Salient Rewards, Payoff Protocols and Biased Data

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Abstract

Paying salient rewards to subjects is expensive. Is it worth it? We describe previous data from otherwise identical treatments with hypothetical or salient payoffs that indicate opposite conclusions about the central research question in a paper. If we are going to pay salient rewards, how should we? The answer depends on the theoretical model underlying hypotheses being tested with the data, hence the choice of payoff protocol is an essential feature of experimental design. In recent years there has been renewed interest in theoretical and experimental research on properties of payoff protocols. We present an extension and critical discussion of the literature intended to promote uptake.

1. Introduction

The dominant view among experimental economists is that researchers should pay salient rewards to subjects in experiments. There is revealed disagreement about the specifics of saliency: how to relate subject rewards to experiment outcomes to incentivize unbiased choice from options in the experiment. We discuss "should", "salient" and "how".

Why should researchers pay salient rewards? One answer is that data from experiments without salient rewards can be inconsistent with *economically motivated* behavior, the central topic of economics. There is recent literature on the statistical significance or insignificance of differences in average (or some other statistic) outcomes with hypothetical vs. salient rewards (Branas-Garza et al. 2023; Hackethal et al. 2023). We bring back to the attention of the profession that subjects' behavior elicited with hypothetical rewards has been observed to support the *opposite* conclusion about the preference reversal phenomenon than does behavior elicited with salient rewards. And we discuss the characteristics of subjects' tasks that produced this outcome.

In a seminal paper, Smith wrote: "… *In both the field and the laboratory, value is induced on messages by the institution* whose rules state how messages are to be translated into valuable outcomes. … Thus in an experiment, … we must also give the subject a property right to rewards that are related appropriately to the realized experimental outcomes" (Smith, 1982, pg. 931). In order for a subject's messages to be related "appropriately" to rewards, the institution must be incentive compatible: it must always give a subject whose most preferred outcome is associated with message M an incentive to choose M rather than some other feasible message. The relationship between this last straightforward statement and much experimental practice is more interesting and more controversial than it might at first appear to be. We explore this topic in our paper and argue that the answers about incentive compatibility vary with the purpose of the experiment and the theory being applied or tested. There is no unique payoff protocol that is appropriate for all research questions. The choice of payoff protocol should be treated as an essential feature of experimental design. It often is not, as made clear by two surveys of the literature reported in section 6. Section 4 focuses on theoretical results, new and old, on incentive compatibility of alternative payoff protocols for salient payoffs. Section 5 dwells on recent discussions of empirical properties of pay one randomly, an often-used payoff protocol and the very one that inspired thought-provoking ideas in the preference reversal literature.

We begin section 2 by discussing some content in the literature on the preference reversal phenomenon which, forty years ago, first focused researchers' attention on potential effects of payoff protocols on individual choices and valuations, that when not accounted for, may lead to incorrect inferences pertaining to the original research question of a study.

2. Important lessons from preference reversal experiments

Preference reversal experiments originated in psychology and were introduced into the economics literature by Grether and Plott (1979).[1] Conventional preference reversal experiments use pairs of binary lotteries for which subjects are asked to: (1) choose between the lotteries in each pair; and (2) state minimum selling price for each lottery in each pair using Becker-DeGroot-Marshak (BDM) mechanism. Each pair includes a "dollar bet" ($-bet) with a relatively low probability of a relatively high win-state payoff, and a "probability bet" (P-bet) with a relatively high probability of a relatively low win-state payoff. Many subjects state higher selling price for the $-bet than for the P-bet but choose the latter over the former; this is known as "predicted preference reversal" (PPR). An "unpredicted" reversal is when a subject chooses the $-bet but places a higher selling price on the P-bet. A common feature of data from preference reversal experiments is much higher incidence of predicted reversals than unpredicted reversals.[2] Psychologists argue this can be

[1] The standard interpretation of the preference reversal phenomenon by psychologists is inconsistent with the conventional economics view that preferences are a characteristic of an agent. Instead, a common view in psychology is that the preferences of an agent are dependent on the response mode used to elicit them (Slovic and Lichtenstein 1968; Lichtenstein and Slovic 1971).

[2] Note that simply including unbiased random errors in decision theory cannot explain higher relative frequencies of predicted than unpredicted reversals.

explained by the anchoring and adjustment theory (and later variations).[3] But if risk preferences are a characteristic of an agent then elicited preferences should be independent of response modes and the higher stated price should be for the chosen lottery.

2.1 Hypothetical and salient incentives with BDM and random decision selection

Grether and Plott (1979) were skeptical about the preference reversal experiments reported by psychologists for reasons including their use of hypothetical payoffs. A central feature of the Grether and Plott design was use of paired treatments, one with hypothetical payoffs and another (otherwise identical) treatment with salient monetary payoffs. They report *higher* incidence of the PPR in the monetary payoff treatment than in the hypothetical payoff treatment. Grether and Plott (1979, pg. 623) concluded that "…this behavior is not simply a violation of some type of expected utility hypothesis. The preference measured one way is the *reverse* of preference measured another and seemingly theoretically compatible way. … The inconsistency is deeper than mere lack of transitivity or stochastic transitivity."

Grether and Plott's central conclusion was challenged by Holt (1986), Karni and Safra (1987), and Segal (1988) who maintained that the observed behavior could indeed be simply a violation of the expected utility hypothesis. Holt (1986) shows that, given reduction of compound lotteries, Grether and Plott's procedure of randomly selecting one of a subject's multiple responses for payoff depends on the independence axiom of expected utility theory to interpret the data as supporting the preference reversal phenomenon. Karni and Safra (1987) explained that use of the BDM procedure to elicit responses that could be interpreted as (minimum) selling prices required the reduction and independence axioms. While these two studies assume reduction axiom, Segal (1988) illustrates how BDM provides incentives for preference reversal if preferences over lotteries satisfy the compound independence axiom but not the reduction axiom. Both Karni and Safra (1987) and Segal (1988) interpret BDM procedure as a two-stage lottery but while the former uses reduction axiom to convert compound lotteries to simple lotteries the latter does not.

These criticisms introduced an important principle into the methodology of experimental economics. *The validity of conclusions that can be drawn from experiment data depends on the payoff protocol. Hence the choice of payoff protocol is an essential feature of experimental design.*

[3] See Lichtenstein and Slovic (1971) and Tversky et al. (1990). For an informative survey see Seidl (2002). Sugden (2015) presents a discussion of the psychology of "inner rational agent".

Forty years later, this principle remains to be internalized in the practice of experimental economics (see section 6).

2.2 Hypothetical and salient incentives without BDM or random decision selection

Within the preference reversal literature, Cox and Epstein (1989) and Cox and Grether (1996) responded to the methodological critique by conducting experiments that do *not* use either random decision selection or BDM. These researchers realized payoffs after each round and paid each subject the total of their payoffs at the end of an experiment session.[4] The data was analyzed for possible income effects, which were not found; hence their data is usable for studying preference reversals. Treatments in Cox and Grether include market decision making with valuation and choice response modes. The market valuation response mode is the second price sealed bid auction. The market choice response mode is the English clock auction.

2.2.1 Opposite conclusions from hypothetical and salient incentives in repetitive markets

In the first round in the market treatments, significant asymmetric (predicted greater than unpredicted) preference reversals were observed with *both* hypothetical and salient payoffs. By round 5, the outcomes changed dramatically. With hypothetical payoffs, significant asymmetric preference reversals were robust to five rounds of repetition in the markets. In contrast, with salient payoffs, predicted reversals were slightly lower than unpredicted reversals after five market rounds. In this way, data from hypothetical or salient payoff treatments lead to opposite conclusions about the central question posed in the research: Is the PPR pattern robust to repetitive decisions in markets? This provides an example of unambiguously clear support for the importance of using salient incentives in experiments to study *economic* behavior.

2.2.2 What accounts for the contradiction between results from hypothetical and salient payoffs?

The general idea is that with hypothetical payoffs there are no monetary costs from making suboptimal choices, and therefore there are weak incentives for learning. Specific to this study, there are some distinctive features of the tasks. The market (sequential) choice task is the English clock auction in which, at each tick of the price clock, a subject chooses between keeping the

[4] See section 4 below for incentive compatibility properties of this "pay all sequentially" (PAS) payoff protocol.

lottery for sure (by exiting the auction) or maintaining the right to sell it. Lottery pair 2 (in Cox and Grether 1996) provides a representative example. In the English auction, clock price starts at the amount of the win-state payoff and decreases by 5 cents with each tick, every second. In both hypothetical and incentivized treatments, in the $-bet the clock price starts at $9 whereas in the P-bet it starts at $2. For the $-bet it takes 153 ticks, extending over 153 seconds, for the price on the clock to decrease from the $9 starting price to the bet's expected value of $1.35. Subjects may be impatient or get disutility from the attention-intensive activity of watching the price clock tick down and choosing at each tick whether to exit. If so, they can be relieved of these costs by exiting the auction. Of course, exiting early produces high minimum selling prices for the $-bet and results in high predicted preference reversal rates. This is what many subjects did with hypothetical payoffs but not with salient payoffs. On average, subjects exited the English auction for the pair 2 $-bet 74 seconds earlier (at a $3.65 higher price) with hypothetical payoffs than with salient payoffs. This central finding in Cox and Grether (1996) makes clear why it can be important to *avoid* hypothetical payoffs.

The experimental methods analyses by Holt (1986), Karni and Safra (1987) and Segal (1988) apply whether there are or are not response mode effects that can elicit different risk preferences. We now turn our attention towards properties of alternative payoff protocols used in many-decision experiments for eliciting preferences that are a characteristic of an agent.

3. Alternative mechanisms for salient payoffs

The Holt (1986) critique of Grether and Plott (1979) makes clear the importance of incorporating properties of payoff protocols in hypotheses and data analysis for drawing valid conclusions from experiments. Such questions about payoff protocols arise in many types of experiments.[5] Our focus will be on experiments on decision making under risk.

Discussion of experimental methods for researching decisions under risk is dependent on an answer to the seminal question about what the researcher hopes to learn from conducting an experiment.[6] Is the purpose of an experiment to elicit subjects' latent risk preferences? Or is the purpose of an experiment to study how subjects respond to decision environments that provide

[5] Examples include experiments on decision-making under risk or ambiguity, trust (investment) games with role reversal, public good games, voting and bargaining with alternating offers (Cox et al. 2015).

[6] Cox and Sadiraj (2019) characterize the relationship between an experimenter and subjects as a principal-agent problem. They discuss several examples of misalignment between the objectives of experimenter and subjects.

opportunities for constructing risk preferences? Most of our content will be concerned with experimental methods for eliciting latent risk preferences.

Suppose a researcher wants to elicit a subject's preference over two stochastic options. The traditional "gold standard" method is to ask the subject to choose between the two options and pay the realized outcome from the chosen one. This One Task elicitation is incentive compatible for latent preferences and it is used in experiments to test hypotheses with between-subjects data. There are many experiments that use within-subjects data generated by having individual subjects make multiple decisions. In such experiments, payment of salient rewards necessitates choice of a protocol or "mechanism" for rewarding subjects.

In recent years there has been renewed interest in theoretical and experimental research on incentive compatibility of payoff protocols. Significant progress has been made, however seemingly-inconsistent statements of results in some papers makes uptake by readers of the current state of knowledge a difficult endeavor. We report new theoretical results on incentive compatibility and integrate results from recent literature on payoff protocols to promote uptake.

4. Theoretical results on incentive compatible payoff protocols

Expected value theory (EV) has functional that is linear in both payoffs and probabilities. All conventional payoff protocols are incentive compatible for EV. Incentive compatibility for other decision theories varies with properties of the theory and the protocol.

We first discuss incentive compatibility of randomly selecting one of each subject's choices for payoff. We use Cox et al. (2015) terminology and call this payoff protocol "pay one randomly" (POR).[7]

4.1 Pay one randomly selected decision of each subject

POR is a lottery. When choice options in an experiment are over lotteries, introduction of POR to pay subjects creates compound lotteries. Some theories of decision under risk use reduction of compound lotteries axiom to convert compound lotteries to simple lotteries. Other models use certainty equivalents to convert compound lotteries to simple lotteries.

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[7] This payoff protocol has been given several names in the literature including random lottery incentive mechanism (RLIM), random incentive system (RIS), random incentive mechanism (RIM), random problem selection (RPS) and pay one randomly (POR).

4.1.1 Incentive compatibility with reduction axiom

Previous literature (including Holt 1986; Cox et al. 2015) demonstrates that POR is incentive compatible for expected utility theory but is *not* incentive compatible for rank dependent utility theory (Quiggin 1982), cumulative prospect theory (Tversky and Kahneman 1992), and dual theory of expected utility (Yaari 1987). Given reduction, but absent independence, randomly selecting one decision for payoff creates incentives for biased revelation of latent risk preferences. Recent work by Azrieli et al. (2020, section 6) also explains that, given reduction of compound lotteries, POR (or RPS) is not incentive compatible for non-EU models such as rank dependent utility, in this way reaching the same conclusion as Cox et al. (2015).

4.1.2 Incentive compatibility absent reduction axiom

We here present two counterexamples to incentive compatibility of POR that are not dependent on reduction axiom. Our examples illustrate incentive problems with POR when certainty equivalents (rather than reduction axiom) are used to evaluate compound lotteries.

Example 1. In a two decision-task experiment, an individual is asked to make two decisions. Decision Task 1 is a choice between two options, S and R. Option S pays $30 if a coin flip lands Heads and $10 if it lands Tails. Option R pays twice as much, $60 if Heads, but nothing if Tails. For simplicity, let Decision Task 2 be the same as Decision Task 1, a choice between options S and R.

Without any loss of generality, let u($0)=0 and u($60)=1. Consider an individual with probability transformation, f(0.5) = 0.6 and utilities u($10) = 0.2 and u($30) = 0.9. Our individual prefers S over R as S is valued 0.62 whereas R is valued 0.60.[8] For these latent preferences, SS is the unbiased choice in two isolated decisions.

Suppose that, rather than reduction, our individual uses certainty equivalents to evaluate compound lotteries. Table 1 shows feasible choices in the two decision-task experiment and the last column shows the valuations of each feasible choice. When incentivized with POR, it is

[8] Valuations of the simple lotteries are as follows. S: f(0.5) u(30) + (1-f(0.5)) u(10) = 0.6(0.9) + 0.4(0.2) = 0.62.
R: f(0.5) u(60) = 0.60.

optimal for our individual to choose S in one decision task and R in the other, that is SR (or RS)[9] as follows.

Table 1. Valuations of Feasible Choices in the two-decision task experiment

Feasible Choice	Coin lands Heads	Coin lands Tails	Value of Feasible Choice (Certainty Equivalents Model)
RR	\$60 or \$60	\$0 or \$0	0.600
RS	\$60 or \$30	\$0 or \$10	0.624
SR	\$30 or \$60	\$10 or \$0	0.624
SS	\$30 or \$30	\$10 or \$10	0.620

Note: R pays \$60 (Heads) and \$0 (Tails). S pays \$30 (Heads) and \$10 (Tails).

Value of SR: Choose option S in Decision Task 1 and R in Decision Task 2. If the coin lands Heads, SR pays \$30 or \$60, equally likely depending on whether decision 1 or 2 is selected for payment. The value of this simple lottery is 0.96.[10] Let \$x denote its certainty equivalent, that is, u(x)=0.96. If the coin lands Tails, SR pays \$10 (if decision 1 pays) or \$0 (if decision 2 pays), equally likely. The value of this simple lottery is 0.12.[11] Let \$y denote its certainty equivalent, that is, u(y)= 0.12. Substituting these certainty equivalents, SR reduces to the simple lottery that pays \$x or \$y, equally likely. Using certainty equivalents, the value of the compound lottery SR is f(0.5) u(x) + (1-f(0.5)) u(y) = 0.6(0.96) + 0.4(0.12) = 0.624. Similarly, we find that the value of the compound lottery SS is 0.620.[12]

One might wonder about the choice of our individual if he used reduction axiom, rather than certainty equivalents. To answer this question, we need more information. Specifically, we also need to know their transformations of probabilities 0.25 and 0.75. Depending on those figures, they may choose SS (unbiased data) or SR (biased data).[13]

[9] Preference for randomization is further discussed in section 4.1.3.
[10] f(0.5) u(60) + (1-f(0.5)) u(30) = 0.6(1) + 0.4(0.9) = 0.96.
[11] f(0.5) u(10) = 0.6(0.2) = 0.12.
[12] SS: If Heads, SS pays \$30 whether decision 1 or 2 is selected for payment, so its ce is \$30. If Tails, SS pays \$10 (for either selected decision) and its ce is \$10. The value of the compound lottery SS, after substituting these two ce, is the same as the value of the simple lottery S.
[13] With Reduction Axiom, value of choice pattern SR (or RS) is f(0.25)u(60) + [f(0.5) - f(0.25)]u(30) + [f(0.75) – f(0.5)] u(10) = f(0.25) + [0.6 - f(0.25)] 0.9 + [f(0.75) – 0.6] 0.2 which can be larger or smaller than 0.62 (value of SS) depending on f(0.25) and f(0.75). E.g. for f(0.25)=0.3, SS is chosen if f(0.75)=0.8 and SR is chosen if f(0.75)=0.86.

Example 2. We draw from Segal's (1988) discussion of BDM to illustrate that POR menu implementation of BDM is not incentive compatible. Consider an individual with risk preferences over simple lotteries represented by utility of money, $u(z) = z^{0.9}$ and Prelec probability transformation, $f(p) = \exp(-(-\ln p)^2)$ and who uses certainty equivalents rather than reduction to evaluate compound lotteries.

Let the lottery of interest be some $X = \{\$35, 0.51; \$0\}$. For our individual, ce(X) = \$21.15.[14] Suppose the experimenter would like to elicit (place bounds on) the certainty equivalent of X. The experimental design includes choice between the lottery X and varying certain amounts of money in three decision tasks:[15]

Decision Task 1: X or \$10

Decision Task 2: X or \$20

Decision Task 3: X or \$25

In isolated choices, the individual would switch from choosing X to choosing the sure amount of money after row 2. What will the individual do when making three choices incentivized by POR for payment?

Switching from X to sure money after row 1, offers X with probability 1/3 and \$20 or \$25 (equally likely) with probability 2/3. The certainty equivalents of the latter[16] and the former are \$23.08 and \$21.15, so the value of switching to the sure amount after row 1 is 16.7, or about \$23.[17]

Switching from X to the sure money after row 2, results in the compound lottery that offers X with probability 2/3 and \$25 with probability 1/3. Use the certainty equivalents to verify that the value of switching to the sure amount after row 2 is 16.3, or about \$22. That is, our individual's choice in POR will be biased as they will switch from X to the sure amount of money after row 1, not after row 2.

4.1.3 Stochastic Choice

The examples above and the ones with reduction axiom in previous literature, illustrate issues with incentives under POR for risk preferences with nonlinear probability transformations. Here we explore the key idea that POR provides incentives for stochastic choice for subjects with

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[14] $f(0.51)u(35) = 0.64(35)^{0.9} = 15.58 = (21.15)^{0.9}$

[15] Of course, one could consider more decision tasks than three, with additional ones within or outside the range of Decision Tasks 1-3, and the inconsistency with incentive compatibility would follow from the same logic.

[16] $f(0.5)u(25) + (1-f(0.5))u(20) = 0.62(25)^{0.9} + 0.38(20)^{0.9} = 16.86 = (23.1)^{0.9}$

[17] $f(2/3)u(23.08) + (1-f(2/3))u(21.15) = 0.85(23.08)^{0.9} + 0.15(21.15)^{0.9} = 16.7 = (22.8)^{0.9}$

preferences for mixtures (Machina 1985). Stochastic choice (different choices in repeated decision tasks with the same feasible set) is not a thought experiment, it is an empirically prevalent phenomenon.[18]

Consider a set S of two lotteries, S={A, B} and let ζ = {α, β, γ} be the feasible set of probability distributions on S, such that α offers lottery A with certainty, β offers lottery B with certainty and γ offers A or B with equal probability. Our individual prefers A over B but also prefers equal randomization of A and B against getting either one for sure. As commonly assumed in theoretical literature, for all lotteries X our individual is indifferent between X and the degenerate distribution, χ={X,1} that offers X with certainty. It follows that individual's ranking of options in ζ is $\alpha \succ \beta$ and $\gamma \succ \beta$ and $\gamma \succ \alpha$.

The experimenter is interested in eliciting this individual's ranking of A and B. In a One Task experiment, the experimenter promises to pay with probability 1 the chosen option. So, when our individual is asked to choose between lotteries A and B in the experiment they choose between getting A for sure or getting B for sure. That is, in the experiment the feasible set is {α, β}. Given his preferences, $a \succ \beta$, and indifference between A and α, it is optimal to choose A from set {A, B} and end up with the most preferred choice, α from the feasible set {α, β}.

Now let the individual be asked to choose between lotteries A and B twice and the experimenter randomly select which decision task to implement. In this two-decision task experiment with POR, the feasible set is ζ = {α, β, γ}. The most preferred option in ζ for our individual is γ, and the only way they can get that is by making a stochastic choice, choose A from set {A, B} in one of the decision tasks, and B from the same set {A,B} in the other decision task. Unbiased data for ranking of A and B, requires pattern AA, but that corresponds to option α in the feasible set ζ, in the experiment, which is less preferred than option γ. That is, as Machina (1985) reasons, even though our individual has deterministic preferences over A and B, when offered the opportunity to choose more than once from {A, B} their choice be stochastic.

[18] Agranov and Ortoleva (2017) report that in their experiment the majority of subjects choose different lotteries when asked to choose from the same set of lotteries three times in a row and are told about the repetition. For an overview of empirical literature on preferences for randomization see Agranov and Ortoleva (2022).

4.2 Incentive compatibility or incompatibility of other commonly used payment protocols

We next summarize what is known about incentive compatibility of several other commonly used payoff protocols.[19]

One Task (OT) protocol: With OT, each subject is asked to respond to only one choice task; outcome from a subject's chosen option is realized and is paid to the subject. Since there exists only one decision task, a subject has an incentive to reveal their latent preferences truthfully for the most preferred option available in that task. Hence OT is incentive compatible for all decision theories.

Pay all sequentially (PAS) protocol. With PAS, realization of outcome from a chosen option occurs and is revealed to a subject immediately after the choice, before the next choice is made, with the sum of all realized outcomes paid to the subject at the end of the experiment session. As accumulated wealth changes between choices, PAS is not incentive compatible for expected utility of terminal wealth[20] (unless the subject is somehow known to have CARA preferences). Changes in wealth are not relevant to models with functionals defined on income (not terminal wealth). Hence PAS is incentive compatible for expected utility of income model, commonly used in auction theory beginning with Vickery (1961). Similarly, PAS is incentive compatible for rank dependent utility theory if payoffs are identified as amounts of income but not if they are identified as terminal wealth.[21] PAS is incentive compatible for cumulative prospect theory with fixed reference point ("prospect theory, no memory" as in Thaler and Johnson 1990, p. 646) but not for some other editing rules. The functional for dual theory of expected utility is linear in payoffs (by the dual independence axiom) for all risk attitudes; hence PAS is incentive compatible.

Pay all correlated (PAC) protocol. With PAC, outcomes from all chosen options are realized and paid at the end of a session with one realization of the state of nature. This protocol was used for subject payoffs in experiments with comonotonic lotteries in Cox et al. (2015). They demonstrated that, with comonotonic lotteries, PAC is incentive compatible for dual theory (Yaari 1987).[22]

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[19] Statements about incentive compatibility of payoff protocols in this section are based on proofs and counterexamples in Cox et al. (2015).

[20] Classic references for the terminal wealth model are Arrow (1971) and Pratt (1964).

[21] Both specifications of prizes are commonly used in the literature (Wakker 2010).

[22] With PAC, payoff equals the sum of payoffs (for the realized state) from all lotteries. Another way of PAC implementation is by dividing PAC payoff by the number of decisions; this is called PAC_N in Cox et al. (2015).

Pay all independently (PAI) protocol. In many studies, outcomes from all chosen options are independently realized at the end of a session, when the sum of all outcomes is paid to the subjects. PAI creates portfolio incentives; *it is not incentive compatible* for any popular theory except expected value theory.

Pay more than one randomly selected decision. This procedure creates portfolio incentives and, like PAI, is *not incentive compatible* for any popular decision theory other than expected value theory.

4.3 Incentive compatibility or incompatibility of paying only some randomly selected subjects

Suppose an experimentalist has chosen well the decision tasks they want to use to research their questions of interest. And suppose each subject will be asked to make only one decision. If the researcher pays all subjects the realized outcome from their chosen option then the experimental design provides incentives for subjects to truthfully reveal their latent risk preferences (it is incentive compatible).

Next suppose the researcher considers making one change in the above experimental design: *n* subjects out of the total *N* subjects will be randomly selected to receive salient rewards while the others will not be paid. Is the resulting experimental design still incentive compatible with addition of this subject selection protocol?

With reduction, the subject selection protocol multiplies probabilities of receiving payoffs in the simple lotteries in the choice tasks by n/N and assigns the probability $1 - n/N$ to payoff of 0. This creates prospects with a common ratio (Allais 1953). The implication for incentive compatibility depends on other features of the experimental design.

Let lotteries B and D be choice options in the experiment. With random subject selection for payoff, the choice between lotteries B and D is a choice between a compound lottery, β that pays B with probability p= n/N and 0 otherwise, and the compound lottery δ, that pays D with probability p= n/N and 0 otherwise. By the mixture independence axiom, if B is preferred over D, then β is preferred over δ. Hence, the protocol is incentive compatible for expected utility theory. It is not incentive compatible for cumulative prospect theory or rank dependent utility or dual theory of expected utility. For example, an RDU individual with power utility $u(x) = x^{0.6}$ and Prelec probability transformation, $f(p) = e^{-(-\ln p)^{0.8}}$ prefers $\mathrm{B} = \{\$30,1; 0\}$ over $\mathrm{D} = \{\$40,0.8; 0\}$, so chooses B in the one task, pay all subjects protocol. But if only 1/3 of subjects are paid, then our individual prefers $\delta = \{\mathrm{D}, \frac{1}{3}; 0\}$ over $\beta = \{\mathrm{B}, \frac{1}{3}; 0\}$. Similarly, for dual theory, replace

$u(x) = x$ in the example above and verify that B is chosen over D in the one task, pay all subjects protocol but D is chosen in the one task decision experiment that pays 1/3 of subjects.[23]

4.4 The ABC mechanism

In light of the discussion of preference reversal literature in section 2, incentivizing decisions with salient rewards is warranted. As stated above, however, paying *one* decision *randomly* is not incentive compatible for risk preferences exhibiting nonlinearity in probabilities. Paying for *all* decisions *sequentially* is not incentive compatible for risk preferences nonlinear in accumulated monetary payoffs. One might envision paying for only one decision task but using some non-random selection procedure that preserves incentivization of each decision task. Li (2021) presents such a mechanism, the Accumulative Best Choice (ABC) mechanism.

Li (2021) shows that ABC is incentive compatible for complete and transitive preferences. Thus, ABC can be used to elicit risk preferences, whether they are nonlinear in probabilities, payoffs, or both.[24] How does it work? After any decision task, ABC constructs the feasible set for the next task by including the chosen option. ABC pays only the last choice (that is, one task) while preserving incentives for every task. There are, however, limitations on experimental designs where ABC can be applied. The endogenous formation of decision sets may not necessarily be consistent with some research questions.

Li (2021) reports two experiments with ABC as a payoff protocol. In one experiment she uses Cox et al. (2015) five lottery pairs whereas in the other experiment the lotteries are from Harrison and Swarthout (2014). In both experiments, she finds that risk preferences elicited with ABC and OT are *not* statistically different. This finding complements the Cox et al. (2015) and Harrison and Swarthout (2014) finding that pay one randomly *does* elicit different risk preferences than OT.[25]

[23] For a recent study that uses this protocol see Anderson et al. 2023. They find that it affects the ordering of subjects regarding risk aversion and that, compared to paying every subject, paying some subjects elicits less or more risk aversion depending on low or high payoff stakes. See also Baltussen et al. 2012.

[24] Li (2021) uses ABC to elicit risk attitudes in Cox, et al. (2015) pairwise-lottery sets, that include Allais type of lotteries. Pairs of lotteries across rows in their Table 1 satisfy first-order-stochastic dominance leading to a straightforward construction of ABC decision tasks and eliciting (unbiased) preferred choice in every decision task.

[25] This result holds for the Cox et al. (2015) treatment in which subjects were *not* given prior information about lottery pairs.

5. Empirical properties of pay one randomly protocol

In this section we discuss several possible causes of biased elicitation by the pay one randomly (POR) protocol because: (i) it was the focus of critical discussion of implication of preference reversals for rationality 40 years ago; (ii) it is the protocol that has received special attention in recent literature; and (iii) it is the most used protocol in experiments on individual decision making under risk. This payoff protocol has been given several names; as above we use POR except for instances where we are discussing treatments in papers in which authors used a different label for their treatments.

5.1 Empirical validity of the isolation hypothesis

The assumption of isolation of individual decisions is frequently used to defend the use of POR for payment. Recently, there has been accumulating evidence that: (a) decision makers do *not* generally isolate individual decisions; and (b) bias from using POR can be significant. We integrate and interpret findings reported in several recent papers.

5.1.1 Early tests: Isolation vs. whole experiment optimization

Earlier studies (Starmer and Sugden 1991; Hey and Lee 2005a, 2005b) provide data that favor the isolation hypothesis over the alternative hypothesis of "full reduction", which means subjects make every choice so as to yield the most preferred compound lottery from the whole experiment. But full reduction vs. isolation are extreme hypotheses. A more plausible alternative to isolation is provided by cross-task contamination in which choices may be affected by options included in the adjacent decision tasks. Starmer and Sugden (1991, p.977) data suggest cross-task contamination. In contrast, Cubitt et al. (1998) do not find cross-task contamination from random task selection when choice options are presented in list format. This provides a bridge to subsequent literature.

5.1.2 Recent Tests: Isolation vs. cross-task contamination

Cox et al. (2015) report data from elicitation of choices from five classic lottery pairs[26] using nine payoff protocols (or mechanisms) including two alternative versions of POR and two versions of (deterministic) pay one task treatment. The data are dramatically inconsistent with the isolation

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[26] All treatments involved choices over the same five pairs of binary lotteries that had the potential for subjects to make choices exhibiting Allais (1953) paradoxes and dual Yaari (1987) paradoxes.

hypothesis. The isolation hypothesis requires no payoff protocol effects on the percentages of the less risky option being chosen in each of the five lottery pairs. For three (out of the five) lottery pairs, the frequency of the less risky lottery choice in some protocol is more than three times the figure in a different protocol whereas for the other two lottery pairs it is more than twice.[27] Other recent papers that report data inconsistent with the isolation hypothesis include Cox et al. 2014, Harrison and Swarthout 2014, Brown and Healy 2018, Charness et al. 2018, Freeman and Mayraz 2019 and Freeman et al. 2019. Some of these papers provide evidence on potential sources of biased choices with POR: incentives, certainties, list formats and menu dependence.

5.2 Causes of bias from POR: Incentives, certainties, list format and menu dependence

POR can affect elicited risk preferences in at least three distinct ways. One comes from the incentives created: the interpretation of data requires a theory of how subjects respond to compound lotteries. As stated in section 4, a subject whose preferences are characterized by the commonly used non-expected utility theories may be incentivized to reveal biased preferences in an experiment using POR. An immediate implication is that data from the large literature reporting experiments using POR, intended to test hypotheses from cumulative prospect theory or rank dependent utility theory, could be biased for *the decision theory applied to the data*. The researchers who use POR for testing or applying non-EU decision theories need to show that their data are not biased; including OT controls for subsets of the decision tasks in the experiment seems promising (as in Harrison and Swartout 2014).

A second way in which POR can affect elicited choices occurs if a subject's preferences are characterized by the certainty effect (Allais 1953). With such preferences, use of POR will transform a certain payoff (a degenerate lottery) into a stochastic payoff received with probability $1/n$, where n is the number of decision tasks in the experiment. This can cause elicited preferences over a certain prize and a nondegenerate lottery to be the reverse of preferences elicited by the One Task protocol in which the certain option is received with probability 1 when chosen by the subject (Freeman et al. 2019).[28]

A third way in which random task selection can affect elicited choices comes from an experimenter's decision about the set of options included in the experiment as determined by the

[27] See Table 4 in Cox et al. (2015).
[28] Note that this feature is always present in one decision task experiments with random *subject* payment protocol.

research questions of the study. Different compositions of this menu of choices can cause POR to elicit different preferences over individual choice pairs. For example, inclusion or exclusion of asymmetrically dominated lotteries in the menu of options has been shown to elicit significantly different risk preferences (Cox, et al. 2014).

Recent studies (Brown and Healy 2018; Freeman and Mayraz 2019) focus on disentangling incentives from presentation effects such as: (a) making one choice from a list; (b) making sequential choices from a list; (c) seeing a list and then making one choice on a separated screen; and (d) not seeing a list but sequentially making choices on separated screens. One of the objectives of these papers is to develop and implement experimental procedures intended to minimize bias in data generated through use of POR to pay subjects. Such developments have the potential to offer researchers valuable tools. We discuss some promising procedures in individual papers (Table 2) and evaluate them in the larger context of other papers in recent literature to ascertain the robustness of reported findings and conclusions.

5.2.1 Separated choice format effects

Brown and Healy (2018) examines behavior when decision tasks are presented separately (S) or as a list (L). One of their findings is that with lists, POR (or RPS) elicits more risk aversion than OT[29] leading to the conclusion that the former elicits biased data (row 1, Table 2). They attribute the bias to the list inducing menu-dependent preferences as, absent lists, in their experiment choices in POR (or "RPS") and OT are similar.[30] They conclude that when decision tasks are separated (for example, each displayed on a separate computer screen), incentive compatibility of POR (or "RPS") is restored.

This suggests there might be a simple solution to the problem of POR producing biased data: present choice tasks on separate screens rather than in list format. This would be important for experimental methods if it were a robust result. Unfortunately, this simple remedy is not supported by data from Harrison and Swarthout (2014), Cox et al. (2015), and Freeman and Mayraz (2019).[31]

[29] Brown and Healy 2018, Table 3: The risky option in decision 14 is chosen by 51.7% (L-RPS), 70% (L-14) and 55.7% (O-14) of subjects. Options in decision task 14 are (10, 0.5; 5) and (15, 0.7; 0).
[30] Brown and Healy 2018, Table 6. The risky option in decision 14 is observed in 59% (S-RPS) and 55.6% (S-14).
[31] See Table 2: Freeman and Mayraz 2019 (p=0.001, row 10); Harrison and Swarthout (p=0.055, row 13) and Cox et al. 2015 (p=0.001, rows 4 and 5).

Table 2. Recent Experimental Tests for Payoff Protocol Effects on Choices

Paper	Row	Treatment Comparison	Cer-tainty Effect	List	Separate Choice Screens	Menu Effects	p-value
Brown & Healy (2018)	1	L-RPS vs. L-14	no	yes, yes	no, no	yes, yes	0.041
	2	S-RPS vs. S-14	no	no, no	yes, yes	yes, yes	0.697
Cox, et al. (2015)	3	PORpi vs. ImpureOT (2,3,4)	no	yes[a], yes[a]	yes, yes	yes, yes	0.643
	4	PORnp vs. OT	no	no, no	yes, yes	no[b], no	0.001
	5	1st Choice Only PORnp vs. OT	no	no, no	yes, yes	no, no	0.001
Freeman, et al. (2019)	6	L1 vs. P1	yes	yes, no	no, yes	yes, no	0.001
	7	L2 vs. P2	no	yes, no	no, yes	yes, no	0.17
	8	S1 vs. P1	yes	yes, no	yes/no[c], yes	yes, no	0.001
	9	S2 vs. P2	no	yes, no	yes/no[c], yes	yes, no	0.21
Freeman & Mayraz (2019)	10	Q85: R-list vs. SC	yes	yes, no	no, yes	yes, no	0.001
	11	Q85: R-list vs. K-list	yes	yes, yes	no, no	yes, yes	0.152
	12	Q85: K-list vs. SC	yes	yes, no	no, yes	yes, no	0.013
Harrison & Swarthout (2014)	13	1 in 30 vs. 1 in 1	no	no, no	yes, yes	yes, no	0.055

a. Subjects could construct lists from separate slips of paper for individual lottery pairs
b. Subjects' memory of previous choice pairs could have a "menu-type" effect.
c. Decisions first made on separate screens then reported in a filled-in choice list with opportunity to change choices.

Harrison and Swarthout (2014) compares risk attitudes estimated for rank dependent utility model with data from the OT treatment in which subjects make a single choice (treatment "1 in 1") and data from a treatment with *separated* decisions in which subjects makes 30 choices and are paid with POR (treatment "1 in 30").[32] Their data reject the null hypothesis that "1 in 1" and "1 in 30" choices can be characterized by the same risk aversion parameters for rank dependent utility model.

In Cox, et al. (2015) treatment with random payment and no prior information, PORnp the first time a subject saw a lottery pair was when they encountered the choice screen for that pair.[33]

[32] Their subjects were not given lottery pairs in list format; instead, the first time a subject encountered a lottery pair was on the separate screen for entering a choice from the pair.
[33] Subjects could not return to an earlier screen after entering their decision and advancing to the next screen.

The significantly lower risk aversion observed in OT that in PORnp (using all rounds or only the first-round choices) cannot be attributed to a list format.

Freeman and Mayraz (2019) data also do *not* provide support for eliminating bias from POR by presenting choice tasks on separate screens. Instead, they attribute bias from POR to certainty effects, the topic of our next section.

5.2.2 Certainty effects

Pairwise choices in list format and POR are often used to elicit certainty equivalents of lotteries (in place of BDM). Each row in the list contains the same lottery but the certain amount of money changes (usually monotonically) across rows. If a switching probability is to be elicited, each row in the list contains the same amount of money but probability of the outcomes (of the risky option) monotonically changes across rows.

Freeman et al. (2019) researches effects of lists and payoff protocols on two pairs of lotteries of Allais type and observe that, when the pair in the decision task contains a degenerate lottery, POR and OT elicit different choices[34] with or without "choice lists" but the effect disappears with non-degenerate lotteries.[35] They conclude that when decision tasks are embedded in lists, POR (or "RTS") elicits: (i) less risk aversion in pairs with degenerate lotteries, but (ii) similar risk attitudes in pairs with non-degenerate lotteries. The latter is inconsistent with Brown and Healy's (2018) conclusion. The former is inconsistent with observed choices in Cox et al. (2015) pairs 2 and 5 that included a degenerate lottery.[36] Compared to OT treatment, POR with prior information, POR_{pi} elicits significantly more risk averse behavior in pair 2 (the risky option includes payoff 0) but the effect is not significant in pair 5 (the risky option includes only positive prizes). More data is needed, but it seems like the data may be telling a story of "zero effect", not "certainty effect".

5.2.3 Menu effects

A menu effect occurs when the choice among options in one task can depend on the options available in other tasks. Cox, et al. (2014), who experiment with OT and two tasks with separated

[34] Table 2, rows 6 and 8. L1 data, and S1 data are significantly different (p=0.001) from treatment P1 data.
[35] Table 2, rows 7 and 9. L2 data, and S2 data are not significantly different from treatment P2 data.
[36] Pair 2: $6 for sure or ($10, 0.8;0). Pair 5 adds $12 to all prizes in pair 2: $18 for sure or ($22, 0.8; $12). The sure option chosen 50% (PORpi) and 15% (OT) in pair 2; for pair 5, these figures are 50% (PORpi) and 38.46% (OT).

decisions and POR[37], find that choices over risky options elicited with POR depend on presence or absence of asymmetrically dominated choice options in the experiment. This is a menu effect. Freeman and Mayraz (2019) experiment with R-lists, K-lists, and SCs. R-lists are treatments which pay subjects according to POR (or "RTS"). Presentations of lottery pairs in K-lists are the same as R-lists but the subjects are informed they will be paid according to their choice in one pair rather than a randomly selected choice pair; SC treatments offer subjects a *single* choice pair. They report that their data indicate that OT and SC elicit different choices than K-list (row 12, Table 2) which has the same financial incentives, and different choices than R-list (row 10, Table 2) that pays according to POR (or "RTS"). With "choice-list" format, data from R-list and K-list are not significantly different. This finding is consistent with PORpi and ImpureOT data observed in Cox, et al. (2015).[38]

6. Why is the incentive compatibility issue important?

The mounting evidence of risk preference elicitation bias from random task selection has stimulated research on identifying new payoff mechanisms that are incentive compatible for non-EU decision theories and on experiments with their behavioral properties. Some progress has been made. Cox, et al. (2015) introduce two versions of a payoff mechanism that is incentive compatible for dual theory of expected utility (Yaari 1987). More importantly, Li (2021) introduces the accumulated best choice (ABC) mechanism that is incentive compatible for all decision theories that have complete and transitive preferences and can be used to elicit risk preferences in many types of experiments.

It has been about 40 years since Holt (1986) stated why conclusions that can be correctly drawn from data can depend on the subject payment protocol used in an experiment. In following decades there has been additional theoretical work on payment protocols and data from experiments on payoff protocol effects on behavior. To date, this literature has had only modest effect on practice in experimental economics.

A survey in Azrieli, et al. (2018, pgs. 1473-1474) of papers on decisions under risk published in 2011 in top five general readership journals and *Experimental Economics* reveals use of many distinct payoff protocols. In about 29 percent of papers in the survey, authors did not

[37] All decision tasks were given to the subjects in the instructions.
[38] See row 3 in Table 2.

describe how subjects were paid in many-decision experiments. Another 48 percent of papers described how subjects were paid but provided no justification for the chosen mechanism. In those papers with identifiable payoff mechanisms: 56 percent paid for every decision, 25 percent paid for one randomly selected decision, and 13 percent paid for more than one randomly selected decision. The high incidence of unexplained and divergent choices of payoff protocols suggests researchers may consider this to be an "unimportant detail" of experimental methods. In more recent years, have researchers used incentive compatible payoff protocols?

We recently surveyed papers published in *Experimental Economics* during 2016 – 2024. Here is what we found. On a positive note: (1) the payment protocol used in an experiment was usually clear from the text or the subject instructions or both; and (2) there were many papers with models based on expected value theory for which all commonly used payoff protocols are incentive compatible. Choice from among alternative payment protocols varied a lot across papers. There were many heuristic experiments designed to collect interesting behavior but not to test or apply formal models. For these papers, theory is not a guide for choice of payoff protocol but empirical properties of payoff protocols reported in our cited literature (in section 5) is informative. On a disappointing note, a substantial number of papers (38) used incentive-*in*compatible payoff protocols, almost half of them by using *pay one randomly* for non-EU models (16 papers) and the others distributed between *paying two or more randomly* for EU models, *paying two or more randomly* for rank dependent utility models, *paying all independently* at the end, and combination of *paying one randomly* and *paying all independently* at the end, and *paying all sequentially* for expected utility of terminal wealth models.[39]

There was virtually no discussion in any of the surveyed papers of reasons why a particular payoff protocol was chosen, nor any attempt to test for potential biases in the data. It appears many researchers may believe that one's choice from among familiar payment protocols is not relevant to validity of tests of hypotheses with experimental data. Except for testing expected value models, such belief is demonstrably incorrect.

7. Suggestions for experimental methods

Incentive compatibility or incentive incompatibility of payoff protocols follows from theory. Whether use of an incentive incompatible payoff protocol yields data that is *significantly* biased is

[39] We did not count the number of papers paying only some but not all of the subjects.

a distinct, empirical question. We have suggestions for experimental methods that reflect this distinction.

7.1 Avoiding incentive incompatible protocols

For testing EU models, randomly selecting *two or more* decisions for payoffs introduces portfolio effects into the incentives in the experiment. This is easy to avoid by randomly selecting only one decision when testing or applying EU models. For testing or applying *prospect theory* or *rank dependent utility of income use the pay all sequentially protocol, which is incentive compatible,* not the pay one randomly protocol which is not; or use the ABC mechanism or One Task (OT) or Impure OT. For testing *rank dependent utility of terminal wealth*, randomly selecting one, two or more decisions for payoff is not incentive compatible; use the ABC mechanism or OT or Impure OT. *Paying all decisions at the end* with independent random draws creates portfolio incentives. This should be avoided unless one is testing a theory of portfolio choice. With EU, *paying all decisions sequentially* is incentive compatible with the EU income model (as in most auction market theory) but not for the EU terminal wealth model (as in many other applications). *Randomly selecting (only) some subjects* for payoff creates prospects of Allais (1953) type and brings EU "in the back door". This should be avoided in experiments where OT or an alternative (otherwise) incentive compatible protocol is used to provide data for testing non-EU models. There is a simple, although expensive, solution: pay all the subjects.

7.2 Checking for significance of bias with incentive incompatible protocols

Bias from using an incentive incompatible payoff protocol may or may not be economically or statistically significant. There are known methods for checking that can be incorporated into experimental designs. The preference reversal literature provides an example. Cox and Epstein (1989) and Cox and Grether (1996) needed to avoid random decision selection to distinguish between response mode effects and inconsistencies with EU for reasons explained by Holt (1986). They used pay all sequentially, which could introduce bias from income effects. They analyzed the data for income effects, and for order effects, which were found to be insignificant. Hence the sequential choices with different response modes could be interpreted as response mode effects. Harrison and Swarthout (2014) used OT (one task) as a control treatment in an RDU risk attitude experiment (otherwise) using random decision selection. The OT data made it possible to measure the significance of bias caused by random decision selection. Other papers that have used OT as a control treatment to ascertain how payment protocols affect decisions include Beattie and Loomes (1997), Cubitt et al. (1998), Cox et al. (2014, 2015) and Freeman et al. (2016). With OT, a subject makes a single decision whereas payment protocols are used in within-subjects designs and require subjects to make many decisions. In a variant of OT, which we have called Impure OT, a subject makes several hypothetical decisions followed by a single decision with salient rewards. Impure OT has been used as a control treatment in Starmer and Sugden (1991), Cubitt et al. (1998), Cox et al. (2015), Brown and Healy (2018) and Freeman and Mayraz (2019).

8. Concluding remarks

We present a finding in the literature in which data from paying salient rewards clearly leads to the opposite conclusion than does use of hypothetical payoffs about a central research question − and we describe the features of the experimental task that produced this outcome. This finding is reported in the literature on the preference reversal phenomenon, the literature that initiated inquiry into how the validity of conclusions that can be drawn from experimental data depends on the subject payment protocol used in the experiment. We take up this topic in an extension and critical discussion of theoretical and behavioral properties of subject payment protocols. As we explain, which payment protocols are incentive compatible – and which ones incentivize biased responses – depends on the research question and relevant theoretical models. There is no unique payoff protocol that is appropriate for all research questions. It follows that choice of payoff protocol should be considered an essential feature of experimental design. Surveys of recent literature suggests it often is not considered important.

References

Agranov, M. and Pietro Ortoleva, P., 2017. Stochastic choice and preferences for randomization, *Journal of Political Economy* 125, 40-68.

Agranov, M. and Pietro Ortoleva, P., 2022. Revealed preferences for randomization: An overview." *AEA Papers and Proceedings* 112, 426–30.

Anderson, L.R., Freeborn, B.A., McAlvanah, P. and Turscak, A., 2023. Pay every subject or pay only some?. *J Risk Uncertain* **66**, 161–188. https://doi.org/10.1007/s11166-022-09389-6

Allais, M., 1953. Le comportement de l'homme rationnel devant le risque: Critique des postulats et axiomes de l'e´cole ame´ricaine. *Econometrica* 21, 503–546.

Arrow, K., 1971. *Essays in the Theory of Risk-Bearing*. Markham, Chicago.

Azrieli, Y., Chambers, C.P. and Healy, P.J., 2018. Incentives in experiments: a theoretical analysis. *Journal of Political Economy* 126 (4), 1472-1503.

Azrieli, Y., Chambers, C.P. and Healy, P.J., 2020. Incentives in experiments with objective lotteries. *Experimental Economics* 23, 1–29. https://doi.org/10.1007/s10683-019-09607-0

Baltussen, G., Post, G.T., van den Assem, M.J, Wakker. P.P., 2012. Random incentive systems in a dynamic choice experiment. Exp Econ 15:418–443. DOI 10.1007/s10683-011-9306-4

Beattie, J. and Loomes, G., 1997. The impact of incentives upon risky choice experiments. *Journal of Risk and Uncertainty* 14, 155-168.

Brañas-Garza, P., Jorrat, D., Espín, A.M. and Sanchez, A., 2023. Paid and hypothetical time preferences are the same: lab, field and online evidence. *Exp Econ* **26**, 412–434 (2023). https://doi.org/10.1007/s10683-022-09776-5

Brown, A.L. and Healy, P.J., 2018. Separated decisions. *European Economic Review* 101(c), 20-34

Charness, G., Eckel, C., Gneezy, U. and Kajackaite, A. 2018. Complexity in risk elicitation may affect the conclusions: A demonstration using gender differences. *Journal of Risk and Uncertainty* 56, 1–17.

Cox, J.C., and Epstein, S., 1989. Preference reversals without the independence axiom. *American Economic Review* 79(3), 408–426.

Cox, J.C. and Grether, D.M., 1996. The Preference Reversal Phenomenon: Response Mode, Markets and Incentives. *Economic Theory* 7 (3):,381-405.

Cox, J.C. and Sadiraj, V., 2019. Incentives. Chapter 1 in *Handbook of Research Methods and Applications in Experimental Economics*, Arthur Schram and Aljaž Ule (eds.), Edward Elgar Publishing.

Cox, J.C., Sadiraj, V. and Schmidt, U., 2014. Asymmetrically dominated choice problems, the isolation hypothesis and random incentive mechanisms. *PLoS ONE* 9(3): e90742. https://doi.org/10.1371/journal.pone.0090742

Cox, J.C., Sadiraj, V. and Schmidt, U., 2015. Paradoxes and mechanisms for choice under risk. *Experimental Economics* 18(2), 215-250

Cubitt, R. P., Starmer, C. and Sugden, R., 1998. On the validity of the random lottery incentive system. *Experimental Economics* 1, 115–131.

Freeman, D.J., Halevy, Y. and Kneeland, T., 2019. Eliciting risk preferences using choice lists. *Quantitative Economics* 10(1), 217-237

Freeman, D.J. and Mayraz, G., 2019. Why choice lists increase risk taking. *Experimental Economics* 22(1), 131-154

Grether, D.M. and Plott, C.R, 1979. Economic Theory of Choice and the Preference Reversal Phenomenon. *American Economic Review* 69 (4), 623-38.

Hackethal, A., Kirchler, M., Laudenbach, C., Razen M., and A. Weber., 2023. On the role of monetary incentives in risk preference elicitation experiments. *J Risk Uncertain* **66**, 189–213 (2023). https://doi.org/10.1007/s11166-022-09377-w

Harrison, G.W. and Swarthout, J.T., 2014. Experimental payment protocols and the bipolar behaviorist. *Theory and Decision*. 77(3), 423-438.

Hey, J.D. and Lee, J., 2005a. Do subjects separate (or are they sophisticated?) *Experimental Economics* 8(3), 233-265.

Hey, J.D. and Lee, J., 2005b. Do subjects remember the past? *Applied Economics* 37, 9-18.

Holt, C.A., 1986. Preference reversals and the independence axiom. *American Economic Review*. 76(3), 508-515.

Karni, E. and Safra, Z., 1987. "Preference reversal" and the observability of preferences by experimental methods. *Econometrica* 55(3), 675-685.

Li, Y., 2021. The ABC mechanism: an incentive compatible payoff mechanism for elicitation of outcome and probability transformations. *Experimental Economics* 24, 1019-1046.

Lichtenstein, S. and Slovic, P., 1971. Reversals of preferences between bids and choices in gambling decisions. *Journal of Experimental Psychology* 89, 46–55.

Machina, M.J., 1985. Stochastic Choice Functions Generated From Deterministic Preferences Over Lotteries." *Economic Journal* 95 (379), 575–94.

Pratt, J.W., 1964. Risk aversion in the small and in the large. *Econometrica* 32, 122–136.

Quiggin, J., 1982. A theory of anticipated utility. *Journal of Economic Behavior and Organization* 3(4), 323–43.

Segal, U., 1988. Does the Preference Reversal Phenomenon Necessarily Contradict the Independence Axiom? American Economic Review, 78(1), 233-236.

Segal, U., 1990. Two-Stage Lotteries without the Reduction Axiom, Econometrica, 58(2), 349-377.

Seidl, C., 2002. Preference Reversal. *Journal of Economic Surveys*, 16: 621-655.

Slovic, P. and Lichtenstein, S.,1968. Relative importance of probabilities and payoffs in risk taking. *Journal of Experimental Psychology Monograph*, 78, 1–18.

Smith, V.L., 1982. Microeconomic Systems as an Experimental Science. *American Economic Review* 72 (5): 923-55.

Starmer, C. and Sugden, R., 1991. Does the random lottery incentive system elicit true preferences? An experimental investigation. *American Economic Review*. 81(4), 971– 978.

Sugden, R., 2015. Looking for a Psychology for the Inner Rational Agent. *Social Theory and Practice*, *41*(4), 579–598.

Thaler. R.D. and Johnson, E.J., 1990. Gambling with the house money and trying to break even: The effects or prior outcomes on risky choice. *Management Science* 36, 643-660.

Tversky, A. and Kahneman, D., 1992. Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, 5:297–323.

Tversky, A., Slovic, P. and Kahneman, D., 1990. The causes of preference reversal. *American Economic Review* 80, 204–17

Vickrey, W., 1961. Counterspeculation, auctions, and competitive sealed tenders. *Journal of Finance* 16, 8–37.

Wakker, P.P. Prospect Theory: For Risk and Ambiguity. Cambridge: Cambridge University Press, 2010.

Yaari, M.E., 1987. The dual theory of choice under risk. *Econometrica* 55(1), 95-115