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Abstract

What should you do when confronting a sequence of decisions such that you make some choices and chance makes some others, i.e., a dynamic decision making problem under risk? Standard economic rationality requires you to look at the final choices, determine the preferred options, choose the sequence of decisions that lead to those and follow that sequence through to the end. That behaviour is implied by the conjunction of the principles of separability, dynamic consistency and reduction of compound lotteries. Experimental research on these dynamic choice principles has been developed within the common ratio effect theoretical framework. This paper experimentally investigates what subjects do when confronting such a problem within a new theoretical framework provided by the common consequence effect that manipulates the value of the foregone-consequence in the prior risks.Results suggest that reduction of compound lotteries holds throughout, whilst dynamic consistency and separability do not and theirfailure is related to the foregone-consequence.

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Keywords: reduction of compound lotteries, dynamic consistency, separability, non-expected utility and risk

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1. Introduction

Many decisions (e.g., career, health and investments) involve both the individual and chance in a sequence of choices. Standard economic rationality requires the individual, facing such a sequence and independently of its presentation, to look at the final consequences, determine the preferred one, select the sequence of choices leading to it, and follow that sequence through to the end. This behaviouris implied by the conjunction of the dynamic choice principles of frame independence, reduction of compound lotteries, separability and dynamic consistency.These principles together implythe independence axiom of expected utility theory (EUT)(von Neuman and Morgernstern, 1947). However, the descriptive validity of EUT independence(for instance, seeCamerer, 1995; Starmer, 2000) is at least controversial. Therefore, the descriptive validity of the dynamic choice principles that jointly imply EUT independence is questionable too.

Two well-known empirical violations of EUT independence axiom are the common ratio effect (CRE) and the common consequence effect (CCE)[1]. To this day and the best of my knowledge, the experimental research on dynamic choice principles has been developed within the theoretical framework provided by the CRE[2] (details in Section 2). The CRE offers two instrumental variables to study the dynamic choice principles: the number of chance choices and the overall survival probability. This experimental evidence suggests that dynamic consistency is a crucial explanatory factor of the CRE; and that the descriptive adequacy of frame independence, separability and reduction of compound lotteries is borderline[3]. To extend the experimental research on the dynamic choice principles, I used the distinct theoretical framework provided by the CCE. The CCE adds a new instrumental variable: the value of the common consequence in chance choices.

This paper describes an experiment that presents all choice problems in the form of the standard decision tree diagram (e.g., Keeny and Raiffa, 1976) and, thus, imposes the principle of frame independence. Hence, the experiment tests the dynamic choice principles

[1] Both first predicted by Allais (1953).
[2] Barkan and Busemeyer (1999); Bossman and van Winden (2005); Busemeyer, Weg, Barkan, Li and Ma (2000); Cubitt, Ruiz-Martos and Starmer (2012); Cubitt, Starmer and Sugden(1998); Cubitt and Sugden(2001); Hopfensitzand van Winden (2008) and Johnson and Busemeyer (2001).
[3] These principles seem to hold when individually considered but evidence suggests their violation when they are jointly considered with another principle.

of reduction of compound lotteries, dynamic consistency and separability under the CCE theoretical framework. Section 2 reviews related literature and the CCE dynamic choice framework follows in Section 3. Section 4 presents the experimental design. The hypotheses tested are in Section 5. Results and discussion are in Section 6. Conclusions are in section 7.

2. Related literature and the CCE dynamic choice framework

Cubitt, Starmer and Sugden (1998) adjust Cubit's (1996) dynamic choice framework to the experimental investigation of the CRE. Among other features, Cubitt *et al.* (1998) define each dynamic choice principle as a between-problems condition and introduce timing independence as a testable analogue to dynamic consistency. They observe a failure of timing independence in line with the typical CRE - more risk seeking when lotteries are riskier-, despite not observing a significant typical CRE. This failure of timing independence intuitively implies that subjects plan to choose riskier but they choose safer; in addition, it is found to depend on the reference point (Barkan and Busemeyer, 1999) and on the number of prior risks (Busemeyer*et al.*, 2000; Johnson and Busemeyer, 2001), and to be independent of the existence of practice trials and on the particular experimental design.

Cubitt, Ruiz-Martos and Starmer (2012) study separability. Machina (1989) argues that the typical CRE individual uses a backtracking procedure that makes him dynamically consistent at the expense of separability[4]: he chooses riskierafter surviving a risk than when facing the same choice without history[5]. Isen (1999) finds that subjects who had been induced positive affect are more risk averse than those on a neutral affective state. Both reasons imply opposite failures if, as Cubitt *et al.*(2012) claim, surviving a risk that entitles one to make a choice (otherwise nothing) induces positive affect. Todiscriminateamongboth failures, they compared between subjects choices in different prior risk choice problems. This study finds no evidence of a failure of separability, as to date in dynamic choice experiments.

The conjunction of several dynamic choice principles is also descriptively problematic. Cubitt and Sugden (2001) observe,under a reverse CRE –less risk seeking when lotteries are riskier- a joint failure either of timing independence and separability or of reduction of compound

[4]Machina (1989) names it consequentialism.
[5]This argument is in line with McClennen's (1990) resolute choice and the normal form approach to decision making (Cubitt, Ruiz-Martos and Starmer, 2012).

lotteries and EUT independence. Also under a reverse CRE, Bossman and van Winden (2005) find a joint failure of separability, timing independence and frame independence. The failure of timing independence in the context of a reverse CRE, though it cannot be disentangled from other dynamic choice effects, suggests that subjects seem to plan to choose safer but actually choose riskier[6]. Finally but under a typical CRE, Hopfensitz and van Winden (2008) find evidence of a failure of the conjunction of separability, timing independence and frame independence or of the conjunction of reduction of compound lotteries and EUT independence.

3. The Common Consequence Effect Dynamic Choice Theoretical Framework

3.1. Static Choice

Consider the set of monetary consequences $C=\{c_1,c_2,c_3\}$ where $c_1>c_2>c_3\geq 0$, and the lotteries $S_i=(c_2,p;c^*,1-p)$ and $R_i=(c_1,\lambda p;c_3,(1-\lambda)p;c^*,1-p)$, where $c^*\in\{c_1,c_2,c_3\}$ and probabilities $p,\lambda\in(0,1)$. Under EUT CC property, the value of the CC, c^*, is irrelevant for the preference order between these lotteries[7].

The CCE concerns the value of c^*systematically affecting the choice among lotteries of the form S_i, R_i. Allais (1953) predicted this famous counter-example[8] of EUT independence that has been observed in many subsequent studies (e.g., for reviews see Camerer, 1995 and Starmer, 2000; for a recent study see Huck and Muller, 2012) andreveals a behavioural tendency to choose S when $c^*=c_2$ and the lotteries are safer, but to shift towards R when $c^*=0$ and the lotteries are riskier. Intuitively, individuals choose riskier as c^* decreases.

One can construct pairs of lotteries to which the CC property applies by manipulating the value of c^*. I will refer to the choice between a) S_M and R_M, where $c^*=c_2$, as the medium CCE choice problem; b) $S_L$and R_L, where $c^*=c_3$, as the low CCE choice problem; and c) S_H and R_H,

[6] This is just the opposite to the failure of timing independence under the typical CRE.

[7] To see this, recall that EUT permits, provided that more money is preferred to less, the normalisation: $u(c_l)=1$ and $u(c_3)=0$. Then looking at their expected utilities below, it is clear that whether $EU(S) \geq\leq EU(R)$ is determined by $u(c_2)\geq\leq \lambda$: $EU(S) = p*u(c_2)+(1-p)*u(c^*)$ and $EU(R) = \lambda p+(1-p)*u(c^*)$.

[8] The example calls upon subjects to choose between first: $S_1=(1,1)$ and $R_1=(5, 0.10; 1, 0.89; 0, 0.01)$; and then between: $S_2=(1, 0.11; 0, 0.89)$ and $R_2=(5, 0.10; 0, 0.90)$ -the monetary unit is one million french francs-. The Allais Paradox is the systematic tendency to choose S_1 on the first choice problem but R_2 on the second one. To see why this behaviour contradicts the common consequence property, write the lotteries as: $S_1=(1, 0.11; 1, 0.89)$ and $R_1=(5, 0.10; 1, 0.89; 0, 0.01)$; versus $S_2=(1, 0.11; 0, 0.89)$ and $R_2=(5, 0.10; 0, 0.01; 0, 0.89)$. The 1 million common consequence in the first pair of lotteries has been substituted by 0 in the second pair.

where $c^*=c_1$, as the high CCE choice problem. If individual preferences have the CC property, we should observe either a constant preference for the safer option over the riskier lottery (i.e. $S_H \succ R_H$, $S_M \succ R_M$, $S_L \succ R_L$) or exactly the opposite pattern.

Experimental evidence is mixed regarding the alternative behavioural pattern, i.e., some studies report shifts from risk aversion to risk seeking as c* decreases (Machina, 1987; Starmer and Sugden, 1991; Huck and Muller, 2013); but some others report an opposite or even a mixed behaviour depending on the particular substitution (e.g., Conlisk, 1989; Starmer, 1992; Camerer, 1995; Wu and Gonzalez, 1998; Humphrey and Verschoor, 2004; Blavastkyy, 2013) and on other experimental design features such as the similarity of probabilities or of the non-zero consequences, the population, the stakes, the incentive systemand the representation of the lotteries (for a recent review see Blavastkyy, Ortmann and Panchencko, 2015). The crucial issue is that, parallel to the CRE, the CCE implies the empirical failure of some, or at least one, of the rational dynamic choice principles of separability, timing independence, frame independence and reduction of compound lotteries.

3.2 Dynamic Choice Framework

I report an experiment that tests the CC property in a design featuring the high, medium and low CCE choice problems. Given the existing literature, and appropriately selected parameters, there is a high expectation of finding a CCE reducing the value of c* (comparing the medium and the low CCE choice problems) and some expectation of finding a violation increasing the value of c* (comparing the medium and the high CCE choice problems). Such violations, if they existed, however, would also have implications for the dynamic choice principles. I demonstrate this following the spirit of the approach in Cubitt *et al.*(1998): that is by identifying a set of dynamic choice problems that connect pairs of CCE choice problems. However and unlikethem, I follow a framework of decision trees throughout that imposes the principle of frame independence: all choice problems are presented in the form of standard decision tree diagrams[9] (e.g., Keeny and Raiffa, 1976). Although that means

[9]In the conventional approach to decision trees, lotteries and individual choices are represented by, respectively, circles and squares; a branch out of a square represents a choice option and a branch out of a circle represents an event or state of the world.

that I can test one fewer principle than Cubitt *et al.*(1998), it has an important motivation relative to my experimental objectives which will be discussed in the next section.

Figure 1 depictsthe sequence of choice problems involved in the CCE dynamic choice framework. The decision trees H_1, M_1 and L_1 in the first row represent, respectively, the high, med and low CCE choice problems. Decision tree M_1 calls upon the individual to choose between the lotteries $S_{M_1}=(c_2,1)$ and $R_{M_1}=(c_1,\lambda p;c_2,1-p;0,p(1-\lambda))$, where the lowest consequence is $c_3=0$ and $c^*=c_2$. Similarly, Tree L_1 and Tree H_1represent the choices between, respectively, $S_{L_1}=(c_2,p;0,1-p)$ and $R_{L_1}=(c_1,\lambda p;0, 1-\lambda p)$, and $S_{H_1}=(c_2,p; c_1,1-p)$ and $R_{H_1}=(c_1, 1-p(1-\lambda); 0, p(1-\lambda))$[10].Hence, the CC property of EUT independence axiom makes the decision trees H_1, M_1 and L_1 equivalent to each other.

The decision trees H_2, M_2 and L_2 are the second-stage lottery choice problems version of the "first row" decision trees. For instance, the left-hand side branch of tree M_2 is a two-stage lottery (i.e. two circles): multiplying out the probabilities, we get the probability equivalent single-stage lottery (i.e., one circle) in tree M_1. The RCLA requires the individual to be indifferent between a single stage lottery and its probability equivalent two stage one, and hence makes each one of the two-stage lottery problems in the second row -H_2, M_2 and L_2- behaviourally equivalent to the corresponding single-stage version -H_1, M_1 and L_1- in the first row.

But the "second row" decision trees are also equivalent among themselves if the individual follows the Segal (1987, 1989, 1990)'s procedure (Cubitt *et al.*, 1998) to deal with two-stage lotteries. First, the agent applies, instead of the RCLA, the reduction by substitution of certainty equivalents principle: two-stage lotteries are reduced to single-stage ones by substituting for the second stage lottery its certainty equivalent (CE). That is, the second-stage lottery $(c_1,\lambda;0, 1-\lambda)$ is substituted by the amount of money for sure that is equally preferred to it, i.e., its CE. Then, if the individual obeys a weaker form of EUT independence,

[10]The safe option c_2 in tree M_1 has been represented by a circle whose branches always give c_2 so that it is easy to see that each circle (lottery) in M_1, L_1 and H_1 has a common branch that, with probability (1-p), gives a c* equal to c_2 in tree M_1, to 0 in tree L_1 and to c_1 in tree H_1.

the independence for sure prospects principle (Segal, 1987)[11], H_2, M_2 and L_2 are behaviourally equivalent

The two branches in tree M_2 differ in what they offer if the first lottery resolves in favour of the event with probability p: the gamble (c_1,λ;0,1-λ) on the left-hand side branch versus the consequence c_2 on the right-hand side branch. The prior risk problem M_p calls upon the individual to choose after that first-stage lottery in M_2 has been resolved. Timing independence requires the individual to choose the same option independently of whether the first-stage risk has not, as in problem M_2, or has, as in problem M_p (where it constitutes a prior risk: Cubitt *et al.*,1998), been resolved. Similarly, the problems H_2 and L_2 are equivalent to, respectively, the problems H_p and L_p. Hence, M_p, H_p and L_p are the dynamic versions of M_2, H_2 and L_2. Unlike the CRE framework where the principle is examined only when the foregone-consequence of the prior risk is zero, the CCE framework analyses timing independence under different values of the foregone-consequence.

The prior risk choice problems H_p, M_p and $L_p$only differ from each other in what constitutes the past at the moment of choice: they present the individual to the same choice between the gamble (c_1,λ;0,1-λ) and the certainty c_2. Separability imposes that individual preferences are uniquely determined by the available options at that point -the existence of prior choices or risks, whatever the value of the options no longer reachable, is irrelevant-;hence the problems H_p, M_p and $L_p$are equivalent to each other. As a result, the CCE framework provides a different test of separability than the CRE framework. In the CRE's test, the past referred to the existence or not of one or various prior risks with the same foregone-consequence equal to zero (Cubitt *et al.* (1998)). In the CCE framework, the past differs in the value of the foregone-consequence, i.e., the consequence that the prior risk leaves behind when it has resolved for the event that entitles the individual to make a choice. Thus, the CCE tests a different dimension of separability.

Hence, within the standard decision tree approach, the CCE framework allows to test the three dynamic choice principles of reduction of compound lotteries, timing independence

[11]Given three sure amounts X, Y and Z, this principle entails that X is preferred to Y if, and only if, a probability mixture of X with Z, say (X, p; Z, 1-p) is preferred to the same mixture of Y with Z (i.e., (Y, p; Z, 1-p)). In the current context, $CE \succsim c_2$ if and only if $(CE,p;c_2,1-p) \succsim (c_2,p;c_2,1-p)$ and $(CE,p;0,1-p) \succsim (c_2,p;0,1-p)$ and $(CE,p;c_1,1-p) \succsim (c_2,p;c_1,1-p)$.

and separability for three distinct values of the consequence given by the event represented by the "(1-p) branch". It might be that this feature does not affect the descriptive validity of the principles; alternatively, it might be that the direction of the failure, providing that there is one, of any of these principles is related to the value of that "(1-p)" consequence.

[Insert Figure 1 here]

Figure 2 summarises the corresponding six behavioural equivalences that are analysed by means of the nine choice problems depicted in figure 1. The first horizontal equivalence is implied by EUT independence axiom, labelled as EUT indep; the second horizontal equivalence is determined by Segal's (1987) independence for sure prospects principle (Segal's indep); and the last horizontal equivalence is implied by the separability principle (separability). The RCLA entails the first vertical equivalence and the principle of timing independence (labelled as T-Indep) requires the second vertical equivalence. The traditional individual choice theory under risk implies that all of the nine choice problems are equivalent.

[Insert Figure 2 here]

4. Experimental Design

In the experiment, subjects make 13 choices between risks with "filler tasks" separating each choice. Included in the 13 choices were versions of the 9 CCE problems set out above, the remaining 4 problems looked broadly similar to subjects as they constitute a quasi-replication of Cubitt *et al.* (1998)reported in Ruiz-Martos (2008). For participants, the only difference between the CCE sequential choice problems and the ones from the replica of Cubitt *et al.* (1998) was the monetary consequences.

Subjects were randomly allocated to one of three conditions which differed according to the incentives offered for completing the various tasks.

4.1 Parameters

I use the parameters in the CCE study by Starmer and Sugden (1991): c_1=£10, c_2=£7, p=0.25 and λ=0.8. That study reports an increase in risk seeking as the medium consequence decreases and the effect is statistically significant under the two main incentive systems (below).

4.2 Incentives

There has been considerable discussion about the appropriate incentive mechanism to elicit individuals' preferences in general (e.g., Smith, 1982; Harrison, 1994) and in dynamic choice (Wilcox, 1993; Beattie and Loomes, 1997). Cubitt *et al.* (1998) and Cubitt and Sugden (2001) advocate for a single choice design rather than the standard random lottery incentive system (RLIS). However, thesingle choice design is too costly to implement here[12] and the existing empirical evidence in dynamic choice principles shows that the RLIS leads to the same general patterns of behaviour (Busemeyer*et al.*, 2000; Johnson and Busemeyer, 2001).

Therefore, I use a RLIS as the baseline incentive mechanism in this experiment: each subject faced a total of 13 sequential choice problems, named risk tasks in the experiment, and one of them was randomly selected to determine the payoff.

4.3 Problem Presentation

I assume frame independence from the start and use the decision tree framework to represent the 13 choice problems[13]. The final presentation of decision problems, however, is a particular modification of the standard decision tree diagram (figure 3). This modification allows for state-wise dependency, which was dictated by the operationalisation of risks in the experiment. In order to make the risks the subject faced "vivid" (i.e., both salient and easy to understand), among other features (below), a physical device seemed more attractive than a computerised risk resolution. Specifically, the physical device consisted of 100 coloured poker chips -partitioned in 75 blue, 20 green and 5 red

[12] 13 risk choices and, say, 50 subjects making choices, i.e., a total of 650 individual choices. For each of the four prior risk choice problems, this implies that a larger group of subjects takes part in the experiment so that, with a probability p=0.25, 50 of them survive to make a choice. That is, approximately 1250 participants (50×9 + (200×4) = 1250, as 200×0.25=50).

[13] The text presentation of the problems seemed a "words labyrinth" and, furthermore, without imposing frame independence, the CCE sequence would require 12 choice problems, instead of 9, because the test of frame independence would have required to include, following Cubitt *et al.* (1998), theprecommitment choice problems.

ones- and a black box. That required state-wise dependency, i.e., in figure 3 two lines –one for red chips and one for green chips- go from the first risk –circle- to the second risk –circle- instead of a single line, as in the standard decision tree diagram, with the total number of chips. Any risk choice problem, either from the CCE sequence or from the Cubitt *et al.*(1998) replica, was presented by the relevant adaptation of the diagram in figure 3, which depicts the two-stage lottery problem M_2.

[Insert Figure 3 here]

The top line of the page in figure 3 reminds subjects that risks are resolved by a draw from the 100 coloured chips in the box. The code on the top right-hand side corner of the sheet, the letter "B" in this case, only nominated the risk problem for the RLIS resolution of the risk task to be played out for real: each risk choice problem was labelled by an alphabet letter ranging from A to M.

4.4 Experimental Device and Risks Resolution

The "make it vivid" goal also led to a traditional "pen&paper" design. I mainly aimed at avoiding a sort of hot-hand phenomenon that might appear in computerised experiments on dynamic choice. The pioneer work by Cubitt *et al.* (1998) is "pen&paper" and observes a failure of timing independence, which against any reasonable expectation, does not appear in Cubitt and Sugden (2001) computerised design; and Cubitt *et al.* (2012) fail to observe a separability failure in an computerised design that, according to the literature on psychology of affect (Isen, 1988, 1999), should induce individual affective experiences. Itmight be thatthe computer presentation of problems -asking for a "click with the mouse" answer- encourages more rapid and less thoughtful responses; and the computerised resolution of risks neutralises individual affective experiences of risks. To minimise that, I use a "pen&paper" design and a physical resolution of risks.

There was a procedural distinction in the resolution of risks: any prior risk was resolved publically per session, i.e., one of the participants selected the chip from the box; post-decision risks were individually resolved by the subject picking up the chip from the box. This distinction, motivated by the "pen&paper" and RLIS design, attempted to avoid that resolving too many prior risks too quickly might trivialise subjects' experience of risk.

4.5 Filler Tasks

To grant participants a mental break between the 13 risk tasks and make it harder for them to recall previous risk choices, 3 general knowledge questions were insertedas "fillers"[14] after each risk task and named as Knowledge tasks in the experiment.

Knowledge tasks were general knowledge questionswith an intermediate level of difficulty and over a broad range of topics[15]. To minimise the risk of subjects "learning" across sessions, there were 3 distinct sets of 36 knowledge questions and 1 extra set -a mixture of questions from these sets-; the knowledge sets (available upon request) were randomly allocated to experimental sessions. Here is an example:

What is the second largest country by land area in the world?

a) Usa

b) China

c) Canada

d) Russia

Furthermore, subjects did not receive the typical booklet containing the risk and knowledge tasks. Each task -either risk or the corresponding 3 knowledge questions- was presented on a decision sheet. After completing each task, subjects were instructed to put the decision sheet inside a big manila envelope (each subject had his own envelope). This ensured that subjects would not look at previous risk choices when making a decision.

4.6 Treatments

The baseline treatment is a RLIS design. The RLIS treatment is characterised by 13 decision trees and 36 knowledge questions, each of them paid 10 pence when correctly answered. The other two treatments involved a risk task for real, hypothetical answers to the

[14]Dr.HenrikOrzen suggested the inclusion of "fillers" during an internal seminar presentation of the design.

[15] As the subject pool was comprised of mostly undergraduate students from a wide range of disciplines in the University of Nottingham, the topics were: geography, history, football, basketball, pop music, body anatomy, literature and movies.

remaining 12 risk tasks and 36 incentivised knowledge questions. One of them, hereafter called "Single M_1+", had the medium CCE choice problem (tree M_1) for real and each knowledge question answered correctly paid at 4 pence. The third treatment, labelled as "Single L_1+", had the low CCE choice problem (tree L_1) for real and 30 pence for each correctly answered knowledge question. The main reason to have three treatments is that the study also involves an analysis of the RLIS, single choice and hypothetical choice incentive systems that is fully reportedin Ruiz-Martos (2008).The whole study involved a total of 176 participants: 78, 50 and 48 in, respectively, the RLIS, “Single M_1+” and “Single L_1+” treatments.

Independently of the treatment, the experiment took less than one hour and the distinctive value of the knowledge questions per treatment guaranteed that subjects’ average payoff was approximately £7. In this paper, however, I will focus on the RLIS data.

4.7 Instructions and Procedures

The state-wise decision tree representation used in this experiment is an innovative design feature that makes the sequential risk choices easy to understand. As people are not used to dealing with such decision trees in their daily life, aPowerpoint presentation supported the instructions and helped to illustrate the decision tree diagram in figure 3.

The presentation order of the 13 decision trees was randomized per experimental session, as well as the allocation of the Up and Down choice options to the Riskier and Safer lotteries, and the knowledge sets. The maximum number of participants per session was 10 to keep the whole experiment, including payment, within one hour.

In any treatment, Knowledge tasks were also illustrated by an example. Subjects were informed about the value of each correctly answered question, respectively for the RLIS, "Single M_1 +" and "Single L_1 +" treatments: 10, 4 and 30 pence. The instructions finished with a summary of subjects earnings under the two types of tasks in the experiment.

Table 1 summarises the main features of the three treatments in any of the sessions. The first column lists the treatment. Columns twoshows the initial task -always a risk task-. Column three presents the second task: the first 3 knowledge questions of the relevant set. Columns four and five show the total number of knowledge questions -subjects answered 3 knowledge questions after each risk task (3x12)- and the payoff per correctly answered knowledge question. The sixth column shows the third task, i.e., the remaining 12 risk tasks. For instance, the RLIS had as initial risk task any of the risk tasks -the order of which was randomly determined per session-; whilst in each of the "Single +" treatments, subjects started by facing its corresponding problem for real.

[Insert Table 1 here]

In any treatment, once subjects had completed all the tasks, each subject played out his corresponding risk task and his knowledge tasks were marked to determine his final payoff.

5. Hypotheses

Under the framework and the design features described, let the action-choice function, f(·), represent the percentage of riskier option choices for any choice problem. The 6 behavioural equivalences depicted in figure 2 can be formulated as conditions on the action-choice function. Traditional individual choice theory under risk implies the equivalence of all 9 problems (standard choice theory hypothesis):

H1 (Standard choice theory):

$H1_0$:$[f(H_1)=f(M_1)=f(L_1)=f(H_2)=f(M_2)=f(L_2)=f(H_P)=f(M_P)=f(L_P)]$,

and the alternative hypothesis of which is:

$H1_A$: not $H1_0$.

The first horizontal behavioural equivalence is determined by EUT independence axiom. The CC property entails that the decision trees H_1, M_1 and L_1 should elicit the same risk preferences; i.e., the null hypothesis is:

H2 (EUT independence):

$H2_0$:$[f(H_1)=f(M_1)=f(L_1)]$.

$H2_A$: not $H2_0$.

The first vertical equivalence in figure 1 between decision trees H_1, M_1 and L_1, and, respectively, H_2, M_2 and L_2 follows from the RCLA; which implies the following null hypothesis:

H3 (RCLA):

$H3_0$: $[f(H_1)=f(H_2)]$ and $[f(M_1)=f(M_2)]$ and $[f(L_1)=f(L_2)]$.

$H3_A$: not $H3_0$ [either not $[f(H_1)=f(H_2)]$ or not $[f(M_1)=f(M_2)]$or not $[f(L_1)=f(L_2)]$].

As stated in Section 3.2, Segal (1987, 1989, 1990)'s approach individuals would not obey the RCLA, which is the alternative hypothesis to the RCLA. In addition, these individuals would obey the null hypothesis below on independence for sure prospects that requires the equivalence of the two-stage lottery choice problems:

H4 (Independence for Sure Prospects):

$H4_0$:$[f(H_2)=f(M_2)=f(L_2)]$.

$H4_A$: not $H4_0$.

Timing independence states that the two-stage choice problems -H_2, M_2 and L_2- are, respectively, behaviourally equivalent to the prior risk choice problems -H_P, M_P and L_P-. Cubitt *et al.* (1998) study finds a preferences shift towards risk aversion from before to after the resolution of the prior risk in the CRE framework, where the prior risk has a foregone-consequence equal to zero; which is similar to the case between problems L_2 and L_P. I willgo a step further and conjecture that the failure of timing independence consistently goes in the direction of a shift towards risk aversion from before to after the resolution of the prior riskfor all values of CC, i.e., that the resolution of the prior risk increases risk aversion independently of CC (Post Resolution Increased Aversion to Risk):

H5 (Timing Independence):

$H5_0$:$[f(H_2)=f(H_P)]$ and $[f(M_2)=f(M_P)]$ and $[f(L_2)=f(L_P)]$.

$H5_A$ (Post Resolution Increased Aversion to Risk): $[f(H_2)>f(H_P)]$ and $[f(M_2)>f(M_P)]$ and $[f(L_2)>f(L_P)]$.

Cubitt *et al.* (1998) discuss two hypotheses that accommodate the post resolution increased aversion to risk behaviour in the CRE framework, with distinguishing requirements for individual's awareness of his behaviour[16]. The strategic precommitment (Karni and Safra, 1989, 1990) hypothesis claims that individuals are aware of their shift towards risk aversion after the resolution of the prior risk and use the precommitment facility –here the two-stage lottery- to impose their "before resolution" riskier preferences. Conversely, the prediction failure hypothesis postulates that individuals fail to predict their preferences at the "post resolution" choice node.

Decision Field Theory (DFT), developed by the psychologist Jerome Busemeyer's research group (1992, 1993, 1995, 1999, 2000,2002, 2003), offers an explanation of this shift in individual preferences which fits under the prediction failure hypothesis –though DFT is not discussed in Cubitt *et al.* (1998).

DFT assumes the evaluation of a lottery varies across the decision tree depending on subject's "distance" to it. Distance is defined as the number of previous chance and choice nodes and the overall probability of reaching the choice options: the higher the number of prior nodes and/or the smaller the overall probability, the larger the distance. Similarly to standard choice theory, DFT states that the individual chooses the "highest value" lottery, but that lottery changes as he works up the decision tree. For valuation, a lottery is decomposed into gains and losses, which are weighted separately, and their addition - weighted gains minus weighted losses- determines the lottery's value. Crucially to DFT, decision weights vary with distance: when distance is large, gains are over-weighted with respect to losses; the opposite when distance is small. Thus, the two-stage problem and the prior risk problem are not equivalent as they differ in distance to the choice options. The unresolved prior risk in the former conveys distance: the individual may never reach his chosen option, so he over-weights gains (highest outcome) with respect to losses (zero outcome), and the lottery gets a higher value than the sure option. There is no distance in the prior risk choice problem -he gets exactly what he chooses-: losses are over-weighted with respect to gains and the lottery gets a smaller value than the safe option.

[16] This is related to the difference between myopic and sophisticated behaviour.

To my knowledge of the theory, DFT does not have a prediction for the effect of the distinct values of the CC on distance. It might very well be that the value of CC does not interfere with distance and, subsequently, DFT would predict a generalised post resolution increased aversion to riskbehaviour. Alternatively, consider Machina's (1982, p.288)explanation ofthe typical CCE: individuals evaluate the safer[17] pair of lotteries by a more risk averse utility function than the one used for evaluating the riskier[18] pair of lotteries. I suggest that DFT distance concept could be interpreted as the extension of this characterization of the CCE to a sequential decision making framework in which separability, frame independence and reduction of compound lotteries are imposed, but timing independence is not. With respect to the two-stage choice problems H_2, M_2 and L_2, I interpret that distance decreases as the CC increases from the lowest to the highest consequence: we move from the riskiest pair to the safest one. Thus, this would imply: first, the failure ofindependence for sure prospects in the direction of less risk seeking as the CC increases; and, subsequently, given that the three prior risk problems are equivalent -zero distance to the choice options-, that the failure of timing independence is more extreme between L_2 and L_P -with more risk seeking in the two-stage problem (L_2) than in the prior risk problem (L_p)-; gets weaker between M_2 and M_P, and tends to vanish between H_2 and H_P. I will call this possibility the CC& DFT distance (CC-distance) hypothesis, which constitutes an alternative to the null hypothesis of independence for sure prospects when considered by pair of problems (Equal distance):

H6 (Equal distance):

$H6_0$:$[f(H_2)=f(M_2)]$ and $[f(M_2)=f(L_2)]$ and $[f(H_2)=f(L_2)]$;

$H6_A$ (CC-distance):$[f(L_2)>f(M_2)]$ and $[f(M_2)>f(H_2)]$ and $[f(L_2)>f(H_2)]$ and separability holds.

Separability makes the last row of decision trees in figure 1, the prior risk choice problems – H_P, M_P and L_P-,equivalent to each other and leads to the null hypothesis below:

H7 (Separability):

$H7_0$: $[f(H_P)=f(M_P)=f(L_P)]$.

[17]Stochastically dominating pair of lotteries.

[18]Stochastically dominated pair of lotteries.

As stated, Machina (1989) argues that the typical CRE individual is dynamically consistent by not obeying separability: he is more risk seeking in the prior risk problem than in the scaled-up choice problem (no history).Isen (1999), however, observes that"positive affect" induced subjects are more risk averse than those on a neutral affective state. Following Cubitt *et al.* (2012) claim that subjects in the prior risk problem are "in a good mood" as they have just left behind a zero forgone-consequence, Isen (1999) contradicts Machina (1989).

Now in terms of the CCE sequential choice, Machina (1982, p. 289) characterizes the typical CCE as "contrary to the precepts of the independence axiom, the more that individuals stand to lose if the event E occurs (that is, the better off they would be in ~E), the more risk averse they become in evaluating a given risky prospect a* in E". Next, recall Machina (1989) which, endorsing the principles of frame independence, timing independence and reduction of compound lotteries, shows that a non-separability typical CRE individual can be dynamically consistent[19]. Then looking at the CCE prior risk problems in figure 3 and within a non-separability framework, one can interpret the event E as the choice-outcome that occurs with probability 0.25, the event ~E as the foregone-outcome that occurs with probability 0.75 and prospect a* as the lottery g. If both hypotheses hold, one could expect that as the forgone-consequence increases from the lowest to the highest outcome, the more risk averse the individuals will be. That constitutes the Machina 82&89 hypothesis:

$H7_{A1}$ (Machina 82&89): [f(Hp)<f(Mp)] and [f(Mp)<f(Lp)] and [f(Hp)<f(Lp)].

Isen*et al.*'s research program (1988, 1999) suggests that positive affect increases risk aversion as a strategy to maintain the good mood. Cubitt *et al.* (2012) conjectured that surviving a prior risk with a zero forgone-consequence would induce positive affect as the subject passes from having no reward to make a choice. I furtherconjecturethat the sign (positive or negative) of the induced affect, if there is, depends on the value of forgone-consequence: in particular, that surviving the prior risk which gives as forgone-consequence the highest consequence induces negative affect -the subject just lost a 75 per cent chance of the best result. In this case, we should observe a failure of separability but in the opposite direction to Machina 82&89 hypothesis: risk taking increases as the forgone-consequence

[19]Machina (1989) does not use this terminology to name the principles.

increases from zero to the highest consequence[20].The medium forgone-consequence case is a bit undefined though, if this hypothesis holds, it should start to reveal an increase in risk taking in comparison with the zero foregone-consequence.

This is called the affect hypothesis:

$H7_{A2}$ (Affect): [f(Hp)>f(Mp)] and [f(Mp)>f(Lp)] and [f(Hp)>f(Lp)].

Table 2 summarises the hypotheses tested. The first, second and third column lists, respectively, the hypothesis name, the null and alternative hypotheses.

[Insert Table 2 here]

6. Results

The experiment was conducted at the University of Nottingham between December 2006 and February 2007 across 25 sessions, each of them with a randomly assigned treatment: 15 RLIS sessions and 5 per each "Single +" treatment. From the CeDEx database, which comprises undergraduate and postgraduate students from a range of disciplines, a total of 176 participants were randomly recruited: 78, 50 and 48 for, respectively, the RLIS, "Single M_1 +"and "Single L_1 +"treatments.I used STATA to analyse the data collected. Table 3 summarises the RLIS data. The table has a matrix presentation that resembles the display of the problems in figure 1. Rows one to three present the data for the CCP problems - H_1, M_1 and L_1-; rows four to six do accordingly for each two-stage lottery problem -H_2, M_2 and L_2-; and, similarly rows seven to nine for the prior risk choice problems -Hp, Mp and Lp-. Each problem has three columns that show the number of choices, and the number and the percentage of risky choices. The last row summarises the total number of risky choices: 248, i.e., a 46.5%.

[Insert Table 3 here]

[20]This could also be interpreted as some form of endogeneous reference point formation whereby the foregone consequence in the prior risk defines the individual's reference point in the subsequent choice, just in the spirit of Prospect Theory (Kahneman and Tversky, 1979).

The distinction between participants and choices results from the public resolution of the prior risks per session, which implied that for the prior risk choice problems Hp, Mp and Lpjust, respectively, 38, 29 and 37 subjects survived to make a choice[21]; from which, respectively too, 9, 19 and 37 are RLIS choices.This will make it necessary to look at the hypothetical data later for the discussion of the timing independence and separability principles, but I will focus on the results obtained by the RLIS data for the other principles.

6.1 RLIS data

In the RLIS treatment, the percentage of risky choices is identical for the medium and low CCE choice problems. Hence, the substitution of the medium consequence for the lowest consequence (med-low) does not increase risk seeking; there is not med-low CCE. However, the risk percentage drastically decreases when we look at the high CCE choice problem: substituting the medium or the lowest consequence for the highest consequence increases risk aversion, i.e. and respectively, there is med-high or low-high CCE.

A very similar tendency appears in the percentages of risky choices of the two-stage lottery problems: while M_2 and L_2 are very close, there is a severe decrease in risk taking for problem H_2. Hence too, the weaker form of independence assumed by Segal (1987), independence for sure prospects, does not hold and exhibits quite the same pattern as EUT independence. Without conducting any test yet, it is clear too that the RCLA is not the dynamic choice principle that explains the observed CCE: the differences in the percentages of risky choices between each one of the CCE problems and its corresponding two-stage version are pretty small.

Tests results are summarised in tables 4 and 5. Table 4 shows the chi-square test results for the standard choice theory hypothesis and the principles of EUT independence, independence for sure prospects and separability; all of these tests involve equivalences of more than two choice problems. Table 5 shows the Mann-Whitney U test results for equivalences by pairs of problems in EUT independence, RCLA, equal-distance, timing independence and separability. The first column in table 4 shows the null hypothesis; and

[21]With at least five sessions per treatment, I could reasonably have expected some data for each prior risk problem in each treatment, especially in the RLIS treatment.

columns second, third and fourth report the chi-square test statistic, the p-value and the adjusted[22] significance level for a two-sided test at which the null is rejected ("-" indicates that the null cannot be rejected, here and in any other table onward).

[Insert Table 4 here]

The straightforward conclusion from table 4 is that the traditional choice theory hypothesis, that demands the behavioural equivalence of all of the 9 problems, does not hold (χ^2=82.48, p=0). I examine next each one of the EUT independence, RCLA and independence for sure prospects; for which there are 78 observations in each of the choice problems involved. EUT independence axiom does not hold; however I don't find support for Machina (1987)'s generalised increase in risk seeking as the CC decreases, but only for the substitution of the highest for medium or lowest consequence (similar to Conlisk, 1989).The RCLA cannot be rejected (table 5), which together with the observed failure of the principle of independence for sure prospects, knocks out Segal's (1987, 1989, 1990) procedure to deal with two-stage lotteries.

[Insert Table 5 here]

In interpreting the results on timing independence in table 5, please caution given the small sample size of the prior risk choice problems, in particular only 9 observations for problem Hp. First, timing independence fails for any value of the foregone-consequence. But there is a post resolution decreased aversion to risk behaviour when the foregone-consequence is equal to the highest consequence (in the H pair) as U=-2.754 (p=0.0059); this pattern lines up with the observed CCE and is robust to a 5% FDR correction. Strikingly, there is a post resolution increased aversion to risk behaviour for the smallest -reliable as problem Lp has

[22] As this dynamic choice study conducts a total of 15 hypotheses tests, some downward adjustments to significance levels are due (Benjamini and Hochberg, 1995). The Bonferroni correction (BF) adjusts down the desired significant level by a coefficient equal to (1/15). The less conservative False Discovery Rate correction (FDR) takes into account the distribution of the observed p-values. The BF corrections to, respectively a 5% and a 1% significance level are 0.00333333 and 0.00066667; the corresponding FDR corrections are 0.026666667 and 0.004666667.

sufficient observations- and medium foregone-consequences; whilst, there is no such CCE. The latter result resembles Cubitt *et al.*'s (1998) finding of a post resolution increased aversion to riskbehaviour without a CRE. In addition, the CC-distance hypothesis receives mixed support. First, separability does not hold (below). Second, if independence for sure prospects is analysed per pair of two-stage problems, it does not fail between decision trees L_2 and M_2 (U=-0.835 and p=0.4036). Thus, whereas distance seems to decrease when the foregone-consequence equals the highest consequence, as suggested by CC-distance, in decision tree H_2 with respect to either decision tree M_2 or L_2, it does not so from the lowest to the medium consequence.

On the separability principle, the chi-square test in table 4 (χ^2=11.678 and p=0.0029) allows to reject the null hypothesis that the three prior risk choice problems are equivalent at the 5% BF significance level. It seems that bygones are not bygones. The Mann-Whitney U test study of separability in table 5 provides further information[23]. First, the null hypothesis is rejected atthe 1% BFsignificant level (U=3.441, p=0.0006) only when the foregone-consequence increases from the medium to the highest consequence. Second, the direction of the failure goes in line with the Affect hypothesis between problems Hp and Mp (U=3.441 and p=0.0006) and between problems Hp and Lp (U=2.036 and p=0.0417, thus 10% FDR significant); i.e., as the foregone-consequence increases from the lowest or medium to the highest consequence, risk seeking increases. But when the foregone-consequence increases from the lowest to the medium consequence between problems Lp and Mp, risk seeking decreasesas predicted by Machina 82&89 hypothesis, though only significant at 10% FDR level (U=-2.094, p=0.0363).

6.2 RLIS plus Hypothetical Data in treatments M1+ and L1+

Table 6 (similar to table 3) contains the pooled data including the hypothetical data. Comparing table 6 pooled data with table 3 RLIS data, there are almost no differences in the percentage of risky choices for H_1, H_2, M_2 and L_2, and changes in M_1 and L_1similarly go towards risk seeking. Thus, the conclusions on EUT independence axiom, independence for sure prospects principle and RCLAremain unchanged.

[23]Please recall that the RLIS observations are 9, 19 and 37, respectively for Hp, Mp and Lp.

[Insert Table 6 here]

The pooled data for the prior risk choice problems Hp, Mp and Lp are, respectively: 38, 29 and 37; hence, there are not Lp hypothetical choices. Now, in problem Mp, whereas 6 out of the 10 hypothetical observations are risk seeking, there was just 1 out of the 19 RLIS data.TheSpearman correlation coefficient (ρ =0.6079) suggest that the percentage of risky choices in Mp is positively correlated with the hypothetical data; andthe Yates' correctionfor continuity in the chi-square (Yates' χ^2=7.939, p= 0.0048) and the Mann-Whitney U test (U=-3.217, p=0.0013) reject that RLIS and hypothetical answers for problem Mp are equivalent. Thus, it does not seem advisable to pool problem Mp data.

With respect to problem Hp, we observed 6 out of 9 risky RLIS choices, whilst there are 13 out of 29 risky hypothetical choices. Risk tendencies are not so different. Indeed the Spearman correlation coefficient (ρ =0.2856) suggests a small degree of correlation between hypothetical choices and the percentage of risky choices; as so do the Yates' corrected chi-square value(Yates' χ^2=0.582 and p= 0.4455) and the Mann-Whitney U test (U=1.130, p=0.2587) that allow to pool the RLIS and the hypothetical data.

Bearing the above in mind, table 7 summarises (similar to table 5), the pooled data results relative to timing independence and separability. There are no changes with respect to the RLIS data regarding the CC-distance hypothesis and timing independence –except for the high value of the foregone consequence where the null is rejected only at the 5% FDR level.

[Insert Table 7 here]

Pooling the data has an effect on the separability results. Unlike the RLIS data case, the chi-square test for separabilitywould only reject the principle at 10% (χ^2=5.657, p=0.059) and the Mann-Whitney U testimplies that separability holds between pairs of problems –except for Hp and Mp at a 10% FDR level. Thus, a proper discussion on the separability principle demands more RLIS data to be able to disentangle if the change in the risk seeking tendencies for problems Mp and Hp is due to a general increase in risk seeking on hypothetical dataor to the unrepresentative sample size of the RLIS data.

7. Conclusions

The existing evidence on dynamic choice principles has been developed within the theoretical framework provided by the CRE violation of EUT independence axiom. The primary motivation of the present study was to test the dynamic choice principles under the different framework provided by the CCE, another violation of EUT independence. Thus, it was crucial to choose the parameters that maximised the possibility of finding this static choice phenomenon. Starmer and Sugden (1991) study seemed the right choice as it reports a significant med-low CCE in the direction of increased risk seeking when the medium CC is substituted for the lowest consequence under single choice and RLIS incentive mechanisms. The current study also included the high CCE choice problem. The results, however, show no med-low CCE but a very significant med-high or low-high CCE in the direction of less risk-seeking with the highest CC. I then find mixed support for Allais' (2008, p.4) intuition of discontinuity of preferences around certainty (discussed in Andreoni and Sprenger, 2010).

Are there any implications of this static pattern for dynamic choice behaviour?

Following Cubitt (1996), the dynamic choice principles of reduction of compound lotteries, timing independence and separability are analysed under the spectrum provided by the CCE sequence of choice problems: the high, medium and low CC choice problems and the corresponding probability equivalent two-stage lottery and prior risk choice problems. Thus, the principles are examined for three distinct values of the CC and within a very particular experimental design.

The primary results are that, regardless of the value of the CC, the RCLA holds and the principle of timing independence does not hold. Does the failure of timing independence go in the direction of *post resolution increased aversion to risk* for any value of the CC? The answer is more interesting than that. When the CC is equal to the lowest value, as in the CRE case, and to the medium value, the failure involves the *post resolution increased aversion to risk* behaviour; despite amed-low CCE has not been observed. But when the CCis the highest consequence the behaviour goes in the reverse direction; which goes in line with the observed med-high or low-high CCE. Nevertheless, the small number of choices in the high consequence prior risk problem calls for caution in considering the reverse *post resolution increased aversion to risk* behaviour. Even so, the failure of timing independence (a testable analogue of dynamic consistency) is empirically robust across experimental designs and across different violations of EUT independence; thus, there are strong grounds for thinking that it should be taken into consideration by any dynamic choice model that claims to describe individual behaviour.

The study includes a test of the independence for sure prospects principle (Segal, 1987). Interestingly, this weaker form of EUT independence exhibits exactly the same pattern of violation than the stronger version. In particular, the percentages of risk choice in the two-stage lottery problems reveal that the certainty equivalent of the second-stage lottery is preferred to the medium consequence when both are in a probability mixture with the lowest and the medium consequences; but not when both are probability mixed with the highest consequence. In terms of my interpretation of Decision Field theory's distance concept, this result implies that there would be the same distance to choice options in the lowest and medium CC two-stage lottery problems but that the highest CC two-stage lottery problem involves less distance to choice options. Thus, Segal's (1987, 1989, 1990) theory that claims that the failure of EUT independence axiom reflects a failure of the RCLA is not descriptively accurate; individuals seem to use reduction of compound lotteries when dealing with two-stage lotteries.

The CCE sequence of choice problems reveals a failure of the separability principle, which has not been observed up to date in the dynamic choice experiments conducted within the CRE framework. It seems that what exactly the prior risk leaves behind does affect individual willingness to take risks: risk taking increases with the highest foregone-consequence(mind small sample size). A potential explanation is that the specific experimental features, like a physical device for the operationalisation of risks instead of a computerised risk resolution, make the risks seem real and induce individuals' disobedience of the principle. But this would imply that a test of separability within the CRE framework and with the same experimental features should also lead to a failure of the principle (see replica of Cubitt *et al.*, 1998, in Ruiz-Martos, 2008).

Furthermore, the simultaneous failure of separability and timing independence in the CCE sequence of choice problems questions the descriptive validity of theories such as Machina (1989) and Karni and Safra (1989, 1990) that attempt to account for the failure of the EUT independence axiom by rejecting only either, respectively, separability or timing independence among the conjunction of dynamic choice principles that imply EUT independence (Cubitt, Starmer and Sugden, 1998, 2004).

A possible limitation of the present study concerns the small number of choices in the prior risk choice problems. That was partly a consequence of bad luck (from the experimenter point of view) in terms of how the prior risks were in fact resolved across sessions. To the extent that this is a limitation, the obvious solution would be more experimental sessions to increase the number of observations and, hence, test the robustness of the current results.

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Figures and Tables

Figures

Figure 1. Common Consequence Effect Sequence of Choice Problems

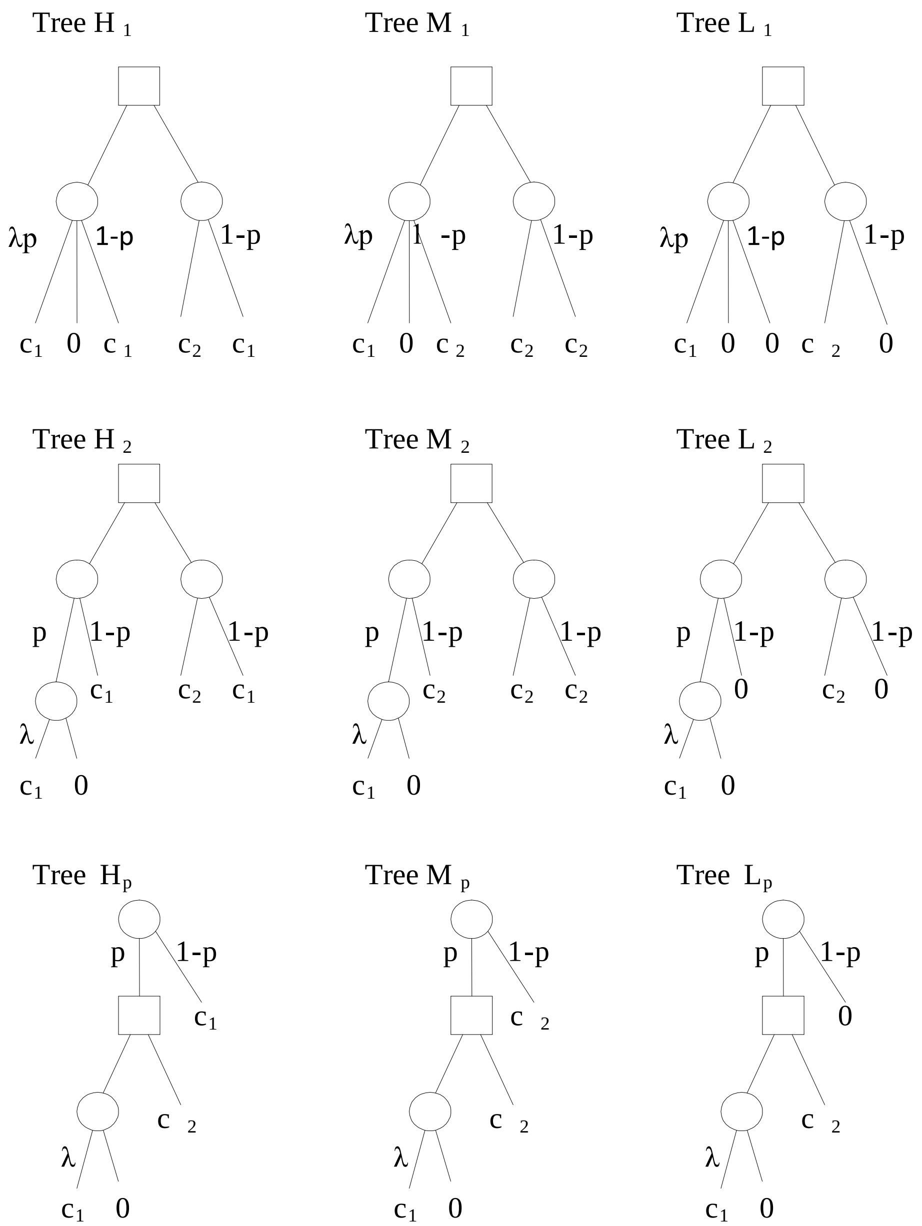


Figure 2. Behavioural Equivalences in the CCE dynamic choice framework

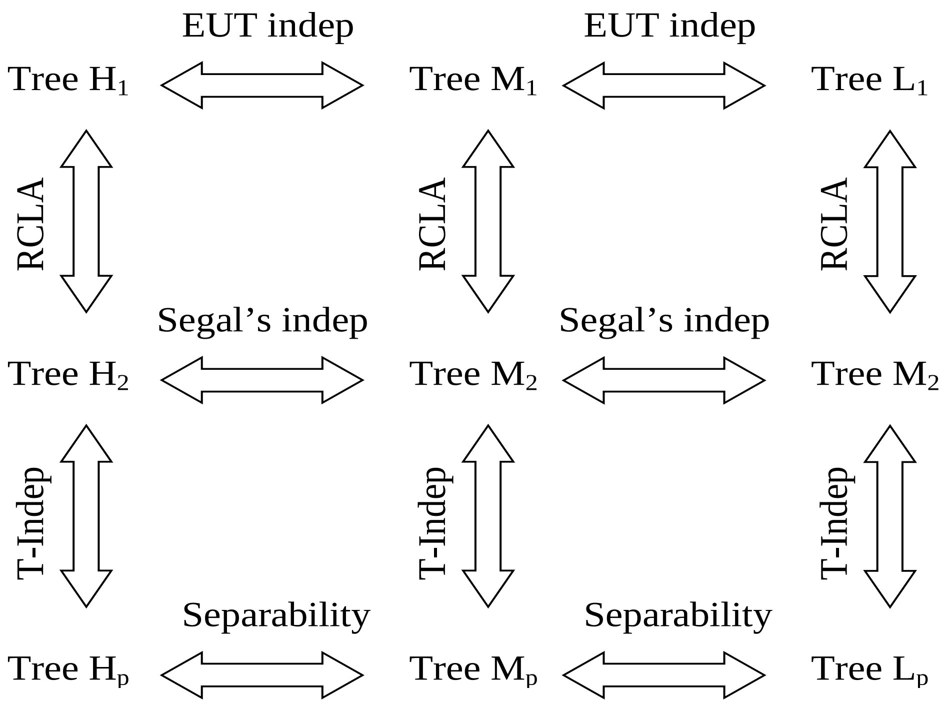
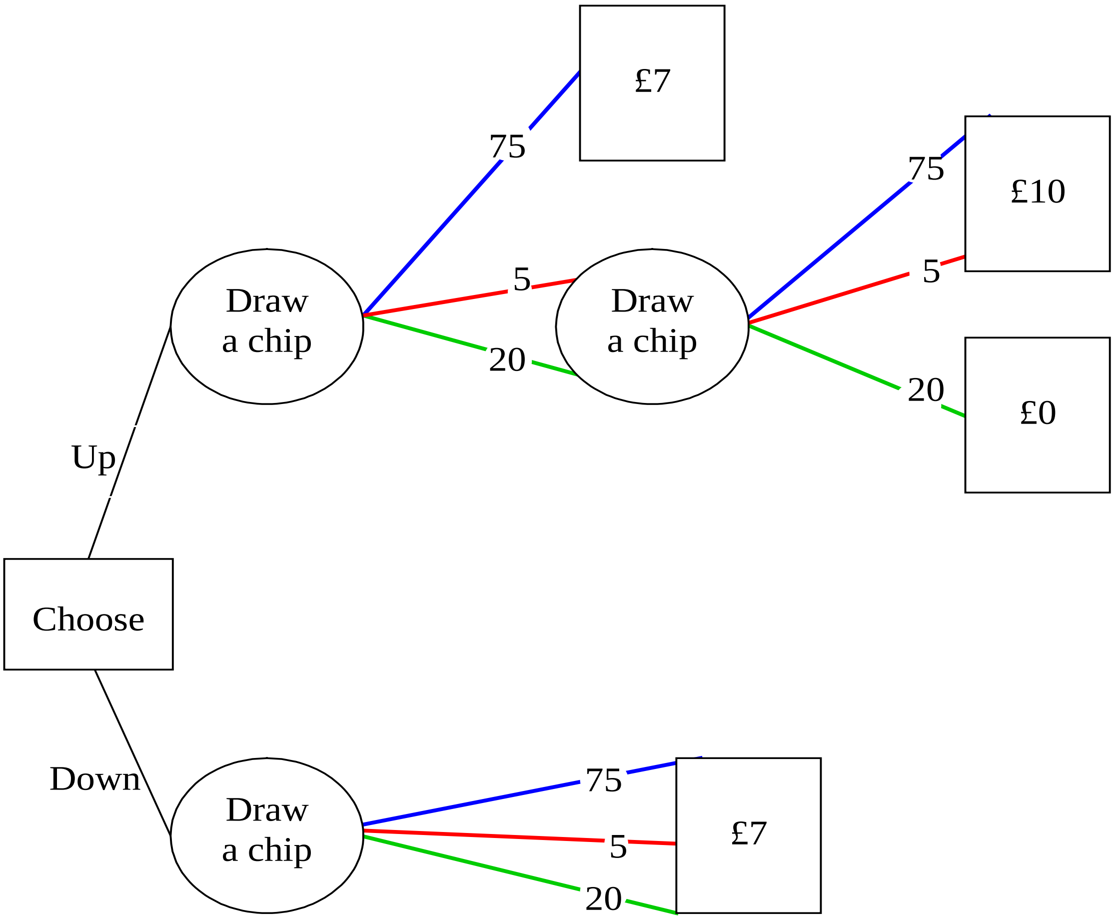


Figure 3. Problem Presentation in the Experiment

B

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

Tables

Table 1: Treatments, Tasks and Time-Line

Treatment	Initial Task	Second Task (KQs)			Third Task	Onward
RLIS	any risk	3 first	36	10 pence	any of (13-initial)	alternatively
Single M_1 +	M_1	3 first	,,	4 pence	any of (13-M_1)	,,
Single L_1 +	L_1	3 first	,,	30 pence	any of (13-L_1)	,,

Table 2: Null and alternative hypotheses

Hypothesis Name	**Null (Hi_0)**	**Alternative (H_{iA})**
H_1:**Standard Choice Theory**	$f(H_1)$=..[all]..=f(Lp)	Not $H1_0$
H_2: **EUT Independence**	$f(H_1)=f(M_1)=f(L_1)$	Not $H2_0$
H_3: **RCLA**	$f(H_1)=f(H_2)$ $f(M_1)=f(M_2)$ $f(L_1)=f(L_2)$	Not $H3_0$
H_4: **Independence For Sure Prospects**	$f(H_2)=f(M_2)=f(L_2)$	Not $H4_0$
H_5: **Timing Independence**	$f(H_2)=f(Hp)$ $f(M_2)=f(Mp)$ $f(L_2)=f(Lp)$	**PRIA:** $f(H_2)>f(Hp)$ $f(M_2)>f(Mp)$ $f(L_2)>f(Lp)$
H_6: **Equal Distance**	$f(H_2)=f(M_2)$ $f(M_2)=f(L_2)$ $f(H_2)=f(L_2)$	**CC-distance:** $f(L_2)>f(H_2)$ $f(M_2)>f(H_2)$ $f(L_2)>f(H_2)$
H_7: **Separability**	f(Hp)=f(Mp)=f(Lp)	**a) Machina82&89:** f(Hp)<f(Mp) and f(Mp)<f(Lp) andf(Hp)<f(Lp) **b) Affect** f(Hp)>f(Mp) andf(Mp)>f(Lp) andf(Hp)>f(Lp)

Table 3: RLIS treatment Risky Choices

Problem H_1			Problem M_1			Problem L_1		
Choices	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**
78	19	24.36	78	46	58.97	78	46	58.97
Problem H_2			**Problem M_2**			**Problem L_2**		
Choices	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**
78	18	23.07	78	48	61.54	78	53	67.95
Problem Hp			**Problem Mp**			**Problem Lp**		
Choices	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**
9	6	66.67	19	1	5.26	37	11	29.73
Total Number of Choices=533 Total Number of Risky Choices=248				Total f(.)=46.5%				

Table 4: Chi-square Tests Results with RLIS data

Statement of Hypotheses Tested **H1: Standard Choice Theory**	χ^2	**p-value**	**Adjusted Sig. Level**
$H1_0$:f(H_1)=[all]=f(Lp)	82.48	0***	1% BF
H2: EUT independence			
$H2_0$: f(H_1)=f(M_1)=f(L_1)	24.98	0.0000***	1% BF
H4: Indep. for Sure Prospects			
$H4_0$: f(H_2)=f(M_2)=f(L_2)	36.76	0.0000***	1% BF
H7: Separability			
$H7_0$:f(Hp)=f(Mp)=f(Lp)	11.678	0.0029***	5% BF

***=1% significance level; **= 5% significance level; *=10% significance level

Table 5: Mann-Whitney U testsResults with RLIS data

Hypotheses Tested	Equivalences by problems pair	Mann-Whitney U test	p-value	Adjusted Sig. level
EUT Indep.	$f(H_1)=f(M_1)$	-4.371	0.0000***	1% BF
EUT Indep.	$f(M_1)=f(L_1)$	0	1	-
EUT Indep.	$f(H_1)=f(L_1)$	-4.371	0.0000***	1% BF
RCLA	$f(H_1)=f(H_2)$	0.188	0.8512	-
RCLA	$f(M_1)=f(M_2)$	-0.326	0.7443	-
RCLA	$f(L_1)=f(L_2)$	-1.160	0.2460	-
Equal-distance	$f(H_2)=f(M_2)$	-4.846	0.0000***	1% BF
Equal-distance	$f(M_2)=f(L_2)$	-0.835	0.4036	-
Equal-distance	$f(H_2)=f(L_2)$	-5.609	0.0000***	1% BF
Timing Indep.	$f(H_2)=f(Hp)$	-2.754	0.0059***	5% FDR
Timing Indep.	$f(M_2)=f(Mp)$	4.377	0.0000***	1% BF
Timing Indep.	$f(L_2)=f(Lp)$	3.837	0.0001***	1% BF
Separability	f(Hp)=f(Mp)	3.441	0.0006***	1% BF
Separability	f(Mp)=f(Lp)	-2.094	0.0363**	10% FDR
Separability	f(Hp)=f(Lp)	2.036	0.0417**	10% FDR

***=1% significance level; **= 5% significance level; *=10% significance level

Table 6: Pooled (RLIS + Hypothetical) Risky Choices

Problem H_1			Problem M_1			Problem L_1		
Choices	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**
176	43	24.43	126	96	76.19	128	94	73.43
Problem H_2			**Problem M_2**			**Problem L_2**		
Choices	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**
176	51	28.97	176	113	64.20	176	114	64.77
Problem Hp			**Problem Mp**			**Problem Lp**		
Choices	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**	**Choices**	**Risk**	**f(.)=%**
38	19	50	29	7	24.13	37	11	29.73
Total Number of Choices=1160 Total Number of Risky Choices=548				Total f(.)=47.2%				

Table 7: Mann-Whitney U Test: Timing Independence and Separability, Pooled Data

Hypotheses Tested	Equivalences by problems pair	Mann-Whitney U test	p-value	Adjusted Sig. level
Equal-distance	$f(H_2)=f(M_2)$	-6.615	0.0000***	1% BF
Equal-distance	$f(M_2)=f(L_2)$	-0.111	0.9114	-
Equal-distance	$f(H_2)=f(L_2)$	-6.719	0.0000***	1% BF
Timing Indep.	$f(H_2)=f(Hp)$	-2.499	0.0124**	5% FDR
Timing Indep.	$f(M_2)=f(Mp)$	4.048	0.0001***	1% BF
Timing Indep.	$f(L_2)=f(Lp)$	3.926	0.0001***	1% BF
Separability	$f(Hp)=f(Mp)$	2.136	0.0327**	10% FDR
Separability	$f(Mp)=f(Lp)$	-0.502	0.6154	-
Separability	$f(Hp)=f(Lp)$	1.780	0.0752*	-

***=1% significance level; **= 5% significance level; *=10% significance level

Appendix

A.1. Instructions and Procedures

The instructions started by illustrating the "poker chips & black box" device and three examples of risk tasks -medium common consequence, two-stage and prior risk choice problems-. The parameters for these examples were slightly different (They are: c_1=8 and c_2=5.) to the ones faced for real incentives.

For the RLIS treatment, as the participant entered the room, the experimenter asked him to pick a little manila envelope from a box. The three examples of risk tasks were followed by the subjects being instructed that they would face several risk tasks similar to the ones just described and that only one of them would be for real. They were told that the little envelope contained the code of the risk task they would play for real at the end of the experiment, and that they could not open it until required to do so. Instructions continue with "In addition, you will complete some knowledge tasks".

For each of the "Single +" treatments, the three examples of risk tasks were followed by the subjects being told that they will face a risk task for real similar to the ones just described. Next, they effectively faced their risk task for real and were informed that they will play out their chosen option at the end of the experiment. Then each subject put the risk task inside his big manila envelope. Instructions continue informing them that they would answer some more risk tasks hypothetically -though were asked to please consider them as if they were for real- and with "In addition, you will complete some knowledge tasks".

The decision sheet for each task was handed in just before the subjects were asked to make their choices or to answer the questions. Simultaneously, the corresponding risk task was displayed on the Powerpoint presentation. For knowledge tasks, just the name of the task was displayed. After completion of any task, subject kept the decision sheet inside their big manila envelope; which allowed the experimenter to know when every subject had finished the current task and avoided the possibility that subjects would have a look at their previous risk choices.