observed by Cubitt et al. (1998). In addition, there is almost no difference in risk seeking between the two-stage lottery and the scaled-down choice problems; and there is an increase in risk aversion from the scaled-up to the prior risk choice problem, as predicted by the affect hypothesis. Which of these differences are statistically significant?

Please, in table 5, let Up, Prior, Two and Down stand for the scaled-up, prior risk, two-stage lottery and scaled-down choice problems in the first column list of the hypotheses. Columns two and three show the relevant test statistic[8]. The last two columns capture the status of the null hypothesis and the significant level of rejection.

[Insert Table 5 here]

Similarly to Cubitt et al. (1998), the χ^2 value of 33.456 rejects the null hypothesis that all of the four problems are equivalent. Similarly too, neither separability nor reduction of compound lotteries can be rejected, and timing independence exhibits the PRIA failure. Interestingly, unlike the original study, the z-statistic implies that the observed typical CRE is significant at the 1% level. Recall that when explaining the current design features, one of the questions was the implications for the dynamic choice principles of a significant CRE. The latter could have implied the failure of another dynamic choice principle, besides timing independence. However, the results show that the significance of the CRE is translated only into an even more significant rejection of timing independence (please compare the z-statistic value in table 3 and in table 5).

The diagram in figure 4 offers a visual comparison of the percentages of risky choices in both studies. The data from the current study lie above, though close to, the Cubitt et al. (1998) data; the only substantial gap between the two lines is for the scaled-down problem. That reflects the finding that the current study finds a typical CRE with the classic test whilst Cubitt et al. (1998) does not. The diagram conveys very good methodological implications for the use of the RLIS to elicit individual dynamic choice preferences as the RLIS data follow almost exactly the same pattern of risk tendencies as the single choice data: the two sets of data move in synchrony. Obviously, it also supports the robustness of the behavioural patterns observed in the original study and makes timing independence a crucial determining dynamic factor of the typical CRE.

[Insert Figure 4 here]

[8]The critical values of the z statistic are: ±1.96 (1.65 for one-sided test) at 5% significance level and ±2.58 (2.35 for one-sided test) at 1% significance level.

5.2. Extension

This Section explores one of the advantages of within-subject comparisons provided by the RLIS. The main replication findings are a significant typical CRE and a significant violation of timing independence -in the PRIA direction-. Thus, it is very interesting to compare each individual's behaviour in the CRE problems with his behaviour in the timing independence problems.

With respect to the CRE, i.e. the scaled-up and scaled-down choice problems, the individual can exhibit four types of behaviour: a constant preference for risk (for short: R-R), a constant preference for safe (S-S), fanning-in (risk in the scaled-up and safe in the scaled-down: R-S) or fanning-out (S--R). And the same typology applies to the timing independence problems, prior risk and two-stage lottery; where I have called PRIA –post resolution increased aversion- and reverse PRIA the switch in individual preferences, respectively, from risky to safe and from safe to risky. If the typical CRE is explained or caused by the PRIA failure of timing independence, one could expect a relatively large number of subjects that exhibit that combination of behaviour. The contingency table 6 describes the behaviour in both sets of problems of those subjects (32) that survived the prior risk. First, one can see that 15 subjects violate EUT independence (46.87%); and 17 (53.12%) violate timing independence. Then, out of the 13 subjects that exhibit the typical CRE (fanning-out), none of them incurs in the reverse PRIAviolation whilst 9 subjects exhibit the PRIA behaviour. Also it is worth noting that, for these subjects, S-R is modal in both sets of problems. And of those subjects who violate standard theory in both pairs of problems, all are S-R in both problems. The lack of observations in some of the categories makes, however, the chi-square test of independence unreliable.

[Insert Table 6 here]

6. Conclusions

Cubitt et al. (1998) is a pioneer study of the dynamic choice principles within the CRE framework. The study tests the dynamic choice principles of separability, timing independence, frame independence and reduction of compound lotteries that jointly imply the equivalence between the scaled-up and the scaled-down choice problems. It is a “pen & paper” design characterised by a single choice incentive mechanism, a text presentation of problems to subjects and an individual resolution of any risk. The main finding is a failure of the timing independence principle-in the direction of post resolution increased aversion to risk- without, strictly speaking, a typical CRE –shift towards risk seeking the riskier the lotteries-.

The current “pen & paper” study tests the robustness of Cubitt et al. (1998) with a different population and under sensibly distinct design features. The most important design differences are: the use of state-dependent trees; the public draw for prior lotteries; and the use of a RLIS. The first two features aimed to enhance the dynamic structure of the problems -

by imposing frame independence- and the saliency of the prior risks. The last one aimed to investigate the appearance of dynamic choices effects under an incentive system that, while economising on subjects, extends Cubitt et al. (1998) findings to within-subject comparisons. Despite the experimental differences, individuals risk tendencies are pretty much the same with respect to the dynamic choice principles of separability, timing independence and reduction of compound lotteries. Timing independence fails, the only one that does, and it does so in the PRIA, post resolution increased aversion, direction. The discrepancy with Cubitt et al.'s (1998) results is that there is a significant typical CRE. Thus, a first conclusion is that Cubitt et al.'s (1998) dynamic choice findings are robust. Second, it seems that the RLIS can replicate dynamic choice behavioural patterns. That is to say, the results of this study suggest that the empirical difference, if there is, between the preferences elicited in a RLIS and the preferences elicited in a single choice design, due to timing independence and separability, may be common for the choice problems involved. In fact, many dynamic choice studies (Busemeyer, Weg, Barkan, Li, and Ma, 2000; Johnson and Busemeyer, 2001; Ruiz-Martos, 2017) use this incentive system and their findings are pretty much in line with those in Cubitt et al. (1998).

The within-subject comparison between individuals' behaviour in the CRE choice problems and in the timing independence problems is very interesting. Out of the 13 subjects that show a typical CRE, 9 subjects have the PRIA –post resolution increased risk aversion- behaviour and none of them has the reverse PRIA violation. But the numbers are small and the chi-square test of independence cannot be applied.

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Figures

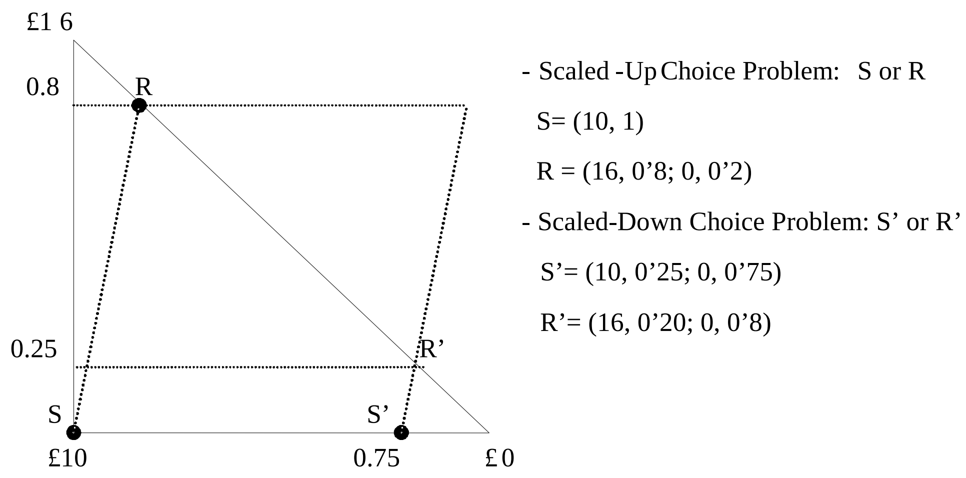


Figure 1: Cubitt et al.’s (1998) CRE choice problems in the probability triangle

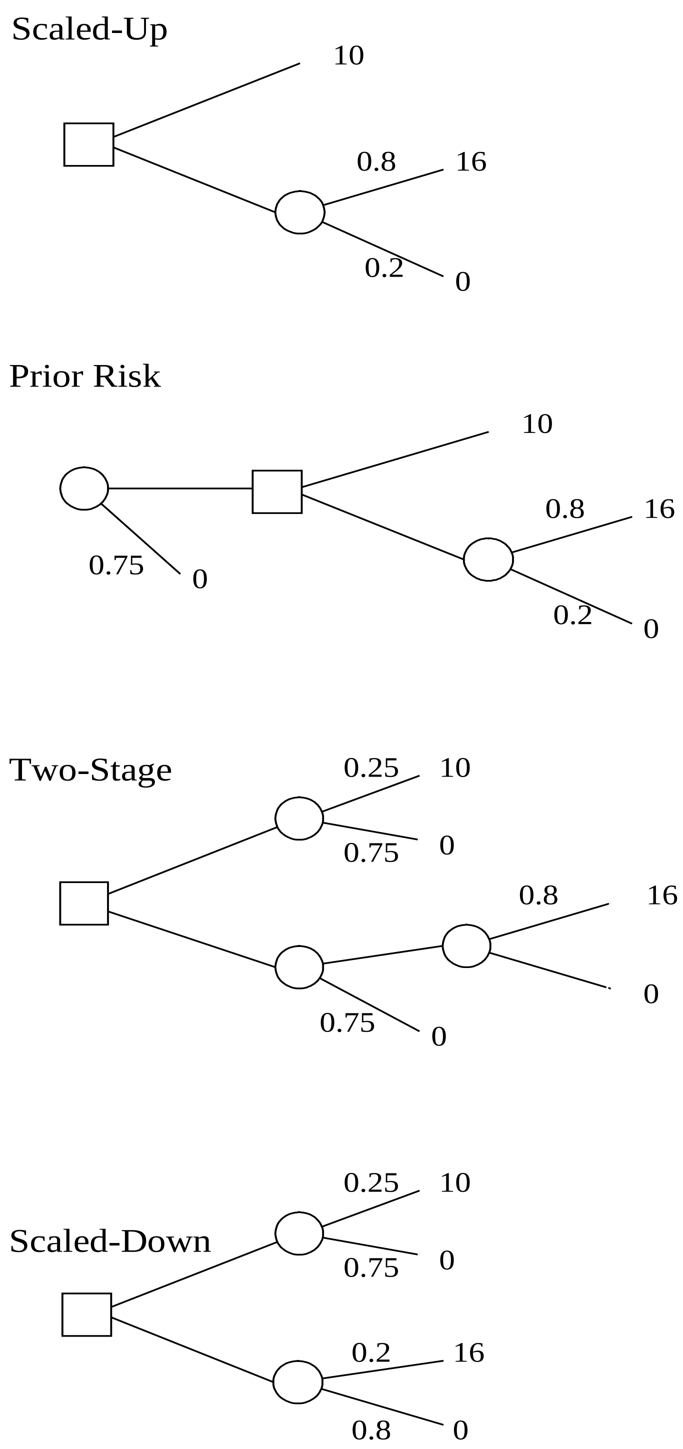
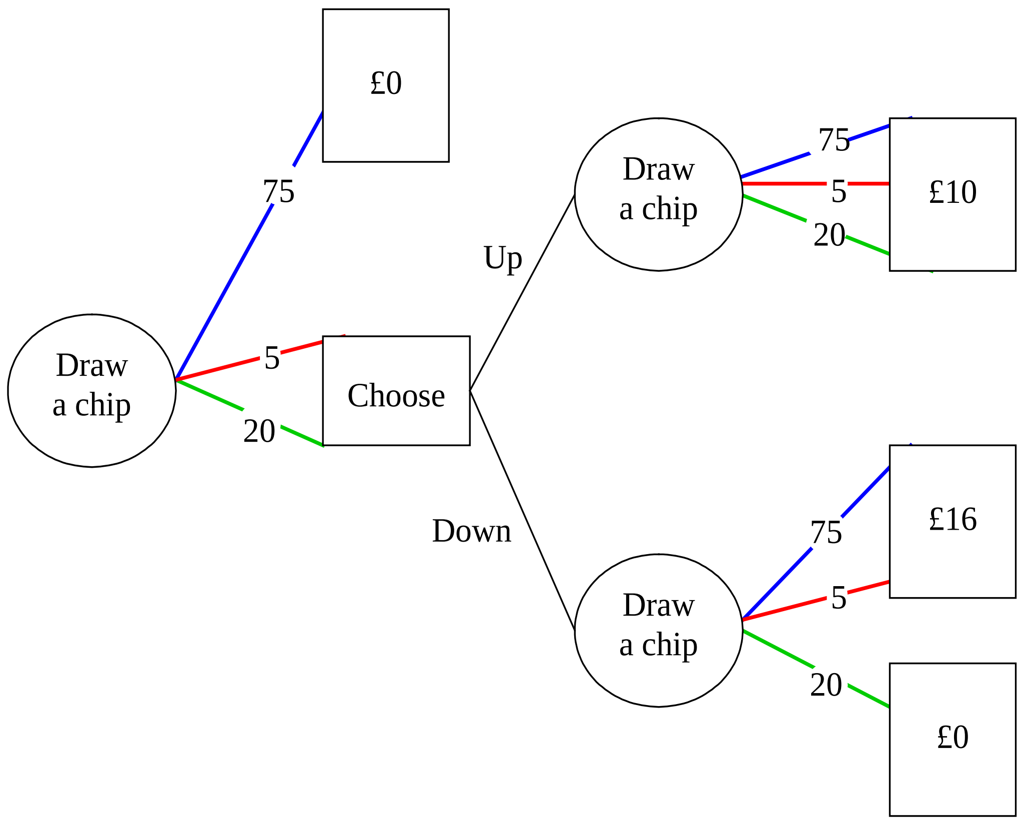


Figure 2: Cubitt et al.'s (1998) decision trees

K

There are 100 chips in the box: 75 blue, 5 red and 20 green.

Choose either Up or Down:



I'm subject number ____________ ☐ I choose Up

☐ I choose Down

Figure 3: State-wise decision tree diagram for the Prior Risk Problem in Cubitt et al. (1998)

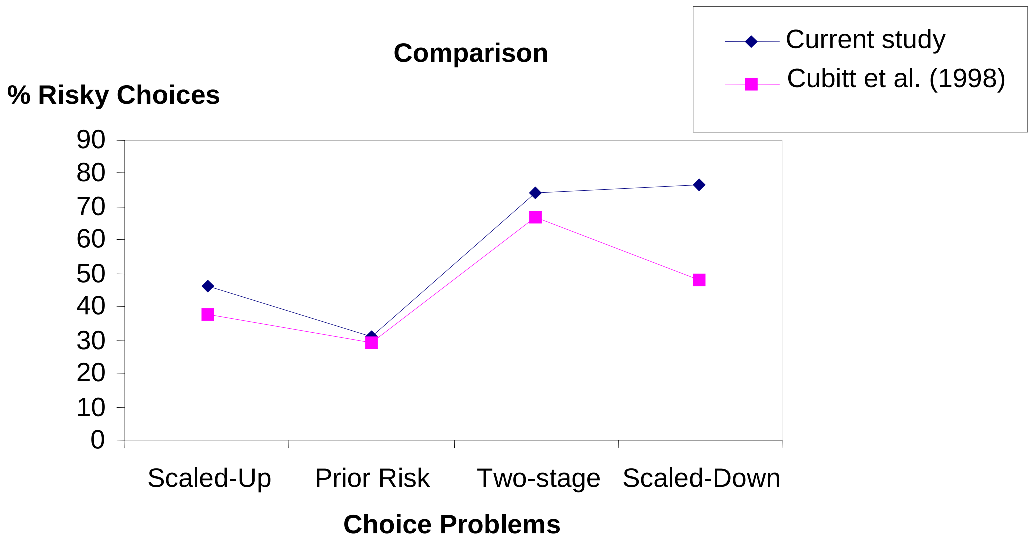


Figure 4: Risky tendencies in Cubitt et al. (1998) and current study

Table 1. Cubitt et al.'s (1998) set of choice problems.

Scaled-Up problem	Choose either option A or option B: **Option A**: The controller will draw a chip from the bag. If it is numbered 1-20, you will receive nothing. If it is numbered 21-100, you will receive £16. **Option B**: No chip will be drawn from the bag. You will receive £10.
Prior Risk problem	The controller will draw a chip from the bag. If it is numbered 1-75, you will receive nothing. If it is numbered 76-100, you will receive one of the following: **Option A**: The controller will draw a second chip from the bag. If it is numbered 1-20, you will receive nothing. If it is numbered 21-100, you will receive £16. **Option B**: No further chip will be drawn from the bag. You will receive £10. IF THE FIRST CHIP DRAWN IS NUMBERED 76-100. YOU WILL BE ASKED TO CHOOSE EITHER OPTION A OR OPTION B.
Precommitment problem	The controller will draw a chip from the bag. If it is numbered 1-75, you will receive nothing. If it is numbered 76-100, you will receive one of the following: **Option A**: The controller will draw a second chip from the bag. If it is numbered 1-20, you will receive nothing. If it is numbered 21-100, you will receive £16. **Option B**: No further chip will be drawn from the bag. You will receive £10. YOU MUST NOW CHOOSE WHICH OPTION TO HAVE IF THE FIRST CHIP DRAWN IS NUMBERED 76-100.
Two-Stage Lottery problem	Choose either Option A or Option B: **Option A**: The controller will draw a chip from the bag. If it is numbered 1-75, you will receive nothing. If it is numbered 76-100, the controller will draw a second chip from the bag. If it is numbered 1-20, you will receive nothing. If it is numbered 21-100, you will receive £16. **Option B**: The controller will draw a chip from the bag. If tis numbered 1-75, you will receive nothing. If it is numbered 76-100, you will receive £10.
Scaled-Down problem	Choose either Option A or Option B: **Option A**: The controller will draw a chip from the bag. If it is numbered 1-80, you will receive nothing. If it is numbered 81-100, you will receive £16. **Option B**: The controller will draw a chip from the bag. If it is numbered 1-75, you will receive nothing. If it is numbered 76-100, you will receive £10.

Table 2: Summary of Cubitt et al.'s (1998) Results

ChoiceProblem	Number of Subjects	Risky Choices (%)	Safe Choices (%)
Scaled-Up	50	38.0	62.0
Prior Risk	45*	28.9	71.1
Precommitment	51	56.9	43.1
Two-stage Lott.	48	66.7	33.3
Scaled-Down	52	48.1	51.9
Total	246	48.0	52.0

*Out of 201 participants in the prior risk problem, 45 made a choice.
Source: Table 2 in Cubitt et al. (1998).

Table 3: Summary of hypotheses tested in Cubitt et al. (1998)

HypothesesTested	Test Statistic	
	χ^2	z
Standard Choice Theory	16.89***	n.a
Separability	-	0.938
Timing Independence	-	-2.76***
Frame Independence	-	-1.00
RCLA	-	1.88
Typical CRE (Classic Test)	-	-1.03
Typical CRE (Timing Variation)	-	-3.56***

Source: Table 3 in Cubitt et al. (1998).
*** means 1 % significance level.
"-" means "not applicable".

Table 4: RLIS Risky Choices for Cubitt et al. (1998)quasi-replica

ChoiceProblem	Scaled-Up	PriorRisk	Two-Stage	Scaled-Down	Total RiskyChoices
Number	36	10	58	60	164
Frequency (%)	46.15	31.25	74.36	76.92	61.65
Total Choices (N)	78	32	78	78	266

Table 5: Summary of Hypotheses Tested with RLIS

Statement of Hypotheses	Test Statistic	
	χ^2	z
H1: Standard Choice Theory $H1_0$: *f(Up)=f(Prior)=f(Two)=f(Down)* $H1_A$: not	33.456	-
H2: Separability $H2_0$:*f(Up)=f(Prior)* $H2_{A_1}$ Machina87: *f(Up)<f(Prior)* $H2_{A_2}$ Isen99: *f(Up)>f(Prior)*	-	1.49
H3: Timing Independence $H3_0$:*f(Prior)=f(Two)* $H3_A$(PRIA): *f(Prior)<f(Two)*	-	-4.5
H4: RCLA $H4_0$:*f(Two)=f(Down)* $H4_A$:not	-	-0.37
H5: EUT independence $H5_0$:*f(Up)=f(Down)* $H5_A$ (typical CRE): *f(Up)<f(Down)*	-	-4.16

*** means 1 % significance level.
"-" means "not applicable".

Table 6: CRE and Timing Independence

CRE Problems	Timing Independence Problems				Totals
	R-R	S-S	R-S	S-R (PRIA)	
R-R	3	1	1	4	9
S-S	1	4	1	2	8
R-S	2	0	0	0	2
S-R (typical)	2	2	0	9	13
Totals	8	7	2	15	32