Preferences for the Resolution of Uncertainty and the Timing of Information

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Abstract

We present results from a laboratory experiment designed to elicit preferences over the resolution of uncertainty and timing of non-instrumental information acquisition in a rich choice set. Treatments vary whether the uncertainty is framed as a compound lottery or information structure. We find that individuals prefer to delay uncertainty resolution when the choice is framed as a compound lottery and prefer to expedite uncertainty resolution when framed as an information structure. Preferences are strict, as individuals are willing to pay for information in one treatment and they pay to avoid information in the other. We find no evidence of an aversion to gradual resolution in either context.

KEYWORDS: Resolution of uncertainty; Information preferences; Anticipatory emotions

JEL CODES: C91, D81, D83

Standard economic theory prices information according to its *instrumental* value to decision makers. This implies that individuals are only willing to pay for information if it can inform subsequent decisions and that individuals will never have an incentive to avoid information.[1] However, recent experimental evidence suggests that individuals have strict preferences over *non-instrumental* information, or information that has no value in decision-making. To understand the domain of these preferences, imagine a genetic test that can reveal to you whether you're at a high or low risk of developing a disease. Would you want to know the test results? Or would you rather just wait to find out whether you develop the condition later in life? Of course there are instrumental considerations at play—knowledge of the results could affect lifestyle choices, savings decisions, insurance coverage, etc. But it's not hard to imagine non-instrumental considerations playing a role in the decision as well. The test results might induce a great deal of anxiety, disappointment, or hope, among

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[1] This does not take into account environments where information avoidance provides strategic benefits. See Poulsen and Roos (2010) for an example of experimental evidence on strategic information avoidance.

other emotional responses, which can enter directly into interim utility. As a result, individuals may have preferences over this information itself, absent the role it plays in decision-making.

Experimental evidence on preferences over uncertainty resolution and non-instrumental information acquisition is sparse, and results to date are inconclusive on when and where to expect information avoidance. One factor which may contribute to this lack of consensus is that uncertainty resolution is studied in two different, though theoretically equivalent, experimental frameworks—*multi-stage lotteries* (Arai, 1997; Ahlbrecht and Weber, 1997; Lovallo and Kahneman, 2000; Budescu and Fischer, 2001; Brown and Kim, 2013; Kocher et al., 2014; Zimmermann, 2015) and *information structures* (Eliaz and Schotter, 2010; Ganguly and Tasoff, 2016; Falk and Zimmermann, 2016; Masatlioglu et al., 2017). While the two environments are isomorphic, a key difference lies in when the outcome in question occurs. In a multi-stage lottery, uncertainty resolves throughout the lottery with the outcome ultimately determined in the last stage. On the other hand, an information structure generates signals about an outcome that has already been determined. Despite the fact that economic theory treats these identically, evidence from psychology suggests that individuals may perceive uncertainty that has been resolved differently from uncertainty which has yet to be determined.[2] One possible explanation for the mixed results in the literature on uncertainty resolution is that preferences for non-instrumental information differ between these two types of uncertainty.

We conduct an experiment to compare uncertainty resolution preferences in a multi-stage lottery framework to those in an analogous information structure framework. Subjects choose their most preferred two-stage lottery or information structure that has a fixed prior 50% chance of giving a high prize and 50% chance of giving a low prize. In the Lottery treatment, we first select one of two "urns," each of which contains some red and blue balls. After a time delay, we draw a ball from the chosen urn. The color of the ball determines the payoff-relevant outcome for the subject. In the Information Structure treatment, we resolve the lottery at the beginning of the experiment but reveal the outcome to subjects in two steps. We show a ball from one urn if the subject won the high prize and show a ball from the other urn if he won the low prize. After a time delay, we reveal the urn from which the ball was drawn. Subjects choose how much uncertainty to resolve in the first and second stages by choosing the urn compositions. While the framing as a compound lottery or information structure differs, the choice sets are isomorphic between the two treatments. We carefully set up the experimental environment in such a way that information cannot confer any strategic, ego-relevant, or otherwise tangible advantages, ensuring that choices reflect pure uncertainty resolution preferences. We also move beyond binary choices, which have been the focus of the literature to-date. We use a "budget set" design which allows individuals to express any uncertainty resolution preference and allows us to test theories

[2] In particular, Rothbart and Snyder (1970) find differences in risk taking across these two domains. Individuals bet more on a die before it has been rolled than they do on a die that has been rolled already.

rigorously.

We find subjects in the Information Structure treatment choose significantly earlier resolution than those in the Lottery treatment. This is driven both by "extreme" individuals who choose to learn the outcome immediately as well as by individuals choosing an earlier form of gradual resolution. Our experiment is also designed to test for an aversion to gradual information as predicted by a number of theoretical models (Palacios-Huerta, 1999; Kőszegi and Rabin, 2009; Dillenberger, 2010). We find no evidence for this in either treatment. Using willingness to pay elicitation, we conclude that these results reflect strict preferences. 60–80% of subjects are willing to pay for their preferred manner of uncertainty resolution despite understanding that their choice cannot affect the uncertain outcome. Secondary treatments mirror the original, but with only negligible time delay between the two stages of resolution. We find this results in fewer strict preferences, but the treatment difference persists.

Our results contribute to the literature in several ways. Ours is the first experiment to compare information structures to analogous compound lotteries. The previous literature has studied both independently, failing to come to consensus on preferences over the resolution of uncertainty. Papers finding a preference for early resolution tended to use information structures (Eliaz and Schotter, 2007; Falk and Zimmermann, 2016; Masatlioglu et al., 2017) while those finding any substantial evidence of a preference for gradual or late resolution used compound lotteries (Budescu and Fischer, 2001; Zimmermann, 2015). Our paper demonstrates this difference in a unified framework. In doing so, our results provide empirical evidence to guide new theories which can accommodate the observed empirical regularities. We are also one of the first to show that there is little evidence of an aversion to gradual resolution, separating this preference from standard preferences for or against earlier information. Finally, we show how introducing a time delay affects preferences over multi-stage outcomes. The delay increases willingness to pay for preferred resolution, which we interpret as direct evidence for anticipatory utility and belief-based factors playing a role.

Characterizing preferences for non-instrumental information gives insight into how behavioral factors will influence information acquisition more generally. It's likely that the preferences studied in our experiment would play a role in shaping *instrumental* information acquisition, as well, which has economic consequences.[3] Our experiment shows an underlying aversion to resolving uncertainty in contexts perceived as a compound lottery, and this can lead to information avoidance at the expense of informed decision making. Information avoidance has long been a puzzling concern for economists, and our results suggest that information avoidance will be most common over outcomes to be resolved in the future.

[3] This does not follow directly. One could imagine an individual who avoids information about events where he can't take any action, but would prefer to know if given the chance to do something about it.

I. LITERATURE

The theoretical literature has focused on three dimensions of information preference: early vs. late, one-shot vs. gradual, and positive vs. negative skewness. A standard expected utility maximizer is indifferent along all three dimensions and would not be willing to pay to avoid or acquire any form of non-instrumental information. However, recent theories have relaxed this assumption, and below we outline these models and the choices they prescribe. These dimensions of preference apply equivalently to both the information structure and lottery domains.

EARLY VS. LATE. — Most of the early theoretical work in the literature focused on the preference for early or late resolution of uncertainty. Naturally, earlier resolution of uncertainty corresponds to earlier acquisition of information and a choice of more precise signals. In models such as Kreps and Porteus (1978), Epstein and Zin (1989), and Grant et al. (1998), the authors derive conditions on an individual's local utility function leading to a preference for early or late resolution. For example, Epstein and Zin (1989) show that the relationship between an individual's risk preference parameter and intertemporal substitution parameter determines whether he would prefer early or late resolution of uncertainty.

Behavioral models incorporate beliefs directly into the utility function, which can contribute to a preference for earlier or later resolution. Kőszegi and Rabin (2009)'s decision maker is loss averse over changes in beliefs, which means that information has negative expected utility. This, combined with the assumption that changes in beliefs weigh heavier the closer in time they are to actual consumption, implies that individuals tend to prefer earlier over later resolution of uncertainty.[4]

On the contrary, Loewenstein (1987) models a decision maker who derives direct utility from anticipation. He shows that these anticipatory emotions lead to a preference for postponing pleasure and expediting pain. This decision maker would prefer to experience losses early on to "get them over with," while deriving positive anticipatory utility from looking forward to delayed gains in the future. In contrast to the model above, this would predict a preference for late resolution of uncertainty about the outcome of a lottery with positive payoffs, like the lottery in our experiment.

Finally, Brunnermeier and Parker (2005) model a decision maker who chooses the beliefs he wants hold. In their model, the decision maker balances this belief-based utility against holding optimal beliefs and taking better-informed decisions. When information is non-instrumental, however, the second component plays no role. This implies individuals would avoid learning the state for sure, as this precludes belief distortion, but would be indifferent among all other signals since they all allow for optimal distortion of beliefs.

[4] As we discuss below, the decision maker is also averse to gradual resolution, so it's not the case that he will choose the earliest resolution possible in all cases. We discuss predictions specific to our experiment in later sections.

ONE-SHOT VS. GRADUAL. — One-shot vs. gradual resolution pertains to *how* uncertainty resolves more than *when* it resolves. Uncertainty resolution is said to be "one-shot" when all uncertainty resolves at once, regardless of when in time this happens. This is in contrast with "gradual" resolution, when information is revealed piecewise over time. Palacios-Huerta (1999) was one of the first to study preferences over one-shot versus gradual resolution of uncertainty. Building on the disappointment aversion model of Gul (1991), Palacios-Huerta (1999) shows how a disappointment-averse decision maker is averse to the gradual resolution of uncertainty. Gradual resolution exposes the decision maker to more opportunities at which he could experience disappointment, and therefore he prefers all uncertainty resolve at once.

Following closely-related intuition, Kőszegi and Rabin (2009)'s decision maker also is averse to gradual resolution. The process of gradual resolution of uncertainty exposes the decision maker to more belief fluctuations. Since their decision maker is loss averse over these changes in beliefs, downward belief adjustments bring a greater utility loss than the corresponding gain of upward adjustments, so gradual resolution has a negative expected value. However, decision makers prefer to receive disappointing news further from the time when the outcome will be realized, so individuals also prefer earlier information. This gives a weak prediction that individuals would prefer to resolve uncertainty all at once as soon as possible, but may prefer some form of gradual resolution over no information.

In a compound lottery framework, Dillenberger (2010) models a decision maker who has a preference for certainty over simple outcomes, and shows that this leads to a preference for one-shot resolution in a dynamic context. The model assumes that individuals are indifferent between a lottery where all uncertainty resolves in the first stage and one where all uncertainty resolves in the second stage. This, together with a preference for certainty, results in a distaste for gradual resolution. Thus, the model predicts that individuals will choose to resolve all uncertainty in a single stage of the lottery, regardless of whether it is the first or second stage.

Finally, Ely et al. (2015) model a decision maker who has a preference for suspense and/or surprise. They define suspense as the variance in beliefs from one period to the next and define surprise is the gap in beliefs. They derive suspense- and surprise-optimal information structures. Naturally, these are gradually resolving lotteries, and their decision maker would dislike one-shot resolution of uncertainty as it provides neither suspense nor surprise.

SKEWNESS. — While not a main focus of this paper, Masatlioglu et al. (2017) discuss the predictions that these various theories make regarding preferences over skewness of information, or whether information resolves more uncertainty about the good state or the bad state. In particular, the theories of Kőszegi and Rabin (2009) and Ely et al. (2015) both require individuals to be indifferent to skewness, while Grant et al.

(1998) and Gul (1991) can accommodate strict preference in either direction. We direct the interested reader to Masatlioglu et al. (2017) for details.

LOTTERIES AND INFORMATION STRUCTURES. — Note that none of these theories allow for preferences to differ between environments where uncertainty resolves as a compound lottery and environments where uncertainty resolves as an information structure. Ely et al. (2015) make this explicit in saying

> "Our model captures both settings in which the state is realized ex ante [information structures] and those in which it is realized ex post [compound lotteries]. An example in which ω is realized ex ante is a game show in which a contestant receives either an empty or a prize-filled suitcase and then information is slowly revealed about the suitcase's contents. In presidential primaries, on the other hand, ω is realized ex post... When a candidate wins a state's delegates, this outcome provides some information about whether she will win the nomination. In this case, the state ω is not an aspect of the world that is fixed at the outset; it is determined by the signal realizations themselves." Ely et al. (2015, p. 224)

The literature has maintained isomorphism between the two environments, and no model predicts differences in behavior. The main contribution of our experiment is to test this underlying assumption.

Experimental Evidence

Early experimental papers (Chew and Ho, 1994; Ahlbrecht and Weber, 1996; Arai, 1997; Ahlbrecht and Weber, 1997; Lovallo and Kahneman, 2000) asked subjects to imagine hypothetical scenarios and rate willingness to delay or speed up information. These experiments generally find a preference for early resolution, but features of the environment can make late resolution more attractive. More recent papers (Von Gaudecker et al., 2011; Brown and Kim, 2013; Kocher et al., 2014; Zimmermann, 2015) incentivize choices but still implement significant uncontrolled time delays such that information could be considered instrumental.[5] These papers generally find a stronger preference for early over late resolution, but this could be confounded with planning benefits of information.

There are few papers studying truly non-instrumental information in incentivized experiments. The literature has not made an explicit distinction between lotteries and information structures, but ex-post we can identify persistent differences in choices depending on which environment was chosen. In the only such paper we know of that uses a lottery framework, Budescu and Fischer (2001) test behavioral phenomena related to the reduction of compound lotteries. In one of the decisions, subjects compare tossing three coins simultaneously (early resolution) to tossing a coin three times sequentially (gradual resolution), where the payoff depends on the number of Heads. They do not find a strong preference for early resolution and, on average,

[5] Von Gaudecker et al. (2011) do not specify to subjects when the uncertainty resolution takes place, so we cannot classify their paper into one of our two frameworks. The other three papers all use a Lottery framework.

subjects are indifferent between the two lotteries. In a similar choice over longer time delays, Zimmermann (2015) finds that 45% of subjects prefer to roll all three dice on Day 1, 31% prefer one die rolled on each of three consecutive days, and 24% prefer all three dice rolled on Day 3. Thus, a majority of subjects in this environment do not choose early resolution even with the instrumental forces encouraging information acquisition. Taken together, these give suggestive evidence that individuals prefer gradual and later resolution in environments framed as compound lotteries.[6]

Most papers studying non-instrumental information have framed uncertainty more like an information structure, and it is in these experiments where we see a stronger preference for early resolution. Eliaz and Schotter (2010) study an environment where subjects choose one of two bets and the payoff from the bet depends on a binary (pre-determined) state of the world. However, the optimal choice of bet does not depend on the state of the world. As a result, learning the state is "non-instrumental" since it does not affect the subject's decision. Nevertheless, subjects are willing to pay for this information.

Ganguly and Tasoff (2016) elicit willingness to pay to expedite or delay learning the outcome of a pre-determined lottery. They find that preferences depend on the stakes of the lottery that has already played out. Individuals prefer to delay resolution more with small stakes than with large stakes, consistent with the earlier literature. Ganguly and Tasoff also look at preferences to acquire or avoid information about the outcome of HSV tests and find that individuals are more likely to avoid getting tested for the more serious strand of the virus compared to the treatable one.

Falk and Zimmermann (2016) also study preferences over uncertainty resolution in the "loss" domain. Subjects were randomized into receiving electric shocks or not and could choose when to learn whether they would be shocked. Their fate had already been determined, so the only choices was in waiting to learn the information or learning it immediately. They find a strong preference for early resolution of uncertainty, but this varies with attention. When subjects are given a distraction task to occupy their attention during the waiting period, they preferred not to know whether they would receive shocks.

Most recently, Masatlioglu et al. (2017) broadly investigate preferences over information structures using binary choices. Their primary interest is in skewness, focusing on whether individuals prefer positively- or negatively-skewed information about the outcome of a lottery. Individuals in their experiment prefer early resolution; however, when information structures are equally informative, individuals exhibit a preference for positively skewed information.

Our paper presents an experimental paradigm designed to take steps in unifying these conclusions. While

[6]Note, Brown and Kim (2013) and Kocher et al. (2014) also use a Lottery framework where information can have instrumental value, and they do find a preference for early resolution. The difference in results between their papers and ours is not surprising as individuals would balance instrumental desires with their underlying desire for delaying uncertainty resolution. Thus, we might expect one or the other to be more prominent depending on payoffs, time delays, etc.

previous papers in the literature differ on many other dimensions, and using a lottery or information structure framework likely was not an explicit design choice, our results show that this framing difference affects preferences. Most papers with non-instrumental information have used information structures and find a preference for early resolution (Eliaz and Schotter, 2010; Falk and Zimmermann, 2016; Masatlioglu et al., 2017), but the literature has not found this preference for early resolution using lotteries (Budescu and Fischer, 2001). Though theoretically equivalent, lotteries and information structures have not been compared experimentally, and indeed we find different choices across the two environments.

II. Design

We use a between-subject design, one treatment presenting choices over two-stage lotteries and the second presenting choices over information structures. We design the two environments to be as similar as possible with isomorphic choice sets. We outline the experimental design for both treatments emphasizing the difference between the two, and then discuss the testable implications of theoretical predictions.

Preliminaries

A subject will win one of two possible prizes—a high prize ($11) or a low prize ($2). There are three relevant time periods, $t \in \{0, 1, 2\}$. At time 0, all individuals have the same objective prior, $pr(\$11) = 0.5$. A subject decides how much information to learn at $t = 1$ about the prize he will receive. Some uncertainty may resolve at $t = 1$, resulting in a new prior at $t = 2$. All uncertainty resolves by the end of $t = 2$, leaving no uncertainty about the state. In our main experiment, 30 minutes will pass between $t = 1$ and $t = 2$. In our secondary treatments, we eliminate this time delay so that negligible time passes between $t = 1$ and $t = 2$.

Lottery and Information Structure Frameworks

LOTTERIES. — The two-stage lottery amounts to drawing a red or blue ball from one of two urns. At time $t = 1$, Nature selects either Urn 1 or Urn 2, according to probabilities p and $1 - p$, respectively. At time $t = 2$, Nature draws a ball from the urn. Drawing a red ball corresponds to winning the high prize and drawing a blue ball corresponds to winning the low prize. From Urn 1, a red ball is drawn with probability q and a blue ball with probability $1 - q$. From Urn 2, a red ball is drawn with probability r and a blue ball with probably $1 - r$.[7] Without loss of generality, we require $q \leq 0.5$ and $r \geq 0.5$, so seeing Urn 1 in the first stage is "bad news" while seeing Urn 2 in the first stage is "good news." All (p, q, r) such that $pq + (1 - p)r = 0.5$ give the

[7] Naturally, we require $p \in [0,1]$, $q \in [0,1]$, and $r \in [0,1]$.

same ex-ante likelihood of winning the high and low prizes; the difference lies in how uncertainty is resolved in Stage 1 relative to Stage 2. This compound lottery framework is shown in Figure I.

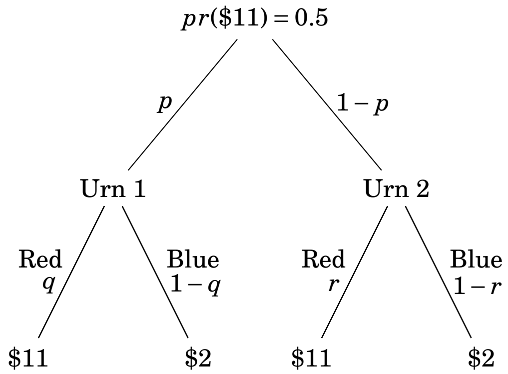


Figure I: Two-stage Lottery

INFORMATION STRUCTURES. — The framework of the Information Structure treatment maps one-to-one into the compound lottery framework. In an information structure, the subject's prize is determined at time $t = 0$, where $pr(\$11) = 0.5$. There are two urns, Urn 1 and Urn 2, each of which can contain some red and blue balls. At $t = 1$, we randomly select and reveal a ball from Urn 1 if the subject won the low prize or from Urn 2 if he won the high prize. At time $t = 2$, we reveal the urn from which the ball was drawn, and therefore which prize he won.

We can model this information structure analogously to the two-stage lottery above. The information structure reveals a blue ball with probability p and a red ball with probability $1-p$. Conditional on seeing a blue ball, the probability it came from Urn 2, the winning urn, is given by q and the probability it came from Urn 1 is $1-q$. Conditional on seeing a red ball, the probability it came from Urn 2 is given by r, and the probability it came from Urn 1 is given by $1-r$. Given the same restriction that $q \leq 0.5$ and $r \geq 0.5$, seeing a blue ball in the first stage is "bad news" and seeing a red ball is "good news."

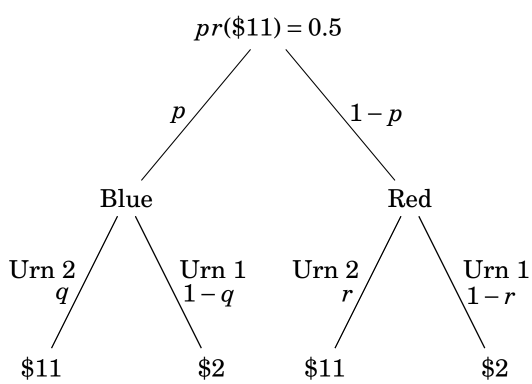


Figure II: Information Structure

Uncertainty resolution is completely characterized by (p,q,r), which are the choice variables in our experiment. Subjects chose any (p,q,r) such that $pq+(1-p)r=0.5$. To make the choice set easier for subjects to understand, we presented the decision variables in a concrete and visible way. Screens had three sliders, one corresponding to each p, q and r. Given a choice of two variables' values, the third variable is uniquely determined by $pq+(1-p)r=0.5$. Because of this, the screens also contained three "Auto" buttons, one attached to each slider. Subjects were told, and the interface enforced, that they needed to put one slider on Auto at all times. This slider would then update automatically to maintain the overall odds as a subject adjusted the other two sliders.[8] Subjects were free to change which slider is on "Auto" at any time. Each slider showed an equivalent color-coded pie chart that visually displayed the selected probabilities and updated in real-time as subjects adjusted the sliders.[9] The Appendix shows an image of the subjects' screen during the experiment.

Figure III shows the space of all compound lotteries or information structures in our framework. The y-axis plots $q \in [0,0.5]$, the probability of winning (or having already won) the high prize given bad news in Stage 1. The x-axis plots $r \in [0.5,1]$, the probability of winning (or having already won) the high prize given good news in Stage 1.[10] The gradient plots the *entropy informativeness* of the lottery, which is a measure of uncertainty resolution described below. We can easily visualize the dimensions of preference in this (r,q) space. We use the language of the Lottery framework for ease of exposition, but the dimensions of preference correspond to Information Structures in the same way.

EARLY VS. LATE. — The most informative lottery is when all uncertainty resolves in the first stage. This is a unique lottery, $(p,q,r)=(0.5,0,1)$, as shown in the lower right corner of Figure III. With probability $p=0.5$, the individual sees bad news and updates his posterior to $q=0$, knowing for sure he will win the low prize in Stage 2. With the remaining probability $1-p=0.5$, he sees good news and updates to $r=1$, knowing for sure that he will win the high prize. The least informative lottery is when no uncertainty resolves in the first stage; regardless of the Stage 1 outcome, the individual will again face posterior $q,r=0.5$. This corresponds to any point along the left edge ($r=0.5$) and/or the top edge ($q=0.5$) of Figure III.

A Blackwell more-informative lottery will have posteriors that are a mean-preserving spread of the posteriors under the Blackwell less-informative lottery. Intuitively, earlier resolution of uncertainty involves signals that are more precise; good news is "better," with a posterior closer to 1 (larger value of r), and bad news is

[8] The only point that is not determined by the other two sliders is when both $q=0.5$ and $r=0.5$. In this case, if p is on Auto, any $p \in [0,1]$ would satisfy the overall odds restriction. In this case, we programmed the interface to choose $p=0.5$. If a subject wanted another value for p, he could choose to place another slider on Auto and choose this p value directly.

[9] The sliders started in a random position which differed across the various sets. The default Auto slider was also randomly determined in each set.

[10] p is uniquely determined by q and r. Figure IX in the Appendix shows how p varies in this diagram.

"worse," with a posterior closer to 0 (smaller value of q), in a lottery that resolves uncertainty earlier. Therefore, Lottery A is said to resolve uncertainty earlier than Lottery B if $q_A < q_B$ and $r_A > r_B$.[11] Thus, in Figure III, any point to the southeast of another is Blackwell more-informative and any point to the northwest is Blackwell less-informative.

For a complete ordering of all other lotteries and information structures, we use the entropy informativeness measure of Cabrales et al. (2013). This measure is compatible with, and a completion of, the Blackwell ordering. Define Shannon entropy as $H(q) = -\sum_{k\in\{H,L\}} q(k) ln q(k)$, where $q(k)$ is the prior probability of state k and 0 $ln(0) = 0$ by continuity (Shannon, 1948). We define the entropy informativeness as $I(Q) = H(q) - \sum_s p(s)H(q^s)$, where signals, s, are the observed urn, {Urn 1, Urn 2}. $p(s)$ gives the probability of receiving signal s, and q^s gives the posterior following observed signal s. In our environment, this simplifies to $I(Q) = -ln(0.5) + p[q ln q + (1-q) ln(1-q)] + (1-p)[r ln r + (1-r) ln(1-r)]$. This informativeness measure ranges from perfectly uninformative, where $I(Q) = 0$, to perfectly informative, where $I(Q) = H(0.5) = 0.69$. As one would expect, entropy increases in the southeast direction of Figure III as we move from the least informative lotteries to the most informative lottery.

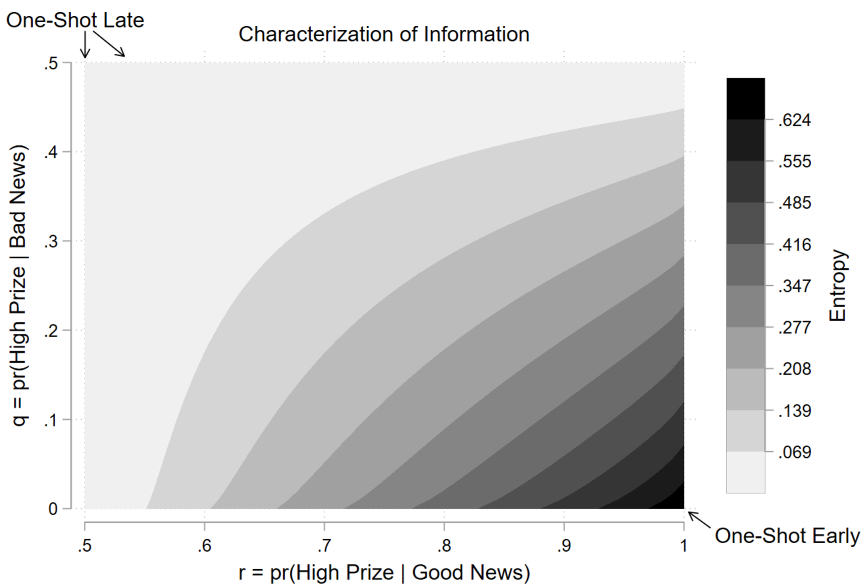


Figure III: Ordering of All Alternatives in (p, q, r) Space

ONE-SHOT VS. GRADUAL RESOLUTION. — Recent theories (Palacios-Huerta, 1999; Kőszegi and Rabin, 2009; Dillenberger, 2010) predict that individuals may have an aversion to gradual information, or a preference for "one-shot" resolution. In our framework, one-shot resolution of uncertainty precisely means that one stage of the lottery is degenerate. Uncertainty resolves either in the first stage *or* in the second stage, but not both.

[11] We consider a lottery to weakly Blackwell dominate another if one of these is a strict inequality while the other is weak. When discussing early or late choices, however, we will consider strict Blackwell dominance.

"One-shot early" resolution occurs when uncertainty resolves all at once in the first stage. This is the unique lottery, $(p,q,r) = (0.5,0,1)$, in the lower right corner of Figure III. "One-shot late" resolution occurs when all information resolves in the second stage. This corresponds to any point along the left edge ($r = 0.5$) and/or the top edge ($q = 0.5$) of Figure III, where the individual faces the posterior $q,r = 0.5$ in the second stage. In our two-stage lottery framework, these are the only possible forms of one-shot resolution—all other lotteries are "gradually" resolving.

SKEWNESS. — The literature also considers a notion of "skewness" of information (Masatlioglu et al., 2017). Intuitively, in a positively-skewed information structure or compound lottery, seeing good news resolves more uncertainty about the high state than seeing bad news resolves about the low state. Positively-skewed lotteries give good news less frequently, but, conditional on seeing good news, the decision maker can be more sure of the high state. Negatively-skewed lotteries resolve more uncertainty about the low state. They give bad news less frequently, but, conditional on seeing bad news, the decision maker can be more sure of the low state.[12]

While notions of skewness are not absolute, we consider a choice of a lottery with $p > 0.5$ to be "positively skewed," since there exists a symmetric lottery with $p < 0.5$ which is equally informative but negatively skewed. It could be that other lotteries exist which could be considered "more positively skewed," but we compare within symmetric, equally-informative lotteries to identify positive or negative skewness.

Choice Sets

We design 9 choice sets to disentangle preferences for one-shot, early, and skewed resolution. In some sets, the ranges of q and r are restricted to prevent one-shot early or one-shot late resolution. In others, we place restriction on skewness.[13] We randomize the order of the choice sets in presenting them to subjects.

Set 1 allows for unrestricted choices—subjects can choose any (p,q,r) such that $pq+(1-p)r = 0.5$. Sets 2 and 3 force choices to be either positively or negatively skewed by requiring $p > 0.5$ and $p < 0.5$, respectively. Sets 4–6 prevent one-shot early resolution by requiring $q > 0$ and $r < 1$. These sets differ in the skewness of the earliest possible resolving lottery—in Set 4, the earliest resolving lottery is unskewed, while it's negatively skewed in Set 5 and positively skewed in Set 6. Similarly, Sets 7–9 prevent one-shot late resolution by requiring $q < 0.5$ and $r > 0.5$. The three sets again differ in the skewness of the latest possible resolving

[12]For example, consider the lotteries $(0.2,0.1,0.6)$ and $(0.8,0.4,0.9)$. The former is negatively skewed—it's less likely you'll see bad news (since $p = 0.2$), but, conditional on bad news, you're pretty sure of the bad state ($q = 0.1$). Good news is not very informative, though, since $r = 0.6$. The latter lottery has exactly the same entropy, but is informative about the good state—it's very likely you'll see bad news (since $p = 0.8$), but bad news is not informative and your posterior only reduces to $q = 0.4$). On the other hand, if you see good news, your posterior increases to $r = 0.9$ and you're quite sure of the good state.

[13]In practice, sliders in the restricted sets simply display a restricted range, but subjects' choices are presented nearly identically to the unrestricted set.

lottery.

	p $[p_{min}, p_{max}]$	**q** $[q_{min}, q_{max}]$	**r** $[r_{min}, r_{max}]$	**Description**
Set 1	[0,1]	[0,0.5]	[0.5,1]	Unrestricted
Set 2	[0.5,1]	[0,0.5]	[0.5,1]	Only positively skewed
Set 3	[0,0.5]	[0,0.5]	[0.5,1]	Only negatively skewed
Prevent One-Shot Early Resolution:				
Set 4	[0,1]	[0.2,0.5]	[0.5,0.8]	Symmetrically prevent early resolution
Set 5	[0,1]	[0.1,0.5]	[0.5,0.8]	Asymmetrically prevent early resolution (-)
Set 6	[0,1]	[0.2,0.5]	[0.5,0.9]	Asymmetrically prevent early resolution (+)
Prevent One-Shot Late Resolution:				
Set 7	[0,1]	[0,0.3]	[0.7,1]	Symmetrically prevent late resolution
Set 8	[0,1]	[0,0.3]	[0.6,1]	Asymmetrically prevent late resolution (-)
Set 9	[0,1]	[0,0.4]	[0.7,1]	Asymmetrically prevent late resolution (+)

Table I: Lottery Sets used in the experiment. "Asymmetrically prevent early resolution (+)" indicates that the earliest possible resolution was positively skewed, while "Asymmetrically prevent...(-)" indicates that it was negatively skewed, and similar for late resolution.

To see how these sets allow us to identify preferences for one-shot resolution, consider a subject who chooses one-shot early resolution of uncertainty in Set 1. From this choice alone, we cannot say whether he expresses a preference for one-shot resolution or a preference for early resolution, since these two things coincide. The additional sets allow us to disentangle these preferences. A subject who chooses one-shot early resolution in Set 1 because he has a preference for *one-shot* information will switch to choosing one-shot late resolution in Set 4, for example, since one-shot late resolution is the only available one-shot information in Set 4. However, a subject who chooses one-shot early resolution in Set 1 because he has a preference for *early* resolution will choose the earliest possible resolution in Set 4 ($q = 0.2$ and $r = 0.8$), despite the fact that it's now gradually resolving. Examples of these restricted sets are shown in Figure IV.

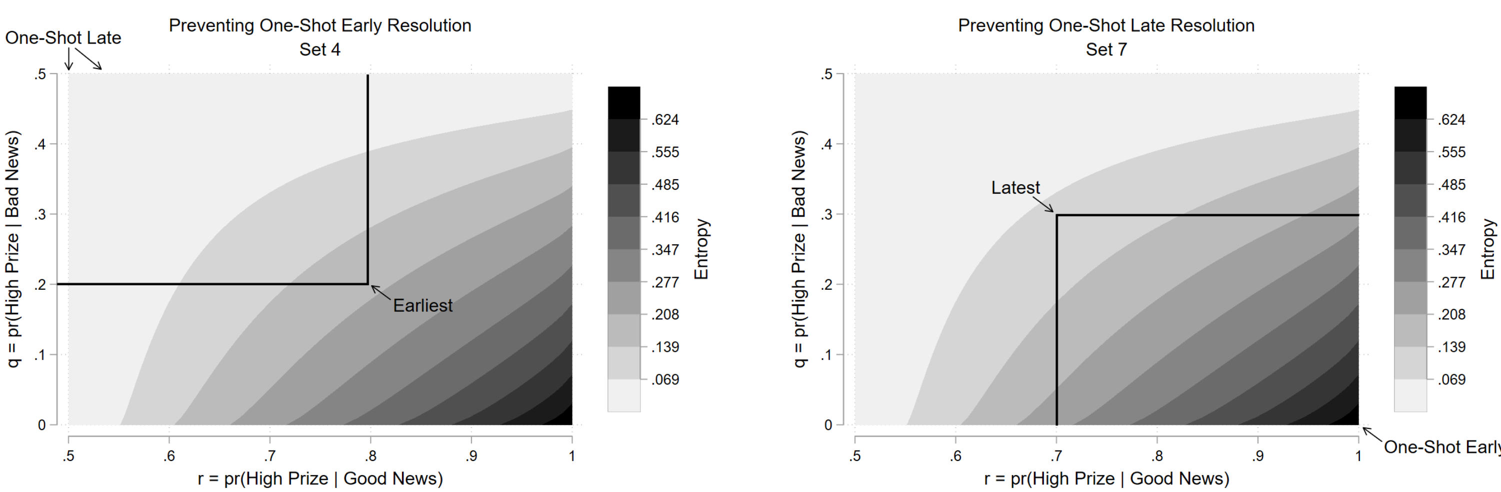


Figure IV: Restricted Sets 4 and 7

In addition to the 9 sets listed in Table I, subjects answer 3 price-list questions comparing different lotteries. These questions serve to elicit the amount of money a subject requires to switch from one lottery to another. We will use these questions to measure strength of preference and rule out the explanation that subjects were simply indifferent over all lotteries. We explain these in more detail in Appendix E.

Timeline

Studying preferences over uncertainty resolution necessarily requires a time delay between the two stages of resolution. However, having subjects wait a significant amount of time, on the order of days or weeks, could introduce *instrumental* information concerns, as subjects might prefer to know their future earnings for planning purposes, for example. We avoid this by keeping subjects in the lab for the entire duration of resolution. To balance these concerns, we implement a fairly substantial but experimentally-controlled time delay in the lab of approximately 30 minutes between the two stages of resolution.[14]

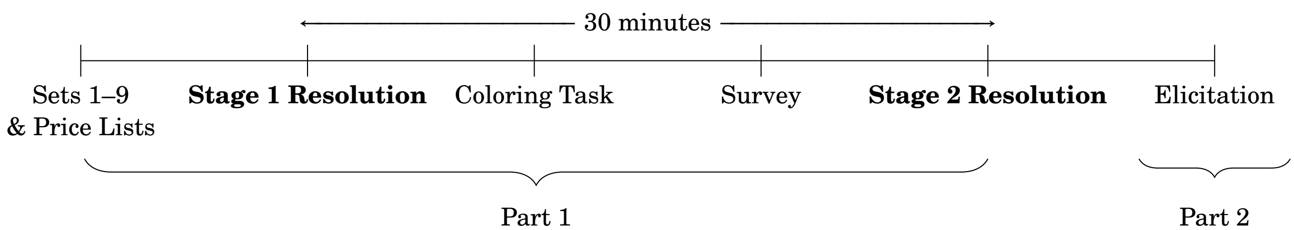


Figure V: Timeline of experiment

We refer to the Lottery task and related events collectively as Part 1. After reading aloud instructions for all of Part 1, subjects participated in a number of practice rounds to familiarize themselves with the computer and slider mechanics. At this time, they answered comprehension questions to ensure they understand the task. They were not able to proceed without answering the questions correctly. Following this, they chose their most preferred lottery in Sets 1–9 and in the price lists. Once all subjects had finished, the computer randomly selected one set or price list and revealed the first stage outcome (**Stage 1 Resolution**).[15]

After the Stage 1 resolution, subjects participated in a "Coloring Task" and a non-incentivized survey. The coloring task had subjects electronically color a representation of their selected urn and the survey asked a number of questions about preferences and hypothetical choices. The primary purpose of these tasks was to

[14]30 minutes certainly pales in comparison to the years spent waiting to know whether or not one will develop a health condition, for example, so we view this as a lower bound on preferences. Masatlioglu et al. (2017) also use a duration of approximately 30 minutes and find significant willingness to pay for information, so we expected 30 minutes to be a reasonable wait duration and this allowed us to compare our results to theirs directly.

[15]Section I in the Appendix confirms that this random problem selection mechanism does not interact with a preference for one-shot resolution.

create a time delay between Stage 1 and Stage 2 resolution.[16] After all subjects completed the Coloring Task and survey, the computer randomly drew the selected ball from the urn and revealed it to the subject (**Stage 2 Resolution**). Approximately 30 minutes passed between Stage 1 Resolution and Stage 2 Resolution, and subjects knew ahead of time that this would be the case.

At the beginning of the experiment, we told subjects that there would be a short "bonus" Part 2. This consisted of various elicitation questions from Dean and Ortoleva (2019). The questions were designed to measure risk aversion, present bias, time discounting, common ratio and common consequence violations, and violations of several axioms. Since the time preference elicitation questions involved future payments, all payments from Part 2 were paid through Venmo money transfers. So as not to interact with uncertainty over the main payment lottery, we paid one lottery from Part 1 and one question from Part 2, and subjects knew this ahead of time. See the Appendix for elicitation instructions and specific Part 2 payment details.

Budget Sets

Allowing subjects to choose over all (p,q,r) rather than asking binary lottery comparisons provides a number of advantages. Theoretical models predict preferences over the entire domain of lotteries or information structures. For example, a preference for one-shot resolution implies that a one-shot lottery is preferred to *any* gradually resolving lottery. This is impossible to see with binary choices—one would have to compare one-shot resolution to every possible gradually resolving lottery. In order to test the theories rigorously, we need to be able to see whether one-shot resolution is chosen from the entire set of actuarially-equivalent lotteries.

Admittedly, however, there are drawbacks to using this design. Budget sets are more demanding on subjects' attention and understanding. To mitigate this, we gave many examples along with the instructions. We use a screen-captured video to demonstrate how to adjust the sliders and how the lotteries changed as a result. Additionally, we gave a number of practice rounds and corresponding comprehension questions. The price list questions also help us to identify subjects' understanding, as we can compare willingness-to-pay in binary choices to choices in the main experiment.

Another drawback of a budget set design is that it is difficult to test for some types of preference orderings. For example, Masatlioglu et al. (2017) find that individuals prefer early resolution on average, but prefer positively skewed over negatively skewed information when the two are equally informative. Our design cannot capture this, as the preference for positive skew would be overshadowed by an individual always choosing early resolution. Therefore, we focus on the treatment differences and on preference for gradual resolution, as these are the main innovations of our design.

[16] We included the coloring task to help subjects understand the probabilities and also to make the lingering uncertainty (or lack thereof) more salient.

Analysis

We analyze data from a total of 182 subjects—69 subjects in the Lottery treatment, 73 in the Information treatment, and 40 in control sessions described in the Appendix.[17] Subjects were primarily undergraduate students at the Ohio State University, recruited through ORSEE (Greiner, 2015). Sessions lasted approximately 90 minutes and payments averaged \$19, including a \$10 show-up fee. We conducted the experiment using z-Tree (Fischbacher, 2007). For two-sample statistical comparisons, we use two-tailed Mann-Whitney ranksum tests. We confirm with ranksum tests of equality on the medians. For tests within sample, we use chi-square goodness of fit tests, and for within-subject tests we use two-sided sign tests.

When reporting percentages of early and late choices, we allow for minor rounding errors in classification. Due to the granularity of the z-Tree sliders, we allow for choices to vary by 0.01 from the exact classifications. For example, a subject who chooses $q = 0.01$ and $r = 0.99$ is classified as choosing one-shot early resolution, and a subject who chooses $q = 0.49$ and $r = 0.51$ is classified as choosing one-shot late resolution. The results are qualitatively identical if we use a strict classification.

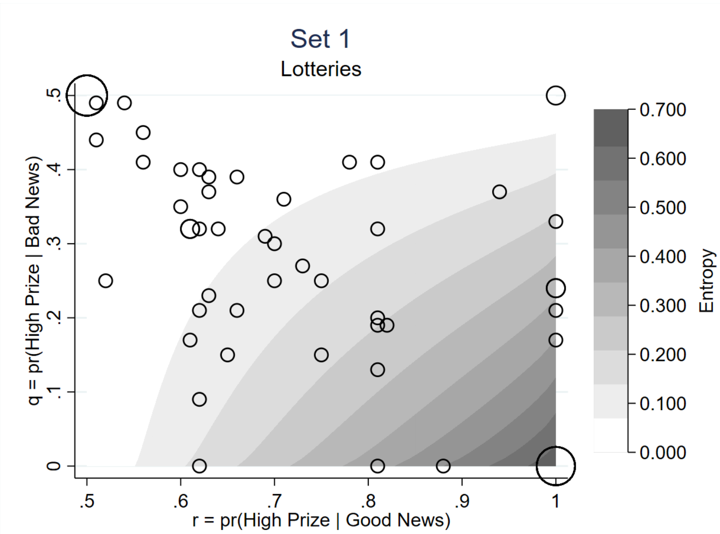
III. Results

To preview our results, Figure VI shows all choice data from the unrestricted set in (r, q) space. Each bubble is an observed choice, and the size of the bubble corresponds to the number of subjects choosing it. Individuals choose significantly earlier resolution in the Information treatment. This results from both more individuals choosing one-shot early resolution (a larger mass in the bottom right corner) and from individuals choosing an earlier form of gradual resolution (interior choices more towards the southeast). Individuals are more likely to choose one-shot resolution in the Information treatment than in the Lottery treatment, though gradual is always prominent. We formalize these results in the following subsections. In Section IV, we document that our main findings persist when we eliminate the time delay between the two stages of uncertainty resolution.

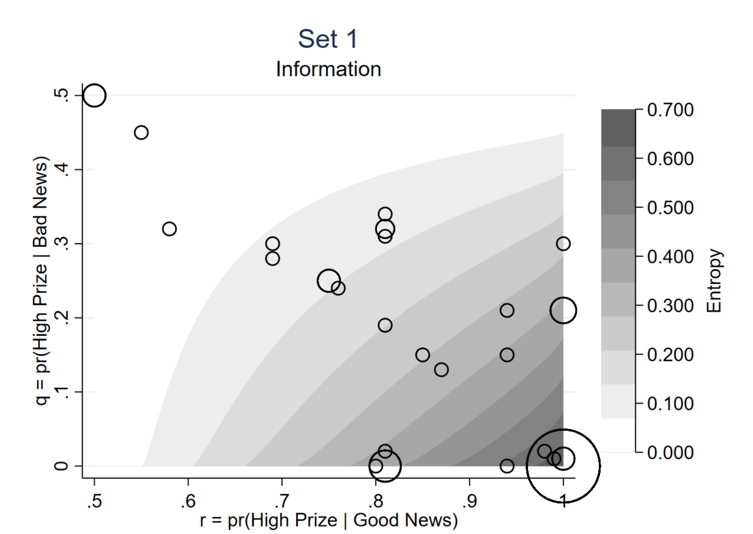
Entropy

We calculate the entropy informativeness of each subject's choice, as defined in Section II. Figure VII shows the cumulative distribution of the entropy informativeness of choices in the unrestricted set across treatments. Individuals in the Information Structure treatment choose significantly earlier resolution than those in the Lottery treatment—the distribution of entropy informativeness from the Information treatment first-order

[17] Due to glitches in the experimental interface, some subject choices result in $pq + (1-p)r \neq 0.5$. This is very rare, for example 5/142 observations in the overall unrestricted data. We will always condition on the fact that the chosen lottery results in $pq + (1-p)r \in (0.48, 0.52)$ for consistency.



(1) Lottery Treatment



(2) Information Treatment

Figure VI: Unrestricted set choices

stochastically dominates that from the Lottery treatment (Kolmogorov-Smirnov p=0.000). This is driven by two forces. First, more individuals choose the earliest possible resolution in the Information Structure treatment. This is evidenced by the difference in the masses at the upper extreme of the distributions, corresponding to one-shot early resolution. Over half of subjects (51%) in the Information Structure treatment choose one-shot early resolution, while only 13% of subjects in the Lottery treatment do (p=0.0000). We see a gap in the opposite direction among subjects choosing one-shot late resolution: 19% of individuals in the Lottery treatment choose to learn nothing in the first stage, while only 4% of individuals in the Information Structure treatment choose this full information avoidance (p=0.0057).

Second, even among individuals choosing gradual resolution, subjects in the Information treatment choose more informative signals than those in the Lottery treatment. Figure XIX in the Appendix shows the distribution of entropy among only subjects choosing gradual resolution, and the first order stochastic dominance of the Information Structure distribution persists. Therefore, even among subjects who leave some uncertainty to be resolved, those in the Information Structure treatment choose to get more information than those in the Lottery treatment. Table IX in the Appendix reports the average entropy across treatments for all nine choice sets, and we confirm the same treatment difference—in every choice set, subjects choose earlier resolution in the Information treatment compared to the Lottery treatment.

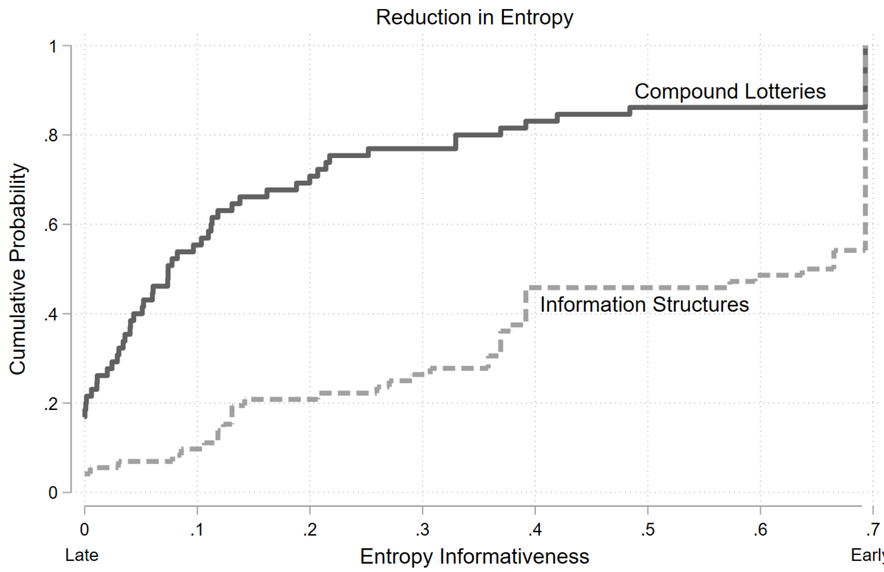


Figure VII: Cumulative distribution of entropy informativeness across treatments

Given that the entropy measure completes the Blackwell ordering—and, as such, could over- or under-state the treatment difference—we also conduct a nonparametric analysis that relies only on the Blackwell ordering. For each point in (r,q) space, we calculate the percent of observed choices, in each treatment, that Blackwell-dominate this point, then compute the treatment difference. The percentage of Blackwell-dominating choices in the Information Structure treatment is weakly larger than in the Lottery treatment for *every* point in (r,q) space. Similarly, the percentage of Blackwell-dominated choices is weakly larger in the Lottery treatment than in the Information Structure treatment for every point in (r,q) space. This ensures that our main results are not systematically biased by the entropy completion of the Blackwell ordering.

Result 1. *Individuals choose significantly earlier resolution of uncertainty in the Information Structure treatment than in the Lottery treatment. This is driven both by more individuals choosing one-shot early resolution and by individuals choosing an earlier form of gradual resolution.*

	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8
Set 2	0.544***							
Set 3	0.697***	0.694***						
Set 4	0.381***	0.449***	0.469***					
Set 5	0.505***	0.510***	0.622***	0.383***				
Set 6	0.566***	0.492***	0.593***	0.538***	0.593***			
Set 7	0.552***	0.650***	0.669***	0.328***	0.565***	0.551***		
Set 8	0.678***	0.684***	0.774***	0.411***	0.618***	0.621***	0.672***	
Set 9	0.472***	0.688***	0.694***	0.422***	0.515***	0.540***	0.510***	0.618***

Table II: Entropy Correlations in the Information Treatment

Table II shows all pairwise correlations in entropy across sets in the Information Structure treatment. We find strong, significant, positive correlations in all comparisons (p <0.0046). Those who choose a more informative information structure in one set are likely to choose a more informative information structure in another set. Table III shows the analogous across-set correlations in entropy in the Lottery treatment. Again, we find strong positive correlations in all but one comparison. Taken together, our results show strong between-treatment differences but strong within-subject consistency: Individuals choose earlier resolution in the Information Structure treatment than in Lottery treatment, and subjects who prefer earlier (or later) resolution in one set tend to choose earlier (later) resolution in all other sets. In Appendix Section D, we analyze revealed-preference measures of choice consistency.

	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8
Set 2	0.606***							
Set 3	0.561***	0.573***						
Set 4	0.450***	0.376***	0.312***					
Set 5	0.375***	0.371***	0.239**	0.409***				
Set 6	0.314***	0.454***	0.451***	0.234*	0.345***			
Set 7	0.502***	0.498***	0.587***	0.463***	0.349***	0.519***		
Set 8	0.342***	0.516***	0.529***	0.322***	0.0679	0.477***	0.491***	
Set 9	0.534***	0.657***	0.574***	0.282**	0.350***	0.545***	0.543***	0.583***

Table III: Entropy Correlations in the Lottery Treatment

Result 2. *Preferences are highly correlated across sets, with individuals expressing a consistent preference for earlier resolution in the Information Structure treatment and for later resolution in the Lottery treatment.*

Indifference

While we see consistent patterns in choices, the natural question is whether these result from strict preferences. As described in the Experimental Design, we presented subjects with 3 price-list choices to get a rough picture of indifference.[18] For example, we elicit a willingness to pay for one-shot early over one-shot late resolution. The details of the price-list elicitation procedure can be found in Appendix Section E. We find that 80% of subjects in the Lottery treatment and 64% of subjects in the Information Structure treatment express positive willingness to pay on at least one price list.[19]

In the Appendix, we also show that willingness-to-pay reflects our main treatment differences. Individuals in the Lottery treatment are more willing to pay for later over earlier resolution, while individuals in the Information Structure treatment pay for earlier over later resolution. From this evidence, we conclude that

[18] These were framed and played out as lotteries in the Lottery treatment and as signals in the Information treatment, consistent with the rest of the experiment.

[19] In the analysis, we exclude price lists on which a subject exhibited multiple switching points. This leaves data from 55 subjects in the Lottery treatment and 72 subjects in the Information treatment.

our results are not an artifact of indifference. Subjects in the Information Structure treatment express a strict preference for early resolution, while those in the Lottery treatment express a strict preference for later resolution.

Result 3. *Preferences are strict as individuals are willing to pay for early resolution in the Information Structure treatment and willing to pay for late resolution in the Lottery treatment.*

One-Shot vs. Gradual

As discussed in Section I, theories make different predictions with respect to observable preferences for one-shot resolution. We discuss respective results in turn, allowing us to differentiate various models.

		One-Shot Early			*One-Shot Late*	
Set	**Lotteries**	**Information**	**p-value**	**Lotteries**	**Information**	**p-value**
1	13.85%	51.39%	0.000	18.46%	4.17%	0.007
2	10.94%	42.25%	0.000	26.56%	7.04%	0.002
3	10.77%	43.84%	0.000	16.92%	2.74%	0.004
4	—	—	—	31.82%	15.07%	0.019
5	—	—	—	18.46%	12.31%	0.331
6	—	—	—	19.70%	10.94%	0.166
7	7.94%	37.50%	0.000	—	—	—
8	14.06%	39.73%	0.001	—	—	—
9	14.06%	38.36%	0.001	—	—	—

Table IV: Percentage of One-Shot Choices Across Treatments

Palacios-Huerta (1999), Kőszegi and Rabin (2009), and Dillenberger (2010) all predict that individuals prefer a form of one-shot resolution in the unrestricted set.[20] Table IV presents the percentage one-shot early and one-shot late choices in each set. In the unrestricted set, 56% of individuals in the Information Structure treatment choose a form of one-shot resolution, significantly higher than the 32% of individuals in the Lottery treatment (Chi-square p=0.006). Appendix Table C shows the comparison of one-shot choices in all nine sets. There are significant treatment differences in six of the nine sets, all showing a stronger tendency to choose one-shot resolution in the Information treatment.

Result 4. *Individuals are more likely to choose one-shot resolution in the Information Structure treatment than in the Lottery treatment.*

As Table IV shows, the direction of one-shot choices follows the treatment difference. In sets that allow for one-shot early resolution, individuals in the Information Structure treatment choose it significantly more often than those in the Lottery treatment. In sets that allow for one-shot late resolution, individuals are more

[20] Kőszegi and Rabin (2009) predict individuals prefer one-shot early, while Palacios-Huerta (1999) and Dillenberger (2010) predict either one-shot early or one-shot late.

likely to choose it in the Lottery treatment than the Information Structure treatment (though this difference is not significant in two sets).

Result 5. *Individuals are more likely to choose one-shot early resolution in the Information treatment than in the Lottery treatment. They are more likely to choose one-shot late resolution in the Lottery treatment than in the Information treatment.*

Nevertheless, one-shot resolution is far from prevailing in either treatment. Across all sets, nearly two thirds of subjects in the Lottery treatment choose a type of gradual resolution instead of resolving uncertainty all at once. One-shot choices are most common in Sets 1–3, where both one-shot early and one-shot late are available, but a significant majority of subjects choose a lottery with gradual resolution in all but Set 2 ($p < 0.0115$, $p = 0.1176$ for Set 2). One-shot resolution is more common in the Information treatment, but still typically constitutes the minority choice. About 55% of individuals choose one-shot resolution in the unrestricted set, and all other sets lie strictly below this percentage. There is no significant difference in the percentages of one-shot versus gradual choices in Sets 1–3, when both one-shot early and one-shot late are available ($p > 0.1979$), but gradual resolution is significantly more common in the remaining 6 sets ($p < 0.0262$). On the whole, aggregate statistics conclude that gradual resolution generally is preferred to one-shot resolution in both treatments.

Result 6. *One-shot resolution is a minority choice in both the Lottery and Information Structure treatments.*

Our experimental design allows us to test the predictions of Palacios-Huerta (1999) and Dillenberger (2010) in more detail. Palacios-Huerta (1999) and Dillenberger (2010) predict that individuals prefer one-shot early or one-shot late resolution to any form of gradual resolution. This gives a clear prediction that individuals who chose one-shot early resolution in Set 1 will switch to choosing one-shot late resolution in Sets 4–6, and those who chose one-shot late resolution in Set 1 will switch to choosing one-shot early resolution in Sets 7–9. Kőszegi and Rabin (2009) predict that individuals will always choose one-shot early when it's available, but might prefer some form of gradual resolution over one-shot late. This predicts individuals will choose one-shot early resolution in Sets 1–3 and 7–9, and doesn't give a clear prediction on choices in Sets 4–6.

In Table V, we analyze subjects who chose one-shot early resolution in the unrestricted set. If these subjects had an aversion to gradual resolution, they would switch to choosing one-shot late resolution in Sets 4–6. We find little evidence for this in either treatment. While the sample size is small in the Lottery treatment (n=9), few subjects switch from one-shot early to one-shot late resolution. This holds to an even greater extent in the Information Structure treatment. Between 8 and 14% of subjects switch to choose one-shot late resolution, but the predominant pattern is to continue choosing early resolution. This suggests that individuals in the

Information Structure treatment choose early resolution in order to resolve as much uncertainty as they can, even if they can't resolve it all.

	Set 4 Choice			Set 5 Choice			Set 6 Choice		
OS Early in Set 1	**Earliest**	**OS Late**	**Other**	**Earliest**	**OS Late**	**Other**	**Earliest**	**OS Late**	**Other**
Lotteries (n=9)	55.56%	22.22%	33.33%	33.33%	11.11%	55.56%	33.33%	11.11%	55.56%
Information (n=37)	81.08%	8.11%	10.81%	51.35%	13.51%	35.14%	59.46%	10.81%	29.73%

Table V: Transition patterns from choosing one-shot early resolution in the unrestricted set to choice in the relevant restricted sets.

In Table VI, we analyze subjects who chose one-shot late resolution in the unrestricted set. If these subjects had an aversion to gradual resolution, they would switch to choosing one-early late resolution in Sets 7–9. Sample sizes are even smaller here, but again we find no evidence of this switching pattern. Subjects in both treatments tend to choose neither the earliest or latest resolving lotteries in these restricted sets.

	Set 7 Choice			Set 8 Choice			Set 9 Choice		
OS Late in Set 1	**OS Early**	**Latest**	**Other**	**OS Early**	**Latest**	**Other**	**OS Early**	**Latest**	**Other**
Lotteries (n=13)	0%	23.08%	76.92%	7.69%	23.08%	69.23%	7.69%	23.08%	69.23%
Information (n=3)	0%	0%	100%	0%	0%	100%	0%	0%	100%

Table VI: Transition patterns from choosing one-shot late resolution in the unrestricted set to choice in the relevant restricted sets.

Result 7. *There is no evidence of an aversion to gradual resolution of uncertainty in either the Lottery or Information Structure treatments.*

Ely et al. (2015) model decision makers who derive utility from suspense or surprise, and therefore dislike one-shot resolution.[21] We formally analyze these predictions in the Appendix. Overall, using looser definitions of suspense- and surprise-maximizing lotteries, 10% of intermediate Lottery choices and 19% of intermediate Information Structure choices maximize suspense or surprise (between-treatment difference $p = 0.27$). While we don't find overwhelming evidence for the specific predictions of the suspense and surprise models, we do find a high proportion of intermediate choices. In general, gradual resolution of uncertainty is more suspenseful and more surprising than one-shot resolution, so our results seem more in line with these motivations than with resolving uncertainty all at once.[22]

[21] These models were primarily designed to analyze situations like sports games and mystery novels where we might expect individuals to have a strong preference for suspense and/or surprise. We can apply these models to our lottery environment, but do not believe this was intended to be their primary application.

[22] The hypothetical questions between Stage 1 and Stage 2 resolution give further suggestive evidence. We asked subjects to rate, on a scale from 1–7, how much they enjoyed mystery novels. We find those choosing gradual resolution in the Information treatment report higher enjoyment of mystery novels compared to those choosing one-shot resolution, an average rating of 5.47 vs. 4.57 ($p = 0.029$). Results are directionally similar in the Lottery treatment, though the difference is not significant (5.38 vs. 5.29, $p = 0.84$).

Testing Theories

A natural question is which of the theories summarized in the Literature Review, if any, are consistent with observed choices. A primary feature of preferences over compound lotteries appears to be that individuals prefer gradual over one-shot resolution. This rules out models like Kreps and Porteus (1978), Loewenstein (1987), Epstein and Zin (1989), Grant et al. (1998), Brunnermeier and Parker (2005), Kőszegi and Rabin (2009), and Dillenberger (2010) which predict individuals will choose the earliest or latest resolution available. Ely et al. (2015) predict a preference for gradual resolution, most similar to observed preferences. While we don't see choices exactly as predicted by the suspense and surprise models, as discussed above, these models come closest to capturing the observed preference for gradual resolution and a local preference for later resolution.

Over information structures, many individuals prefer earlier resolution of uncertainty. This is consistent with the models of Kreps and Porteus (1978), Epstein and Zin (1989), and Grant et al. (1998). In their study of preferences over the resolution of uncertainty in an environment similar to our information treatment, Masatlioglu et al. (2017) also find preferences consistent with the model of Kreps and Porteus (1978). However, while individuals choose earlier resolution in the Information Structure treatment than in the Lottery treatment, they do not always choose the earliest possible resolution. This suggests a need for generalizing these models to accommodate the data.

The most important observation is that preferences over information structures differ quite dramatically from preferences over lotteries. No existing theory captures this difference. It would be very valuable to develop theoretical models that allow for preferences to vary across these two types of uncertainty. The primary patterns in our data suggest that such a theory should allow for a preference for early resolution about states of the world that have been determined, but should allow for delayed resolution of uncertainty about states realized in the future.

IV. Time Delay

Taken together, our results conclude that preferences over lotteries are significantly different from preferences over information structures, despite their theoretical equivalence. In this section, we analyze the extent to which this is driven by preferences for uncertainty resolution compared to preferences over lotteries and information structures more fundamentally.

We run a second set of treatments identical to the first, but where the time delay between Stage 1 and Stage 2 resolution approaches zero. In particular, subjects were given the exact same instructions describing the Lotteries or Information Structures, depending on the treatment, but were told that the Stage 2 outcome would be revealed "immediately after" the Stage 1 signal. In practice, we show the Stage 2 outcome on the subsequent computer screen after a 5 second delay. Therefore, while the outcome still is revealed in two steps, the value of the information as it pertains to anticipatory utility is negligible.[23] We refer to these as "No Delay" treatments.

Other experimental protocols remained the same. In particular, subjects still participated in the "distraction tasks," but these occurred after the realization of the lottery outcome. Subjects were told these tasks would take approximately 30 minutes, as before, but that they would learn the lottery outcome beforehand. The one minor change is that we did not do the Part 2 risk/time preference elicitation for the sake of laboratory time scheduling.

Subjects were primarily undergraduate students at the Ohio State University. Sessions lasted approximately 75 minutes, and payments averaged $17.50 including a $10 show up fee. 69 new subjects participated in the Lottery_NoDelay treatment and 59 new subjects participated in the Information_NoDelay treatment.[24]

Results

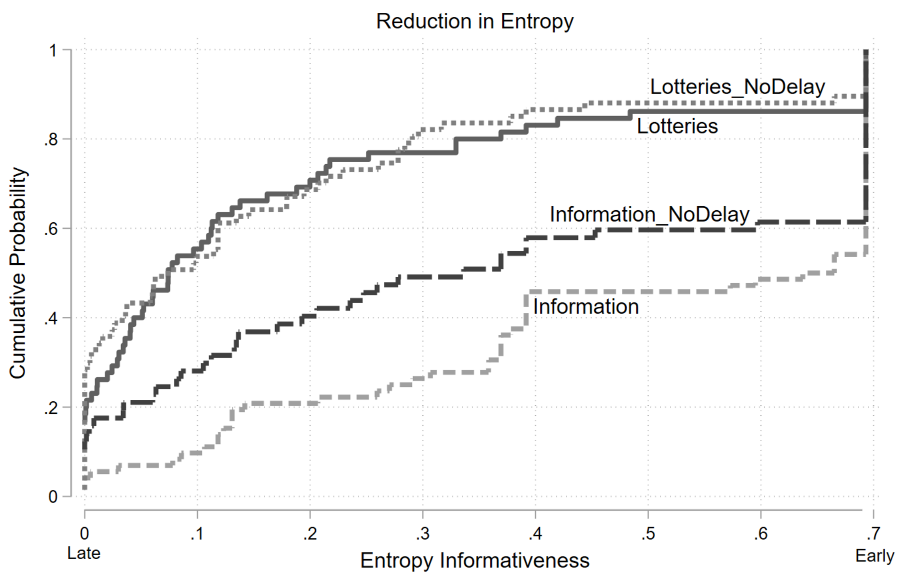


Figure VIII: Cumulative distribution of entropy informativeness across all four treatments

Figure VIII shows the cumulative distribution of the entropy informativeness of choices in the unrestricted set, comparing the No Delay treatments to the original treatments. Choices in the Lottery treatments do not

[23]Recent papers studying compound lottery aversion and reduction of compound lotteries, such as Harrison et al. (2015), use a similar two-step protocol.

[24]While we planned to match sample sizes to the Delay treatment, we had fewer subjects show up to the Information_NoDelay treatments. This seems to be random, not driven by selection, as advertising and recruiting were exactly the same between Lottery_NoDelay and Information_NoDelay.

differ with the delay (Kolgomorov-Smirnov p=0.781), but Information Structure choices are significantly less informative in the No Delay condition (p=0.036). Despite this, the treatment difference persists—choices in the Information_NoDelay treatment are significantly more informative than those in the Lottery_NoDelay treatment (p=0.001). Therefore, while the time delay exacerbates the treatment difference, it is not the only contributing factor.

Table VII shows the percentages of one-shot early and late choices in the unrestricted set across treatments. We see that individuals are more likely to choose one-shot late resolution in both Lottery_NoDelay and Information_NoDelay compared to their original Delay counterparts, but the differences are not statistically significant in the Lottery treatments.

	Lotteries			Information		
	Delay	**No Delay**	**p-value**	**Delay**	**No Delay**	**p-value**
One-Shot Early	13.85%	11.94%	0.745	51.39%	38.39%	0.149
One-Shot Late	18.46%	28.36%	0.182	4.17%	12.28%	0.0882

Table VII: Percentage of One-Shot Early and Late Choices Across Delay Conditions

Unsurprisingly, though, individuals are closer to indifference in the No Delay treatments. Recall that 80% of individuals in the original Lottery treatment and 64% in the original Information treatment express positive willingness-to-pay on at least one price list. This falls to 54% (p=0.0025) and 49% (p=0.0959), respectively, in the No Delay treatments. Among those willing to pay, the direction of preference remains the same as in the original treatments. 21% of subjects in the Lottery_NoDelay treatment were willing to pay for one-shot late over one-shot early, while this is true for only 6% of subjects in the Information_NoDelay treatment (p=0.0185). Conversely, 8% of individuals in the Lottery_NoDelay treatment were willing to pay for one-shot early over one-shot late, compared to 30% of subjects in the Information_NoDelay treatment (p=0.0024).

Taken together, results indicate that a strictly positive willingness to pay for uncertainty resolution stems partially from the anticipatory utility component of information. When individuals are forced to sit with non-instrumental information for some time, they are willing to pay for their preferred type of information. With only a negligible time delay, individuals are less willing to pay for this information. However, we still find differences in preferences over compound lotteries and information structures when we strip out this beliefs-based component of non-instrumental information. This suggests that individuals treat these two objects differently at a fundamental level: Individuals prefer uncertainty resolve differently when framed as a compound lottery compared to an information structure.

One question emerges as to why a substantial fraction (almost 60%) of individuals still choose gradual resolution in the Lottery_NoDelay treatment. A large literature has shown that individuals are averse to compound lotteries. This seems to imply that individuals would be averse to gradual resolution in the No

Delay treatment because this creates a compound lottery, while one-shot resolution is closer to a "one-stage" simple lottery. One factor could be that the first stage of the lottery was revealed to subjects slightly before the second stage outcome, and we emphasized the two separate pieces of information. It could be the case that choices converge to more "standard" compound lottery choices when there is no emphasis on information revealed in the middle. Another likely explanation is that our instructions strongly emphasize the fact that subjects cannot change the "overall odds" of the lottery. A typical experiment on compound lottery aversion elicits certainty equivalents of actuarially-equivalent simple and compound lotteries (see Halevy, 2007 and Harrison et al., 2015, among many others). In these experiments, in contrast with the present experiment, subjects are not primed to focus on the "overall" probability distribution over final outcomes, nor are they told that the equivalent lotteries have the same overall odds. These conjectures leave interesting open questions for future research to explore how individuals perceive compound lotteries and information.

V. Underlying Mechanism: Suggestive Evidence

In the Appendix, we present a number of secondary results and analysis of heterogeneity. In particular, we analyze skewness of information, correlations with risk and time preferences, and test the axiomatic assumptions of Dillenberger (2010). Given that the time delay does not explain the treatment difference, in this section we explore some suggestive evidence as to why individuals treat compound lotteries and information structures differently.

Auto Choices

Recall that subjects were required to select either p, q, or r to place on Auto while freely adjusting the other two variables. Subjects' "Auto" button choices give insight into their decision-making processes. An individual focused on choosing his posteriors is likely to place p on Auto, while an individual trying to control the frequency of good and bad signals might be more likely to retain p as a choice variable.

The second and third columns of Table VIII report the percentage of subjects in each treatment placing a given variable on Auto in the unrestricted set.[25] We find that a majority of subjects in the Information treatment place p on Auto, in contrast to a fairly uniform distribution of Auto choices in the Lottery treatment (Chi-square p=0.000). While we did not exogenously manipulate this variable, we take it as suggestive evidence that Information choices are largely focused on the induced posteriors, while Lottery choices are more heterogeneous.[26] Thus, despite the fact that individuals could implement exactly the same outcomes in both

[25] We only have data recorded on a subject's *final* Auto choice. While subjects were free to change which variable they placed on Auto, we are unable to detect switches in the data.

[26] We did randomize which slider started on Auto. However, q was always on the left of the screen to minimize confusion. It could be

treatments, the Auto choices indicate that individuals approach these two situations very differently: Not only do choices differ across treatments, but the way in which subjects make their choices also differs.

	Percentage of Choices		Entropy Informativeness		
	Lotteries	**Information**	**Lotteries**	**Information**	**p-value**
Auto p	28.57%	66.67%	0.306	0.528	0.0069
Auto q	35.71%	9.52%	0.178	0.365	0.128
Auto r	35.71%	23.81%	0.114	0.300	0.0118

Table VIII: Auto choices and average entropy informativeness conditional on auto choices

Furthermore, we find that the differences in Auto choices are correlated with differences in information, but are not sufficient to explain the overall treatment differences. The last columns of Table VIII report the average entropy informativeness across treatments, conditional on Auto choice. We find that, in both treatments, subjects who put p on Auto choose earlier resolution compared to those who put q or r on Auto.[27] However, individuals in the Information treatment still choose earlier resolution than those in the Lottery treatment, even after conditioning on Auto choice. Therefore, while focusing on posteriors does lead to resolving more uncertainty, Auto choices do not drive the the higher informativeness of choices in the Information Structure treatment.

Survey Evidence

In a post-experiment questionnaire, we remind subjects of their choice in the unrestricted set and ask them to explain why they chose that particular lottery or information structure. Very few subjects mentioned choosing randomly. Responses indicate that subjects understood they could not affect the overall odds, but subjects in the Information treatment are very clear in preferring early information for the benefit of knowing the lottery outcome sooner. For example, "I do not like surprises and I get very anxious when I do not know something for certain, so I wanted the signal to tell me exactly what was going to happen... so I did not have to wait."[28]

In the Lottery treatment, it's clear that some some subjects viewed all lotteries identically—"There wasn't much thought since all the chances were 50/50." Furthermore, subjects choosing for uncertainty to resolve in Stage 1 of the lottery did so in order to learn the lottery outcome sooner and not based on other factors irrelevant to our motivation—"As much as possible I wanted my payout to be determined by urn choice so I wouldn't have to wait to know if I had won or lost."

Interestingly, subjects exhibiting a preference for late resolution of uncertainty give two types of motiva-

the case that this results in r placed on Auto more often, or it could be a more deliberate choice of choosing "bad news" posteriors.

[27] This difference is significant between p and r in both treatments (Lottery p=0.0071, Information p=0.0015), and is significant between p and q in the Information treatment (Lottery p=0.219, Information p=0.0368).

[28] All quotes in this section are from the Delay treatments.

tions. The first is the expected preference to avoid information, or to design uncertainty such that it resolves later. Subjects' responses allude to avoiding disappointment in finding out they did not win the high prize—"I didn't want anything to be for sure blue until the end since I wanted the largest payout." Some responses even seem to indicate a preference for one-shot late resolution—"I usually liked just one urn to be at 100% then for that urn to be a 50:50 chance. I know it was all a 50% chance regardless, but I liked my luck being based on only 1 event versus two."

On the other hand, many subjects stated a preference for "diversification," which manifests as a preference for late resolution. These subjects try to have a "high enough" posterior regardless of which urn is selected in Stage 1. This results in equalizing odds across all states of the world, or at least reducing the variance in posteriors in the second stage of the lottery. For example, one subject says "I figured it didn't matter much since the probability would be 50/50 either way, but I tried to keep each urn as close to 50% because I knew I would feel better if, no matter which lottery was selected and no matter which urn from that lottery was selected, there was still a reasonable chance of getting a red ball." These subjects are averse to learning the lottery outcome in the first stage, but not quite because they are simply avoiding information. They avoid resolution in the first stage because they don't want to face a state of the world in which they know they have no chance of winning. They feel as if they haven't lost yet, and don't want to expedite the possibility of guaranteeing a loss.

We hypothesize that these behavioral factors may contribute to the difference between the treatments. In the Information treatment, the outcome has already been determined and subjects simply want to know the result. When the lottery outcome has not been determined, other psychological factors such as luck, illusion of control, etc. may come into play (Langer, 1975; Eliaz and Frechette, 2013). Winning the high or low prize is not yet set in stone, and subjects are averse to locking in the low prize any earlier than need be.

False Diversification

Furthermore, in a hypothetical question between Stage 1 and Stage 2 resolution, we presented subjects with the environment from Eliaz and Frechette (2013), which measures a form of "false diversification." We compare the false diversification tendency between those who choose earliest resolution in Set 1 and those who choose to delay some uncertainty resolution. We find that subjects in the Lottery treatment who do not choose early resolution of uncertainty are significantly more likely to prefer this false diversification (62% vs. 22%, $p = 0.0271$). In the Information treatment, however, there is no significant difference (67% vs. 73%, $p = 0.560$). This gives suggestive evidence that individuals in the Lottery treatment delayed resolution for false diversification and other psychological reasons stemming from the fact that uncertainty had not been resolved yet, while these motivations are absent in the Information treatment. Better understanding this difference is an interesting question for future research.

VI. Conclusion

We demonstrate experimentally that preferences over information structures are not equivalent to preferences over compound lotteries in environments with resolving uncertainty. Instead, preferences for receiving information appear to follow the time at which the outcome occurs. In compound lotteries, when the outcome is determined in the last stage, individuals prefer to delay uncertainty resolution and learn information later. In information structures, when the outcome has already been determined, individuals prefer to expedite uncertainty resolution and learn information sooner. In both scenarios, and especially for compound lotteries, we see a strong tendency for individuals to choose an intermediate form of uncertainty resolution and, therefore, we find no evidence for an aversion to gradual resolution. Preferences are strict, but this dissipates when individuals do not have to wait long for uncertainty to resolve.

In light of our results, we conjecture that information avoidance will be more prevalent about outcomes that will come to fruition in the future, while individuals may be more willing to pay to learn outcomes which have been already resolved. This can help us classify field environments and predict situations in which individuals will require extra incentives to acquire information. Policy makers instead could focus on aspects of the outcome which have already occurred, taking advantage of individuals' natural tendency to acquire information in these environments.

Our experimental results leave open a number of interesting questions for future research. We provide suggestive evidence on the mechanism underlying *why* individuals treat information structures and compound lotteries differently, but this remains an open question. Our results also demonstrate a need for behavioral theories to relax the theoretical isomorphism and allow for preferences to vary across these two domains. Furthermore, previous studies have found information preferences can change with the stakes, prior, and gain/loss outcome. Future research can better understand how varying these dimensions interacts with the difference between lotteries and information structures.

Finally, it's unclear to what extent these preferences would carry over into domains where early resolution of uncertainty could be instrumental. It would be valuable for experiments to be able to disentangle instrumental from non-instrumental considerations in information acquisition to identify what portion of information acquisition or avoidance is driven by underlying information preferences.

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A. Appendix

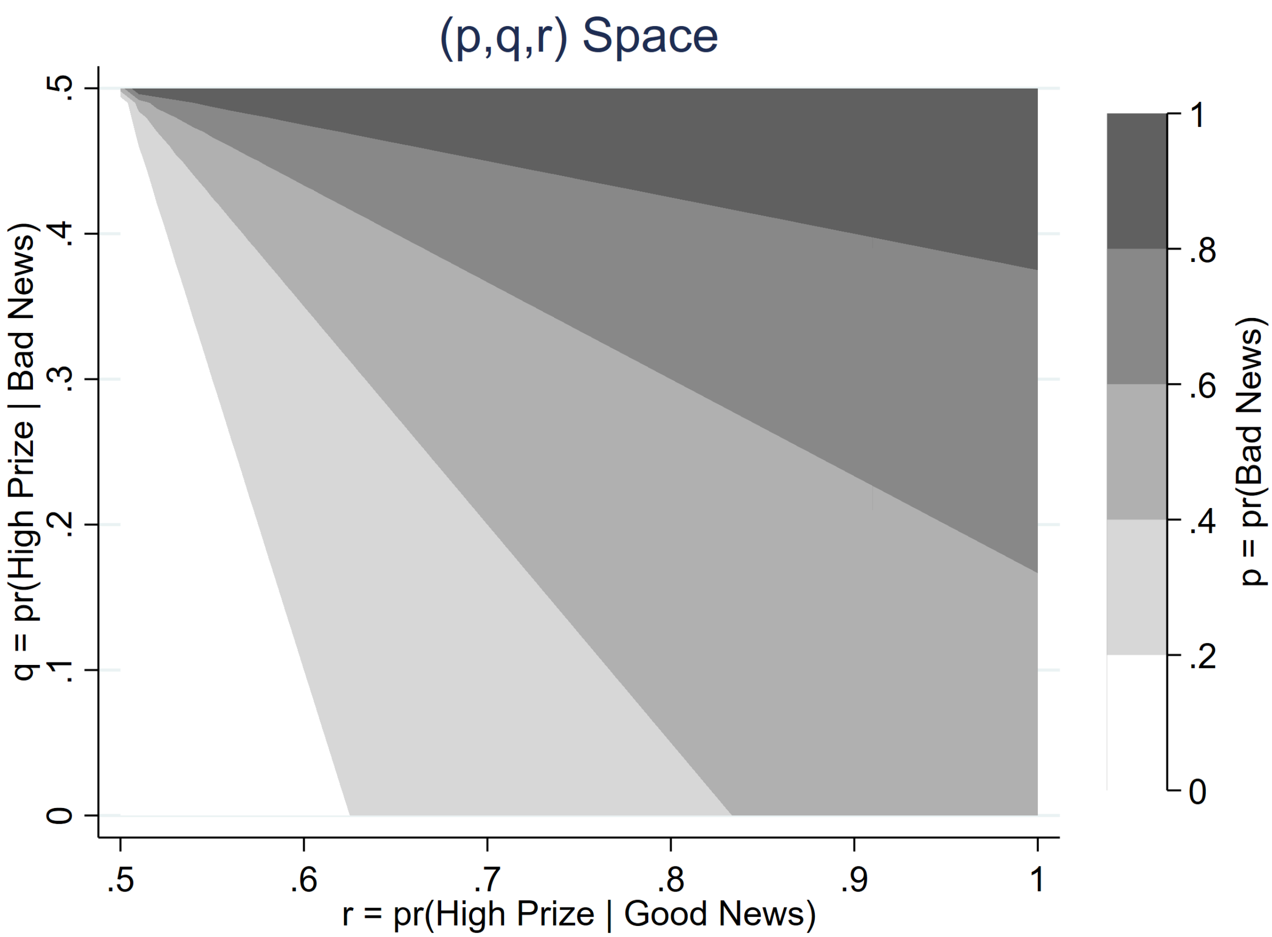
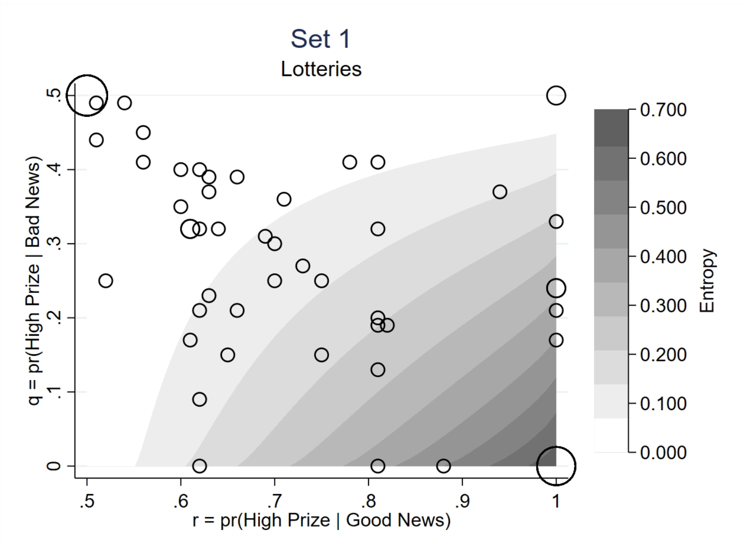


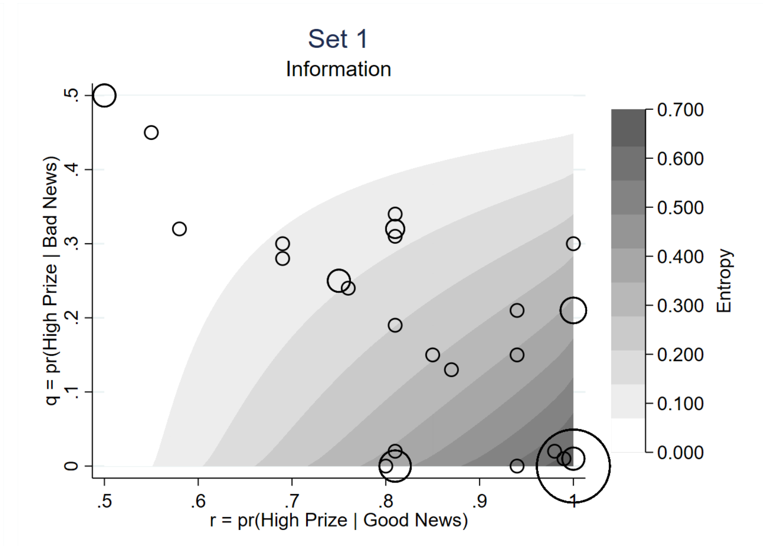
Figure IX: All Possible Lotteries/Information Structures

B. Choice Data in Each Set

The graphs below plot all subjects' choices in (r, q) space, separated by treatment. Plot points are weighted by frequency of choice with bigger bubbles indicating that a larger number of subjects chose a particular lottery or information structure.

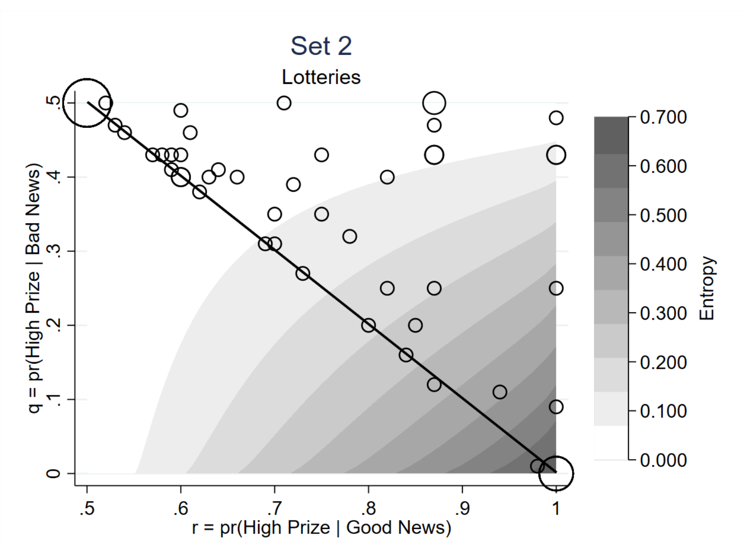


(1) Lottery Treatment

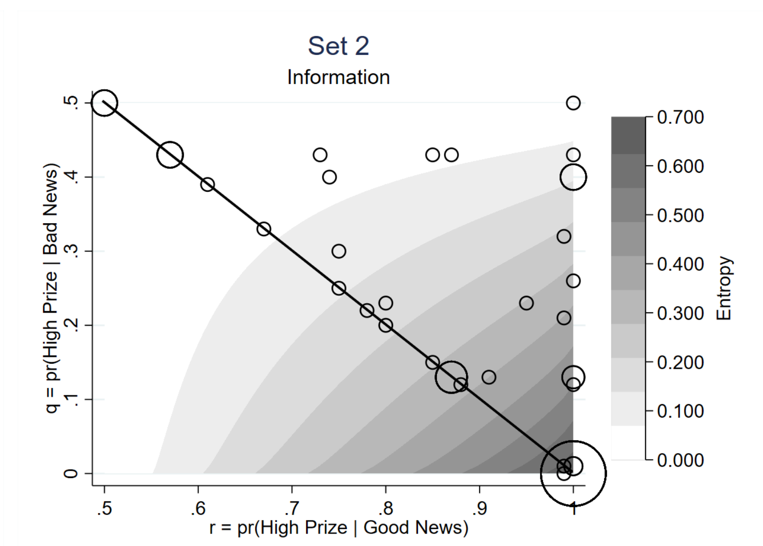


(2) Information Treatment

Figure X: Unrestricted set choices

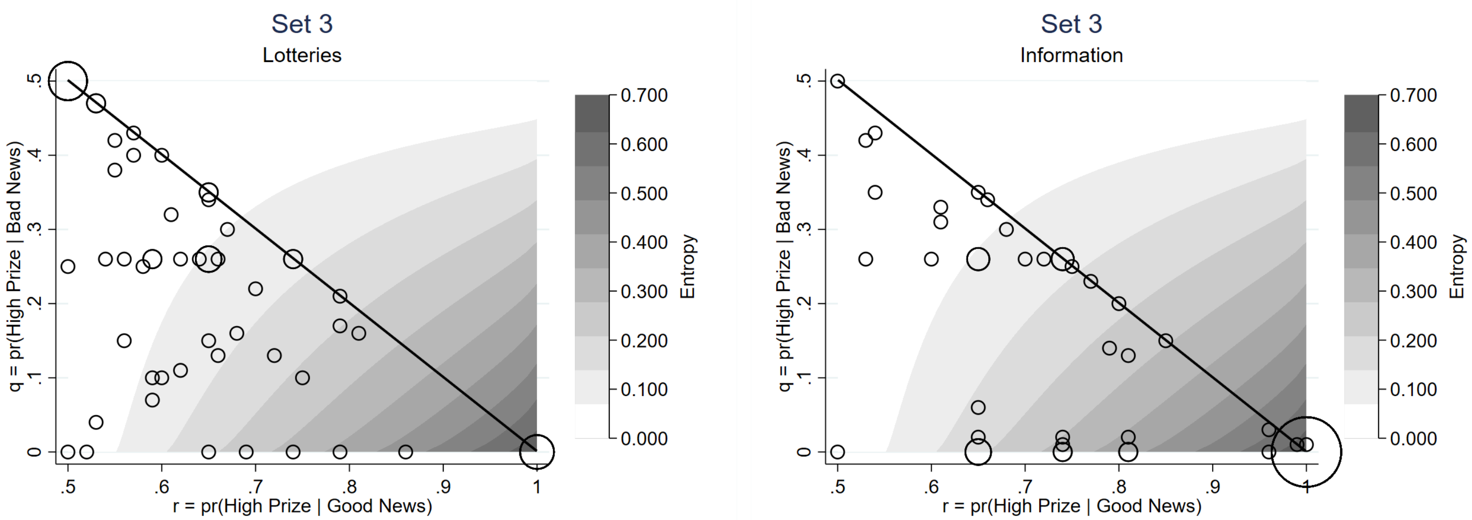


(1) Lottery Treatment



(2) Information Treatment

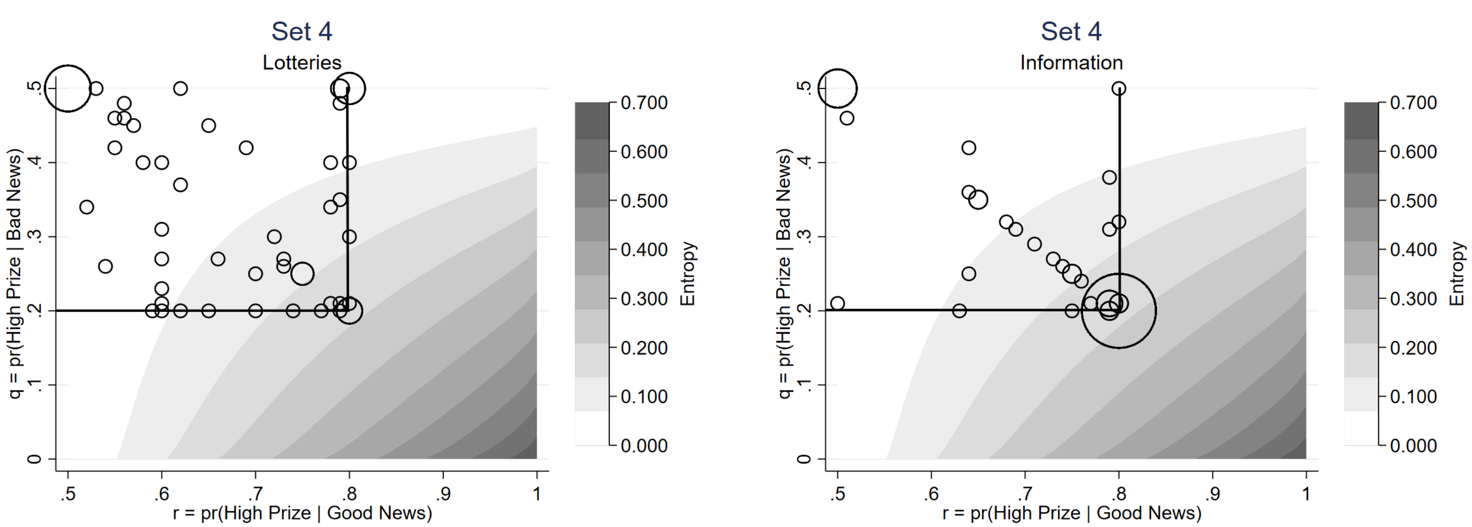
Figure XI: Only positively skewed



(1) Lottery Treatment

(2) Information Treatment

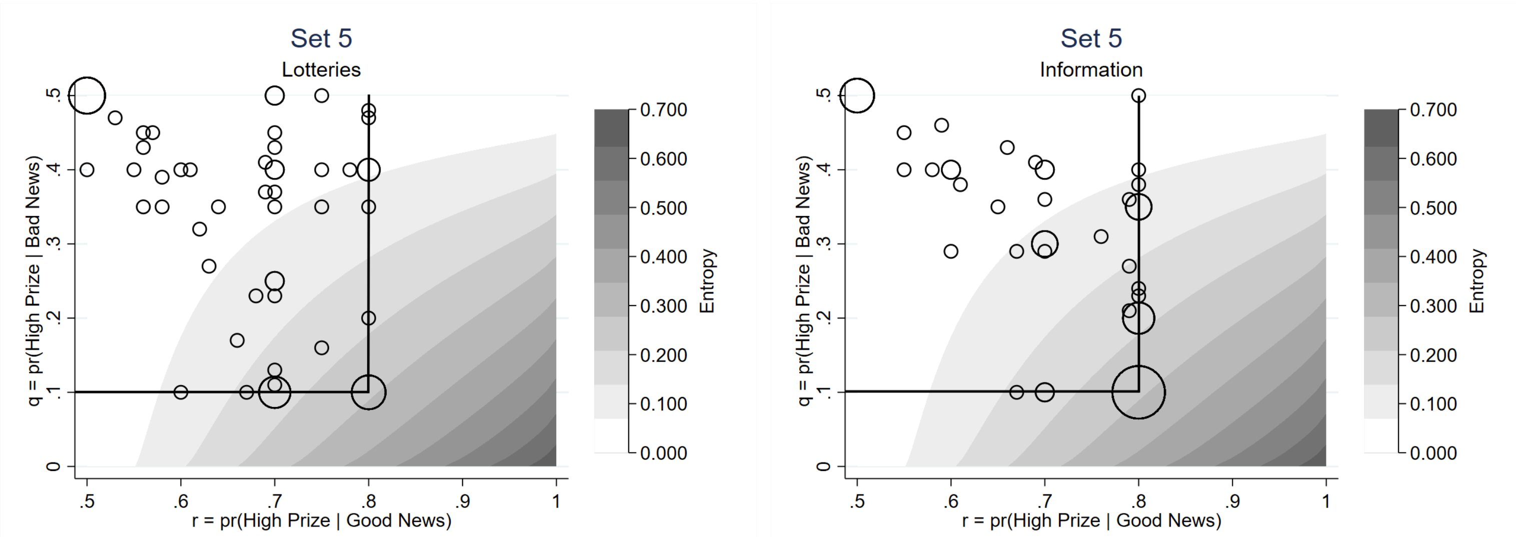
Figure XII: Only negatively skewed



(1) Lottery Treatment

(2) Information Treatment

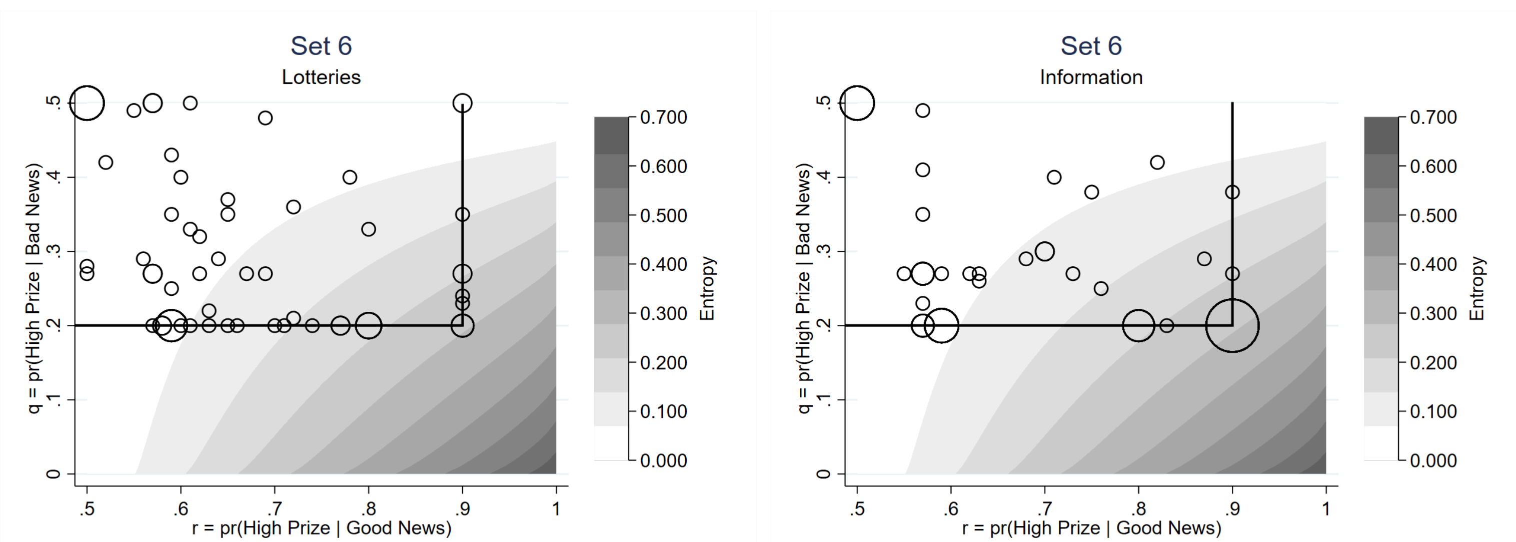
Figure XIII: Prevent One-Shot Early Resolution



(1) Lottery Treatment

(2) Information Treatment

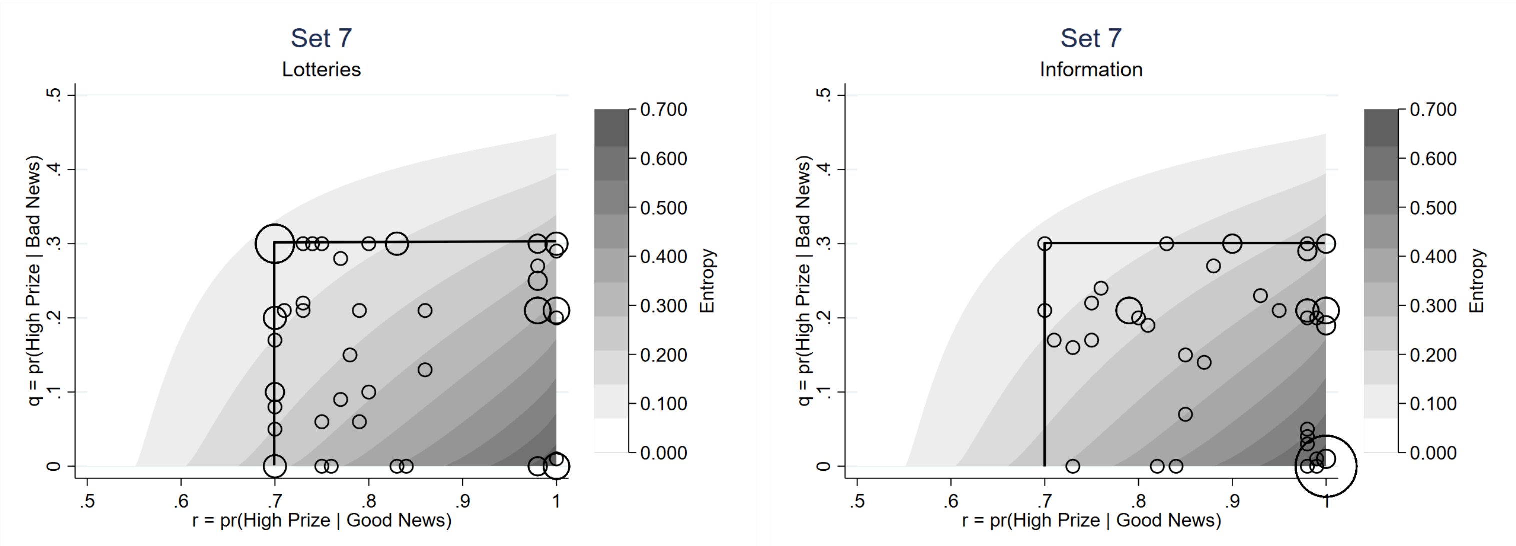
Figure XIV: Prevent One-Shot Early Resolution



(1) Lottery Treatment

(2) Information Treatment

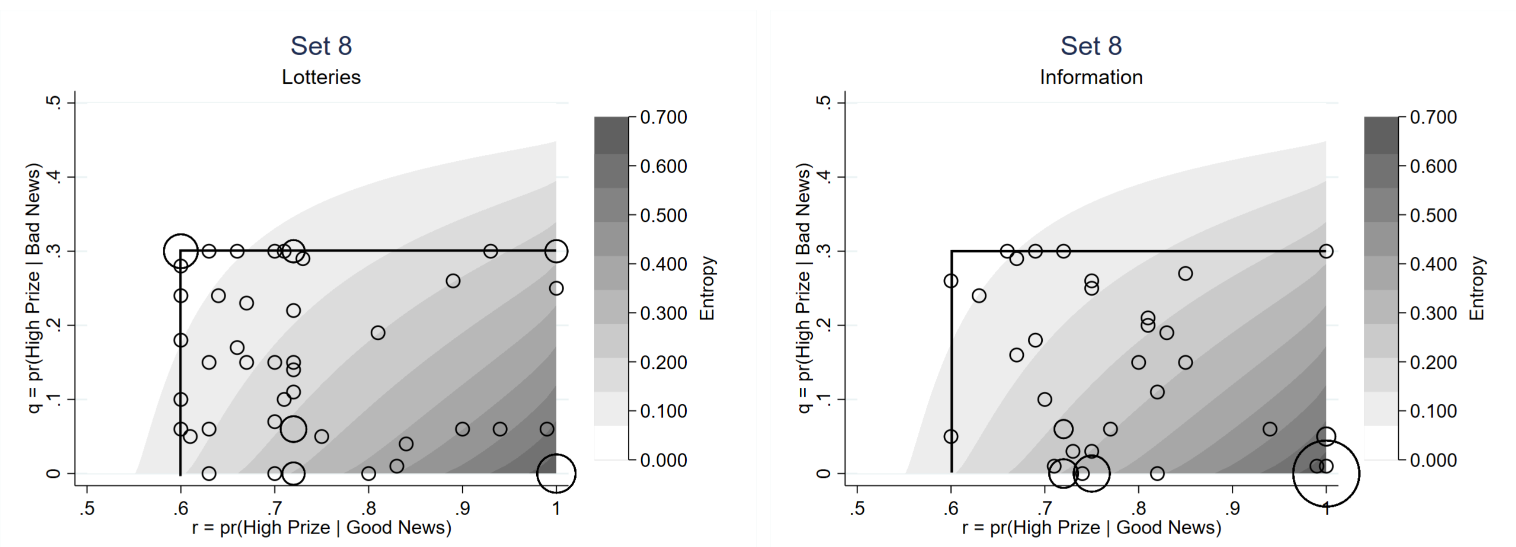
Figure XV: Prevent One-Shot Early Resolution



(1) Lottery Treatment

(2) Information Treatment

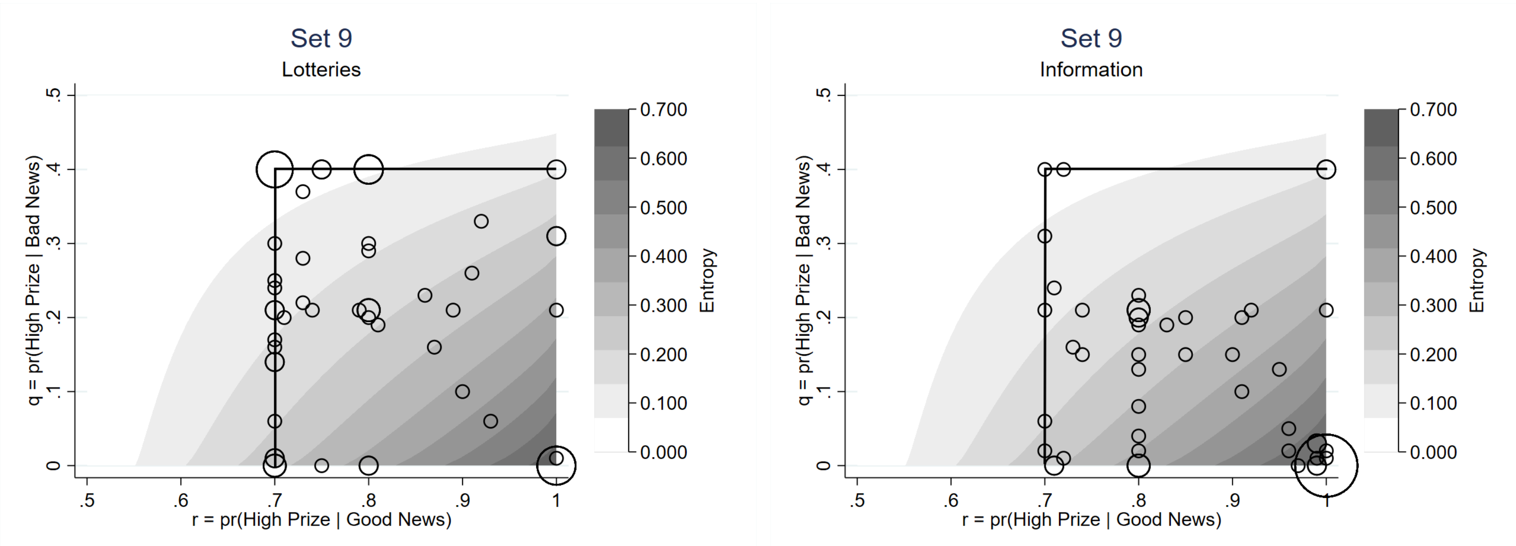
Figure XVI: Prevent One-Shot Late Resolution



(1) Lottery Treatment

(2) Information Treatment

Figure XVII: Prevent One-Shot Late Resolution



(1) Lottery Treatment

(2) Information Treatment

Figure XVIII: Prevent One-Shot Late Resolution

C. Additional Results

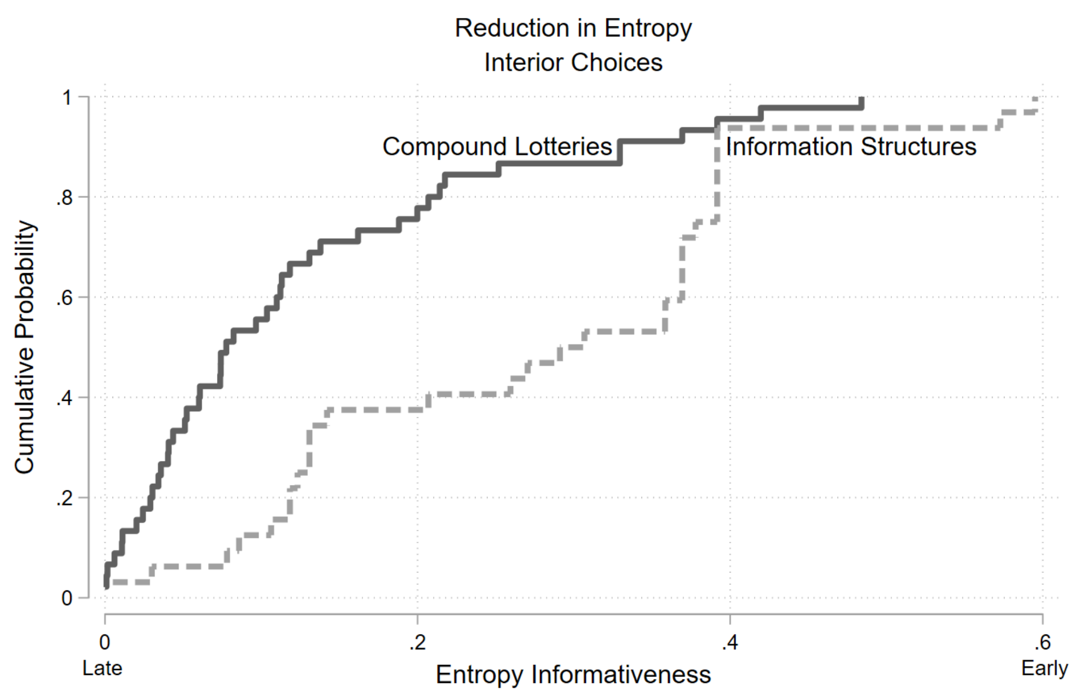


Figure XIX: Cumulative distribution of reduction in entropy among gradual choices across treatments

One-Shot Resolution			
Set	**Lotteries**	**Information**	**p-value**
1	32.31%	55.56%	0.006
2	37.50%	49.30%	0.168
3	27.69%	46.58%	0.022
4	31.82%	15.07%	0.019
5	18.46%	12.31%	0.331
6	19.70%	10.94%	0.166
7	7.94%	37.50%	0.000
8	14.06%	39.73%	0.001
9	14.06%	38.36%	0.001

	Delay Treatments			No Delay Treatments		
	Lotteries	Information	p-value	Lotteries	Information	p-value
Set 1	0.189	0.469	0.0000	0.179	0.358	0.0003
Set 2	0.150	0.389	0.0000	0.125	0.254	0.0022
Set 3	0.176	0.398	0.0000	0.140	0.264	0.0009
Set 4	0.0630	0.134	0.0000	0.0591	0.111	0.0004
Set 5	0.0863	0.136	0.0044	0.0558	0.107	0.0055
Set 6	0.0892	0.139	0.0063	0.0440	0.117	0.0000
Set 7	0.282	0.438	0.0000	0.316	0.418	0.0116
Set 8	0.256	0.423	0.0000	0.256	0.369	0.0170
Set 9	0.251	0.436	0.0000	0.245	0.345	0.0145

Table IX: Average Entropy Across Treatments

D. Consistency

Given that subjects made choices from nine budget sets, we can use standard revealed-preference measures to analyze within-subject consistency. We calculate the Houtman-Maks (Houtman and Maks, 1985) Index (HMI) as the maximal subset of choices consistent with the weak axiom of revealed preference (WARP). This gives the largest number of budget sets (out of nine) in which subjects' choices did not violate WARP.

To calculate this, we allow for slight "trembles." An individual's choice in Set j, (p_j, q_j, r_j), is said to be consistent with his choice from Set i, (p_i, q_i, r_i), if $||(q_i, r_i) - (q_j, r_j)||_\infty < 0.025$. In other words, we consider all choices in the 0.05-unit square centered around (p_i, q_i, r_i) to be consistent with (p_i, q_i, r_i). A subject's choice in Set j is also consistent with his choice in Set i if his choice from Set i is not available in Set j.

We find that choices are more consistent in the Information treatment, with an average HMI of 6.73 compared to 6.01 in the Lottery treatment (p=0.0201). Only seven individuals in the Lottery treatment have a maximal HMI, while 20 individuals in the Information treatment do. Perhaps unsurprisingly, these are almost all individuals who choose one-shot resolution in the unrestricted set (7/7 individuals in the Lottery treatment and 19/20 individuals in the Information treatment). Individuals choosing an extreme form of uncertainty resolution are more likely to make consistent choices across budget sets. Surprisingly, however, we find that those who expressed positive willingness to pay on at least one price-list are actually *less* consistent according to the HMI measure (Lotteries: 7.27 vs. 5.72, p=0.0053 and Information 7.31 vs. 6.43, p=0.0415). So while willingness to pay predicts direction of choices among those willing to pay, it does not predict more consistent choices overall.

E. Indifference

In the price-list questions, we present subjects with two lotteries, one denoted "Option A" and the other "Option B." Then, we ask subjects to choose between Option A and Option B 21 times, where each question adds a nominal payment on top of either Option A or Option B, as shown below. A subject who is indifferent between Option A and Option B will always choose the one which gives additional payment. A subject who strictly prefers Option A, for example, would be willing to forgo this additional payment for some strictly positive payment values in order to receive Option A over Option B.

Would you rather have...		
Option A + \$0.50	or	Option B
Option A + \$0.45	or	Option B
Option A + \$0.40	or	Option B
⋮	⋮	⋮
Option A + \$0.05	or	Option B
Option A	or	Option B
Option A	or	Option B + \$0.05
⋮	⋮	⋮
Option A	or	Option B + \$0.40
Option A	or	Option B + \$0.45
Option A	or	Option B + \$0.50

In one price list, we explicitly ask for strength of preference between one-shot early and one-shot late resolution. The second price list captures the early/late dimension when both are gradually resolving lotteries—Option A, $(p,q,r) = (0.63, 0.32, 0.81)$ Blackwell dominates Option B, $(0.67, 0.4, 0.7)$.[29] Subjects strictly preferring early resolution of uncertainty would be willing to pay for the former, while those strictly preferring late resolution of uncertainty would be willing to pay for the latter. Finally, the third price list offers the choice between symmetric lotteries that differ only in skewness. Option A, $(0.91, 0.45, 0.98)$ is very positively skewed, while Option B, $(0.09, 0.02, 0.55)$ is equally informative but negatively skewed.

[29] Due to a data recording error, we have responses to this question only from 7 individuals in the Information treatment and 59 individuals in the Lottery treatment.

	One-Shot Price List			Gradual Price List			Skewness Price List		
	OS Early	**Indiff**	**OS Late**	**Early**	**Indiff**	**Late**	**Positive**	**Indiff**	**Negative**
Lotteries	13%	59%	28%	16%	59%	24%	22%	27%	51%
Information	45%	51%	4%	57%	43%	0%	23%	49%	28%
	Fisher's exact p=0.000			Fisher's exact p=0.045			Fisher's exact p=0.021		

Table X: Percentage of subjects expressing positive willingness to pay or indifference in the price list elicitation questions

Table X shows the percentages of subjects expressing positive willingness to pay across the three price lists. The first two price lists confirm the main result—individuals in the Lottery treatment are more willing to pay for later over earlier resolution, and the opposite is true for individuals in the Information treatment. In the Lottery treatment, on average, subjects were willing to pay 8 cents for one-shot late over one-shot early resolution, and those in the Information treatment were willing to pay 18 cents for one-shot early over one-shot late resolution. Excluding the indifferent subjects, individuals in the Lottery treatment were willing to pay on average 20 cents for one-shot late resolution, and those in the Information treatment were willing to pay 38 cents for one-shot early resolution. While not enormous in magnitude, this represents up to 5% of the expected value of the lottery to speed up resolution by 30 minutes.

As further evidence of non-indifference, we find a significant relationship between willingness to pay and entropy informativeness on an individual level. Figure XX shows the average entropy informativeness in the unrestricted set, broken down by willingness to pay on the one-shot early versus one-shot late price list. Individuals who are willing to pay for one-shot early over one-shot late choose earlier resolution in the main choice task compared to those who pay for one-shot late.[30] The difference is significant in the Information treatment (p=0.0209), but not for Lotteries (p=0.169). Overall, the correlation between entropy informativeness and amount willing to pay for late over early resolution is -0.213 (p=0.121) for Lotteries and -0.210 (p=0.0833) for Information, suggesting those who are willing to pay for late resolution choose less informative lotteries.

[30] Note also that, in Figure XX, the treatment difference persists for those who are indifferent. We will see this again in the No Delay treatments below, where individuals express more indifference but choices remain the same.

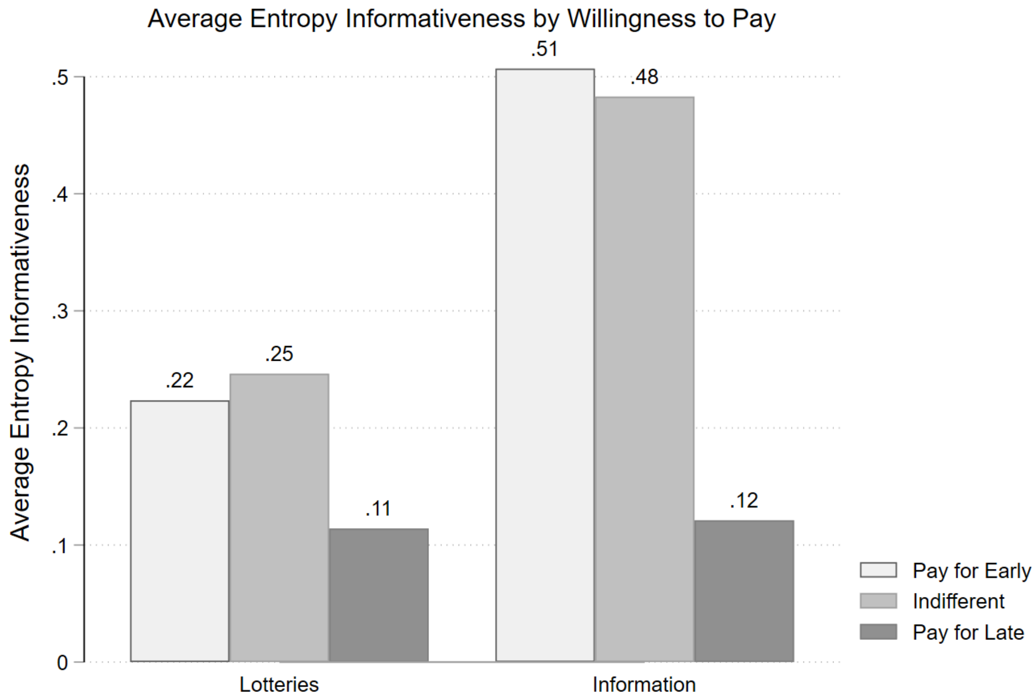


Figure XX: Average Entropy Informativeness by Willingness to Pay

While information is entirely non-instrumental in both treatments, individuals are willing to pay to speed up or delay receipt of this information. Moreover, the Auto data demonstrates that individuals view these environments very differently. Despite their theoretical equivalence, individuals do not view uncertainty resolution with Information Structures the same as with Lotteries, and this contributes to differences in non-instrumental information acquisition.

Suspense and Surprise

The models of Ely et al. (2015) predict a preference *against* one-shot resolution. Ely et al. (2015) model decision makers who derive utility from suspense or surprise.[31] Suspense increases with increasing variance in beliefs from one period to the next, and surprise increases with the difference in beliefs from one period to the next. The authors derive suspense- and surprise-optimal policies for general decision environments. Given our setup with two time periods, Ely et al. (2015) show that the lottery which maximizes suspense is the interior lottery $(0.5, 0.15, 0.85)$, and the lottery which maximizes surprise is the interior lottery $(0.5, 0.25, 0.75)$.[32]

Given an exact definition of suspense, $(0.5, 0.15, 0.85)$, we find that no subject in either treatment chooses

[31] These models were primarily designed to analyze situations like sports games and mystery novels where we might expect individuals to have a strong preference for suspense and/or surprise. We can apply these models to our lottery environment, but do not believe this was intended to be their primary application.

[32] The suspense-maximizing lottery was available in Sets 1–3 and 7–9. The surprise-maximizing lottery was available in all Sets.

the suspense-maximizing lottery. If we allow for some noise around the maximum, and consider any lottery with $q \in (0.10, 0.20)$ and $r \in (0.80, 0.90)$, we find that 6% of intermediate Lottery choices and 8% of intermediate Information choices in the unrestriced set maximize suspense ($p = 0.74$). Turning to surprise, with an exact definition of $(0.5, 0.25, 0.75)$, we find 2% of intermediate Lottery choices and 8% of intermediate Information choices maximize surprise ($p = 0.20$). With a less restrictive definition of $q \in (0.20, 0.30)$ and $r \in (0.70, 0.80)$, this increases to 4% and 11%, respectively ($p = 0.24$). Overall, under our more generous definitions, 10% of intermediate Lottery choices and 19% of intermediate Information choices maximize suspense or surprise (between-treatment difference $p = 0.27$).[33] This accounts for a non-trivial proportion of the intermediate choices we see in the unrestricted set.

While we don't find overwhelming evidence for the specific predictions of the suspense and surprise models, we do find a high proportion of intermediate choices. In general, gradual resolution of uncertainty is more suspenseful and more surprising than one-shot resolution, so our results seem more in line with these motivations than with resolving uncertainty all at once. The hypothetical questions between Stage 1 and Stage 2 resolution give further suggestive evidence. We asked subjects to rate, on a scale from 1–7, how much they enjoyed mystery novels. We find those choosing gradual resolution in the Information treatment report higher enjoyment of mystery novels compared to those choosing one-shot resolution, an average rating of 5.47 vs. 4.57 ($p = 0.029$). Results are directionally similar in the Lottery treatment, though the difference is not significant (5.38 vs. 5.29, $p = 0.84$).

F. Skewness

Briefly, we analyze any differences in skewed choices across treatments. Our experiment allowed for subjects to choose skewed lotteries or information structures, but our design is not optimal for for capturing these preferences. In particular, experimental evidence (Masatlioglu et al., 2017) has found that individuals prefer early resolution, but choose positive over negative skew among equally informative signals. We would not be able to detect this in our experiment since these individuals would always choose the earliest resolution available in the budget set.

As a result, we focus on individuals who chose skewed, gradually resolving lotteries, when the symmetric-but-oppositely-skewed gradually resolving lottery was available in the budget set. We consider an individual to choose a positively skewed lottery when he could have chosen the symmetric and equally-informative negatively skewed lottery, and vice versa. This focuses our analysis on interior choices which do not lie on the

[33] All subjects categorized as choosing the suspense- or surprise-maximizing lottery under either definition express a positive willingness to pay on one of the price list questions. Thus, it is not the case that these subjects are simply choosing randomly and happened to choose an interior lottery corresponding to high suspense or surprise. These subjects have strict preference over information and reveal that their optimal choice is an interior lottery with high suspense or surprise.

diagonal.

	Lotteries	Information	p-value
Set 1	48.84%	45.83%	0.815
Set 4	35.48%	30%	0.754
Set 5	57.57%	70.83%	0.310
Set 6	15%	14.81%	0.984
Set 7	47.17%	72.22%	0.0197
Set 8	31.43%	25%	0.563
Set 9	33.33%	43.24%	0.399

Table XI: Percentage of subjects expressing choice of positively skewed lottery or information structure.

Table XI reports the percentage of individuals in this subset who choose positively skewed lotteries or information structures, with the remaining percentage choosing negative skew. We don't see any stark patterns. The prevalence of positive versus negative skew depends on the specific set, with most treatment differences insignificant. Overall, we don't see strong skewness preferences among this restricted sample.

Finally, we look to see whether early and late resolution are more attractive when the earliest resolution is positively or negatively skewed. We find that 11% of subjects in the Lottery treatment choose the earliest resolution when it's negatively skewed, compared to 5% when it's positively skewed (p=0.103). While the difference is not statistically significant at conventional levels, it suggests that negative skew makes early resolution more attractive in the Lottery treatment. This is consistent with the willingness to pay data, as individuals in the Lottery treatment were more likely to pay for negative over positive skew. On the other hand, we've seen that individuals have a stronger preference for late resolution in the Lottery treatment, and this does not interact with lottery skewness. 9% choose the latest resolving lottery both when it's negatively and positively skewed.

In the Information treatment, 25% of individuals choose the most informative information structure when it's negatively skewed compared to 26% who choose the most informative positively skewed information structure. 0% choose the least informative information structure when it's negatively skewed and 2% choose the least informative information structure when it's positively skewed. Overall, we find little differences in choices as they interact with skewness. This is, however, consistent with results from Masatlioglu et al. (2017). They find that individuals prefer positively skewed information compared to negatively skewed information that is equally informative, but the preference for early resolution dominates. This leaves open questions for future research to address when and where preferences for skewed information dominate preferences for early resolution.

G. Determinants of Preferences

Recall that, in Part 2 of the experiment, we elicited various measures of risk and time preferences following procedures in Dean and Ortoleva (2019). The elicited characteristics and their measurements are summarized in Table XII. We look to see whether choices of early, late, and one-shot resolution are correlated with individual measures of risk and time preferences.

Characteristic	Measurement
Discount Rate	Value x in 5 weeks indifferent to \$6 in 6 weeks, as a percentage of 6
Discount Rate (Present)	Value y today indifferent to \$6 in 1 week, as a percentage of 6
Present Bias	$(x-y)/6$
Risk Aversion	3 minus the certainty equivalent of lottery $(\$6,0.5;\$0)$, as a percentage of 3
Common Consequence	Difference between z, such that \$4 for sure is indifferent to $(\$4,0.89;\$x,0.1;\$0)$, and y, such that $(\$4,0.11;\$0)$ is indifferent to $(\$y,0.10;\$0)$, as a percentage of 4
Common Ratio	Difference between z, such that \$4 for sure is indifferent to $(\$x,0.8;\$0)$ and y, such that $(\$4,0.25;\$0)$ is indifferent to $(\$y,0.2;\$0)$, as a percentage of 4

Table XII: Risk and Time Preference Elicitation

Table XIII reports correlations between these measures and the entropy informativeness of an individual's choice in the unrestricted set. We find no significant correlations in the Lottery treatment. In the Information treatment, higher informativeness is *positively* correlated with the discount rate. That is, more patient individuals choose earlier resolution (p=0.0631). This is perhaps counterintuitive if we expect that patient individuals are willing to wait for information, though most individuals in the Information treatment choose not to wait. We also find informativeness is positively correlated with the risk aversion measure in the Information treatment. Given the construct of the risk aversion measure, a higher measured value corresponds to a *lower* degree of risk aversion. This means that, in the Information treatment, individuals who are less risk averse choose earlier resolution.

	Discount Rate	**Discount Rate (Present)**	**Present Bias**	**Risk Aversion**	**C. Consequence**	**C. Ratio**
Lotteries	0.1279	-0.1495	-0.0436	-0.0918	-0.0230	-0.1096
Information	0.2186*	0.1758	-0.0858	0.2125*	0.0118	-0.0414

Table XIII: Risk and Time Preference Correlations with Entropy in the Unrestricted Set

We take this as suggestive evidence of correlations with fundamental preferences, but more research is necessary to confirm these relationships and establish a link between these preferences.

H. Testing Dillenberger (2010)

Dillenberger (2010) predicts a preference for one-shot resolution of uncertainty under the following three axioms—Time Neutrality, Recursivity, and Negative Certainty Independence (NCI). Time neutrality assumes that an individual is indifferent between one-shot early and one-shot late resolution. He does not care *when* uncertainty resolves as long as it resolves all at once. Recursivity places structure on that way an individual evaluates two-stage lotteries. It states that, in comparing two compound lotteries which differ only in the outcome of a single branch, the decision maker compares these two lotteries in the same way that he would compare the two different branches in isolation. NCI is a novel axiom introduced in Dillenberger (2010) which aims to capture common violations of independence in the form of a preference for certainty. NCI states that, if a lottery p is preferred to a sure amount x, then preferences should not change when both p and the degenerate lottery δ_x are mixed equivalently with a lottery q. That is, if x does not have enough certainty appeal to outweigh lottery p on its own, mixing both with q and thereby eliminating any certainty appeal of x should not result in δ_x being more preferred. While a rigorous test of the theory is beyond the scope of this paper, we are able to run preliminary tests of all three axioms in our design.

The price-list choices between one-shot early and one-shot late resolution allow us to test the Time Neutrality axiom. Positive willingness to pay for either one-shot early or one-shot late resolution in either treatment implies a violation of Time Neutrality.

We include one measure of Recursivity in our Part 2 elicitation. As part of our measure of risk aversion, we elicit an individual's certainty equivalent, x, of the lottery $p = (\$6, 0.5; \$0)$. We add a nominal payment to x, $y = x + 0.75$, such that the degenerate lottery $\delta_y \succ p$. Recursivity requires that, in evaluating any two compound lotteries that differ only in that one gives δ_y at some branch while the other gives p, the lottery giving δ_y should be preferred. We present subjects with the binary choice between two compound lotteries $P = \{p, 0.5; (\$5, 0.75; \$0), 0.25; (\$9, 0.25; \$0), 0.25\}$ and $Q = \{\$\delta_y, 0.5; (\$5, 0.75; \$0), 0.25; (\$9, 0.25; \$0), 0.25\}$. These lotteries differ only at a single branch— P gives p with probability 0.5 while Q instead gives δ_y with probability 0.5. A choice of P over Q implies a violation of Recursivity.

We also include one coarse test of NCI as part of the elicitation in Part 2. We elicit an individual's certainty equivalent, x, of the lottery $p = (\$6, 0.5; \$0)$. Since $p \sim \delta_x$, we assume $p \succ \delta_{x-0.75}$. We mix both p and $\delta_{x-0.75}$ with lottery $q = (0.5, \$12; \$0)$ and offer subjects the binary choice between these two mixtures. NCI requires that $\lambda p + (1-\lambda)q \succeq \lambda \delta_{x-0.75} + (1-\lambda)q$. Thus, a choice of $\lambda \delta_{x-0.75} + (1-\lambda)q$ over $\lambda p + (1-\lambda)q$ constitutes a violation of NCI.

As described above, any positive willingness to pay in the one-shot price list constitutes a violation of the axiom. Table X reports 41% of subjects violate Time Neutrality over lotteries, and 49% violate time neutrality over information structures. 51% of subjects violate the test of NCI, and 18% violate the test of Recursivity. This leaves us with 31% of subjects in the Lottery treatment and only 14% of subjects in the Information treatment who do not violate at least one of the axioms from Dillenberger (2010).

This leaves a small subset on which Dillenberger (2010) makes predictions for one-shot resolution of uncertainty. Even still, we don't find confirmation of the prediction. Of the subjects in the Lottery treatment who satisfy Time Neutrality, Recursivity, and NCI, only 31% choose one-shot resolution in the unrestricted set, compared to 23% who do not satisfy all three axioms (Fisher's exact $p = 0.73$). Of the subjects in the Information treatment who satisfy the axioms, only 30% choose one-shot resolution compared to 49% who do not satisfy the axioms (Fisher's exact $p = 0.32$). This echos our general finding of the lack of preference for one-shot resolution of uncertainty, even on the smaller subset for which Dillenberger (2010) makes predictions.

I. Incentive Compatibility

Subjects made choices in 9 different Lottery sets, and additionally answered questions for 3 different price list scenarios, each of which contained 21 questions. We randomly selected one of these for payment.[34] Azrieli et al. (2018) show that this random problem selection mechanism elicits true preferences in each question under a monotonicity assumption. However, the process of randomly selecting a scenario to implement creates an additional stage of the lottery, a "stage 0" before the chosen two-stage lottery plays out. A subject who prefers one-shot resolution has no option to resolve all uncertainty in one of the stages of this "three-stage" lottery. If subjects view the random problem selection mechanism as part of the lottery, this could critically influence the exact preferences we are trying to study.

We run a control treatment with 40 subjects, where subjects choose their most preferred lottery from *only* the unrestricted set. Here, a subject with a strict preference for one-shot resolution can guarantee this by choosing one-shot early or late in the single choice set. We compare the proportion of one-shot choices in the control treatment to those in the main experiment. If subjects in the main experiment integrate the payment mechanism into the lottery and view it as a three-stage lottery, therefore unable to resolve all uncertainty in one stage, we would expect a lower proportion of one-shot choices than in the control treatment where they can resolve uncertainty in a single stage.

We find no difference in frequency of one-shot choices between the control and main treatments. In the Lottery treatment, 32% of subjects choose one-shot resolution in the main experiment while 33% choose one-shot resolution in the control treatment ($p = 0.907$). In the Information treatment, 55% choose one-shot resolution

[34] To determine which scenario played out, the computer uniformly drew a random number between 1 and 12, where 1–9 corresponded to the Lottery Sets and 10–12 corresponded to the price list scenarios. If the computer drew 10–12, it would then draw a number 1–21 to determine which row of the price list to implement.

in the main treatment while 64% choose one-shot resolution in the control treatment ($p = 0.465$). We conclude that subjects do not appear to integrate the payment mechanism into the main lottery in a way that interacts with a preference for one-shot resolution.

J. Venmo Payments

Andreoni and Sprenger have recently addressed numerous concerns surrounding payments from incentivized intertemporal choice questions (Andreoni and Sprenger, 2012a,b). In particular, choices between payments "now" and payments in the future require transaction costs to be exactly equal at both time periods. That is, subjects should not prefer payments "now" because they are more convenient, in cash compared to checks, etc.

We address this by paying all Part 2 payments through Venmo, a money transfer app. In the recruitment email, subjects were told that there is a possibility of being paid through Venmo and they must already have an account set up. Part 2 instructions indicate that a random question would be selected for payment and money would be directly transferred to them through Venmo according to their choice on that question. Both "now" and "later" payments were paid through Venmo, and subjects would receive Venmo payment regardless of whether a risk or time elicitation question were randomly selected.

Lottery Treatment

Instructions: Part 1

Welcome to our decision making study! Thank you for your participation. Please turn off and put away your cell phones, put away any books or other things you've brought with you, and please refrain from talking to other participants during the study.

Here in the Economics Experimental Lab, our research does not involve deception of any kind. You might have participated in experiments elsewhere on campus where that was not the case, but it will always be true here. What this means is that, in this Lab, we will provide you with all relevant information and we will be truthful. The instructions accurately reflect how decisions and processes will unfold. We will not deceive or lie to you in any way.

This study will take approximately 90 minutes. You will receive $10 for showing up on time. In addition to this "show up payment," you may earn additional money throughout the study. Your earnings may depend on your decisions and on elements of chance.

There are two separate "Parts" to this experiment, and each Part has multiple Tasks. These instructions are for Part 1. Part 2 will take place after Part 1 is finished. Your decisions in Part 1 will not in any way affect your decisions or payoffs in Part 2.

Task 1: Lotteries

The Lottery

Your earnings from Part 1 will be determined by the outcome of a lottery which will take place in two steps. We will represent the lottery as drawing a ball from an urn.

- There are 2 possible urns the ball could be drawn from, Urn 1 and Urn 2.
- Each urn will have some balls in it, and the balls can be either red or blue.
- In Step 1 of the lottery, we will pick either Urn 1 or Urn 2.
- In Step 2 of the lottery, we will draw a ball from the selected urn.
- Step 2 will not occur immediately after Step 1 – some time will pass in between (more on this below)

Payoffs

The color of the chosen ball will determine your payoff from the lottery.

- If the ball drawn from the urn is red, you will receive the high prize -- $11.
- If the ball drawn from the urn is blue, you will receive the low prize -- $2.

Overall Odds

Overall, there is a 50% chance that a red ball will be drawn and a 50% chance that a blue ball will be drawn. This means that there's a 50% chance you will earn the high prize and a 50% chance you will earn the low prize.

Your Choice

There are many different possible lotteries that can be played, all with the same Overall Odds. You will be choosing the lottery that you want to participate in. All the available lotteries have the same Overall Odds and same Payoffs. Essentially, you will decide how many balls of each color you would like in Urn 1 and Urn 2, and you will determine the probability of choosing Urn 1 and Urn 2 in Step 1 of the lottery.

Choosing Lotteries

Every lottery will have the same Overall Odds, 50% chance of drawing a red ball and 50% chance of drawing a blue ball. However, there are many possible lotteries that have the same Overall Odds. There are three things that determine a lottery, and you will be choosing these three things –

1. The fraction of red and blue balls in Urn 1
2. The fraction of red and blue balls in Urn 2
3. The likelihood of selecting Urn 1 vs. Urn 2

When you make your decisions, your screen will have three "sliders" on it. The slider on top determines the likelihood of choosing Urn 1 vs. Urn 2. The bottom left slider determines the fraction of red and blue balls in Urn 1, and the bottom right slider determines the fraction of red and blue balls in Urn 2.

On your screen, you'll also see three "Auto" buttons, one corresponding to each slider. You must put exactly one slider on "Auto" at all times. You can put any of the three sliders on Auto, and then you can adjust the other two in any way you want. This way, the computer will automatically adjust the Auto slider in order to maintain the Overall Odds. We'll go through some examples in a minute to give you an idea how the computer interface works.

Lottery Details

The first important thing to realize is that the Overall Odds of drawing a red ball or a blue ball **does not change** when you make your decisions or adjust the sliders. No matter which lottery you choose, overall there is a 50% chance of drawing a red ball and a 50% chance of drawing a blue ball.

- When you choose your most preferred lottery, you are choosing how you want the odds to be determined in Step 1 relative to Step 2.
- For example, in Lottery 4 in the table, the outcome is ultimately determined in Step 1, since after the Urn is selected the outcome is known. You will either know for sure that we will draw a red ball and you will earn \$11, or you will know for sure that we will draw a blue ball and you will earn \$2.
- On the other hand, in Lottery 1 above, you will know after drawing Urn 1 or Urn 2 that you still have a 50% chance of drawing a red ball and a 50% chance of drawing a blue ball.

- For Lotteries 2 and 3, the outcome is determined partially in Step 1 and partially in Step 2, since the chosen Urn will have a higher or lower fraction of red (blue) balls than the Overall Odds, but there is still a chance of drawing a red (blue) ball from either Urn.
- You are choosing how to spread the odds across Step 1 and Step 2, which is also like choosing what you want Step 1 to tell you about your chances of drawing a red (blue) ball later.

Another important thing to realize is that it can't be the case where both Urns have more than 50% red balls and it also can't be the case where both Urns have fewer than 50% red balls.

- It has to be that one Urn has more than or equal to 50% red balls, but the other Urn has less than or equal to 50% red balls. This way, the Urns will "average" out to equal a 50% chance of drawing a red ball.
- The computer will only allow you to choose options that satisfy these conditions. Urn 1 will have fewer than 50% red balls and Urn 2 will have more than 50% red balls.

Restrictions

You'll be choosing your most preferred lottery under various conditions which we will call "scenarios." Remember, your most preferred lottery is determined by (i) The fraction of red and blue balls in Urn 1, (ii) The fraction of red and blue balls in Urn 2, and (iii) The likelihood of selecting Urn 1 vs. Urn 2.

- In some scenarios, the computer might place "restrictions" on one or more of these things.
- For example, the computer might require that Urn 1 contains at least 10% red balls, or that Urn 2 contains no more than 80% red balls.

Preferences

There are no right or wrong answers in any of these scenarios. We are simply interested in your preferences, so please consider the options carefully and choose the one lottery you most prefer in each scenario. In fact, you should answer each question as if it will directly determine your Part 1 earnings, since one of the scenarios will. If you don't answer according to your actual preferences, you might end up with something you prefer less than another available option.

Experiment Timing

Task 1

Part a:

You will have the chance to participate in a practice lottery, so you can get used to how the computer sliders work, how to pick your preferred lotteries, etc. As you're getting familiar with the task, we will also ask you a few comprehension questions.

Part b:

Next, you'll participate in the Lottery Task described above. You will choose your most preferred lottery from 12 different scenarios. These scenarios might differ in the restrictions that the computer places on the Urns.

Part c:

After you make all your decisions, we will determine which of the 12 scenarios will actually play out. We'll do this in the following way. The computer will randomly draw a number 1-12. Each number is equally likely to be drawn. The number chosen will correspond to the scenario that will play out. You will participate in whatever lottery you chose as your preferred lottery in that scenario.

Part d:

Now that the lottery has been selected, we will determine whether the ball will be drawn from Urn 1 or Urn 2 according to the probabilities <u>you have chosen</u> in your preferred lottery.

How will we do that? Here is an example. Let's say, in your most preferred lottery, Urn 1 will be chosen with 35% chance and Urn 2 will be chosen with 65% chance.

- The computer will randomly draw a number 1-100. Each number is equally likely to be drawn.
- If the number drawn is less than or equal to 35, Urn 1 will be chosen.
- If the number drawn is greater than 35, Urn 2 will be chosen.

Task 2 and 3

After we select the Urn, you will participate in Tasks 2 and 3 of the experiment. This means that, after Part d, you will be told which Urn has been chosen and you will be reminded the proportion of red and blue in that Urn. <u>But we will not randomly draw a ball from the Urn until the very end of Part 1</u>. So when you participate in Tasks 2 and 3, you will know the Urn that will eventually determine your payoffs from Part 1, but we will not draw a ball to determine the lottery outcome until the end of Tasks 2 and 3. Tasks 2 and 3 will take about 30 minutes, so you will be waiting for those 30 minutes to learn the outcome of the lottery.

Task 2: Coloring

After you have been notified which Urn the ball will be drawn from, you'll participate in Task 2. In Task 2, you will use the computer to "color" a representation of your chosen Urn.

More detailed instructions on the coloring task will follow.

Task 3: Questions

We will also ask you various other questions about lotteries and your choices. These questions will be hypothetical, to test your understanding of the lotteries and ask you questions about your preferences.

Remember, the actual Urn determining your payoffs will have already been chosen, but we will not have selected a ball yet to determine your payoffs.

Lottery Outcome

After Task 3, we will determine the actual outcome of the lottery. We will randomly choose a number 1-100. You've colored the 100 balls in your urn in Task 2, so the random number drawn corresponds to one of the colored balls.

If the number drawn corresponds to a ball you've colored red, you will earn the high prize of $11. If it's blue, you will earn the low prize of $2.

Part 2

After the outcome is revealed and Part 1 is finished, you will receive the instructions for Part 2, which is a short additional "bonus" task. Your decisions in Part 1 will not in any way affect your decisions or payoffs in Part 2. The two parts are completely independent.

Information Treatment

Instructions: Part 1

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This study will take approximately 90 minutes. You will receive $10 for showing up on time. In addition to this "show up payment," you may earn additional money throughout the study. Your earnings may depend on your decisions and on elements of chance.

There are two separate "Parts" to this experiment, and each Part has multiple Tasks. These instructions are for Part 1. Part 2 will take place after Part 1 is finished. Your decisions in Part 1 will not in any way affect your decisions or payoffs in Part 2.

Task 1: Signals

The Lottery

Your earnings from Part 1 will be determined by the outcome of a lottery. At the beginning of the experiment, the computer will draw a random number between 1 and 100. Each number is equally likely to be drawn. If the computer draws 1-50, you will win the "low prize." If the computer draws 51-100, you will win the "high prize." This means there's a 50% chance you've won the high prize and a 50% chance you've won the low prize.

You will receive information about the outcome of the lottery in two steps. The computer won't reveal the number drawn, so you won't learn the outcome of the lottery immediately. However, you can receive some earlier information about the outcome, which we'll call a "signal." So the first step in learning the outcome of the lottery is the information in the signal you will receive. In the second step, you'll learn the final outcome.

Payoffs

The randomly selected number will determine your payoff from the lottery.

- If you win the high prize, you'll earn $11.
- If you win the low prize, you'll earn $2.

Overall Odds

Overall, there is a 50% chance of winning the high prize and a 50% chance of winning the low prize. Note that the chance of winning and losing is equal for everyone. This means there's a 50% chance you'll earn $11 from the lottery and a 50% chance you'll earn $2.

Your Choice

There are many possible signals that you could receive to get information about the outcome of the lottery. You will be choosing the signal that you want to receive. The type of signal that you receive does not change the Overall Odds or the likelihood of receiving the high prize or the low prize. You will choose the type of information you want to receive about the outcome of the lottery.

Choosing Signals

Though you will not learn the lottery outcome immediately, the computer will know whether you've won the high prize or the low prize. As a result, the computer can give you a "signal" about the outcome. The signal is just a piece of information that might tell you more about whether you've won the high or low prize. You will choose the kind of signal you want.

The amount and type of information varies across these signals. You will pick your most preferred information option from all of these possibilities. So you will get to determine the type of information you'd like the signal to tell you about the outcome of the lottery.

You'll do that in the following way. There are two "Urns," Urn 1 and Urn 2. You can visualize them as being filled with red and/or blue balls. The computer will randomly pick one ball from one of the Urns; this selected ball is the "signal" you will see. The computer will show you a ball from Urn 1 if you've won the low prize, and it will show you a ball from Urn 2 if you've won the high prize. You won't learn which Urn the ball was drawn from; you'll just see the ball color.

Each possible signal you get is determined by three things:

1. The likelihood of seeing a red or blue signal
2. The chance that you've won the high prize, given that you see a blue signal
3. The chance that you've won the high prize, given that you see a red signal

You'll be choosing these three things. When you make your decisions, your screen will have three "sliders" on it. The slider on top determines the likelihood of seeing a red or blue signal. The bottom left slider determines the chance that you've won the high prize, given that you see a blue signal, and the bottom right slider determines the chance that you've won the high prize, given that you see a red signal.

On your screen, you'll also see three "Auto" buttons, one corresponding to each slider. You must put exactly one slider on "Auto" at all times. You can put any of the three sliders on Auto, and then you can adjust the other two in any way you want. This way, the computer will automatically adjust the Auto slider in order to maintain the Overall Odds. We'll go through some examples in a minute to give you an idea how the computer interface works.

Lottery Details

- The first important thing to realize is that the likelihood of winning the high prize or low prize **does not change** when you make your decisions or adjust the sliders. No matter what type of information you choose, there is a 50% chance of winning the high prize and a 50% chance of winning the low prize. No information choices affect the number that the computer draws to determine whether you win the high or low prize.

- When you choose your information, you are choosing what you want to learn from the signal you see.
- For example, in Information 4 in the table shown, the signal tells you for sure whether you've won the high or low prize.
- On the other hand, in Information 1 shown, the signal does not give you any information about the lottery outcome. You will know that there is a 50% chance you've won the high prize and a 50% chance you've won the low prize, regardless of the signal you see.
- For Lotteries 2 and 3, the signals give you some, but not all, information about whether you've won the high or low prize.

Another important thing to note is that the computer is set up so that there will always be a less than or equal to 50% chance you've won the high prize if you see a blue ball and a greater than or equal to 50% chance you've won the high prize if you see a red ball.

- This ensures that, if you see a red ball as your signal, it's more likely to have come from Urn 2, which means it's more likely that you've won the high prize.
- Thus, seeing a red ball means that your chances of having won the high prize are either equal to or higher than 50%, and seeing a blue ball means that your chances are either equal to or lower than 50%.
- How much your chances of having won changes after you see a red or blue ball depends on the contents of the Urns.

Restrictions

You'll be choosing your Information under various conditions which we will call "scenarios." Remember, your information is determined by (i) The likelihood of seeing a red or blue signal, (ii) The chance that you've won the high prize, given that you see a blue signal, and (iii) The chance that you've won the high prize, given that you see a red signal.

- In some scenarios, the computer might place "restrictions" on one or more of these things.
- For example, the computer might require that there's no more than a 20% chance you've won the high prize, given that you see a blue signal.

Preferences

There are no right or wrong answers in any of these scenarios. We are simply interested in your preferences, so please consider the options carefully and choose the one lottery you most prefer in each scenario. In fact, you should answer each question as if it will directly determine your Part 1 earnings, since one of the scenarios will. If you don't answer according to your actual preferences, you might end up with something you prefer less than another available option.

Experiment Timing

Task 1

Part a:

You will have the chance to participate in a practice scenario, so you can get used to how the computer sliders work, how to pick your preferred signals, etc. As you're getting familiar with the task, we will also ask you a few comprehension questions.

Part b:

Next, you'll participate in the Task described above. You will choose your information from 9 different scenarios. These scenarios might differ in the restrictions that the computer places on the Urns.

Part c:

After you make all your decisions, we will determine which of the 9 scenarios will actually play out. We'll do this in the following way. The computer will randomly draw a number 1-9. Each number is equally likely to be drawn. The number chosen will correspond to the scenario that will play out. You will receive a signal according to how you chose in that scenario.

Part d:

Now that the information has been selected, you will see a signal according to the information <u>you have chosen</u> in that scenario. Here's how that works.

Let's say you've decided to make Urn 1 30% red balls and make Urn 2 80% red balls. If you've won the high prize, the computer will draw a ball from Urn 2, in which case there's an 80% chance you'll see a red ball as your signal. If you've won the low prize, the computer will draw a ball from Urn 1, in which case there's a 30% chance you'll see a red ball.

You will only see the signal, but the computer will tell you how likely it is that you've won the high prize or the low prize, given the signal you see.

Task 2 and 3

After you see the signal, you will participate in Tasks 2 and 3 of the experiment. This means that, after Part d, you will know the information from the signal, <u>but we will not tell you whether you've won the high or low prize until the very end of Part 1</u>. So when you participate in Tasks 2 and 3, you will know the information from the signal, but you won't learn anything else about the lottery outcome until the end of Tasks 2 and 3. Tasks 2 and 3 will take about 30 minutes, so you'll be waiting for those 30 minutes to learn the outcome of the lottery.

Task 2: Coloring

After you see your signal, you'll participate in Task 2. In Task 2, you will use the computer to "color" a representation of how likely it is that you've won the high prize or the low prize.

On your computer, you will see 100 circles labeled 1-100. You will color them red or blue according to the information from your signal. For example, imagine that you see a blue signal, and according to the information you've chosen, this means that there's a 30% chance you've won the high prize and a 70% chance you've won the low prize. In task 2, you would color balls 1-30 red and 31-100 blue. The computer will not allow you to color the balls in any other way. This is just to create a visual for yourself of your chances of winning the prizes.

More detailed instructions on the coloring task will follow.

Task 3: Questions

Task 3 will present you with various possible information specifications and we will ask you to answer various questions. These questions will be hypothetical. Please read the questions carefully before answering, and raise your hand with any questions.

Remember, it will have already been decided whether you've won the high prize or the low prize, and you will have already seen your signal. However, we will tell you the lottery outcome at the very end of Task 1.

Lottery Outcome

After Task 3, we will tell you the actual outcome of the lottery. The computer will reveal whether you won the high or low prize.

Part 2

After the outcome is revealed and Part 1 is finished, you will receive the instructions for Part 2, which is a short additional "bonus" task. Your decisions in Part 1 will not in any way affect your decisions or payoffs in Part 2. The two parts are completely independent.

Instructions: Part 2

In this final Part, you will be asked to answer a number of questions. The questions all take a similar format, but each is unique. At the end of the experiment, one question will be selected at random from all of the questions you answered. The amount of money you will earn from this Task will depend on your answers to this question.

Any earnings you receive in this part will be paid to you directly through Venmo.

Most questions will take the form of lists of choices. There will be multiple choices within one "Decision Stage." For example, Decision Stage 1 might ask you to choose between receiving some amount of money (say $6) in one week's time, or different amounts of money now. In such a case, Question 1 would look like this:

$6 in 1 week	$0.50 today
$6 in 1 week	$1 today
$6 in 1 week	$1.50 today
$6 in 1 week	$2 today
$6 in 1 week	$2.50 today
$6 in 1 week	$3 today
$6 in 1 week	$3.50 today
$6 in 1 week	$4 today
$6 in 1 week	$4.50 today
$6 in 1 week	$5 today
$6 in 1 week	$5.50 today
$6 in 1 week	$6 today
$6 in 1 week	$6.50 today

This Decision Stage is actually asking you 13 different questions, one for each row. For each row, you must choose between the option on the left or the option on the right. Note that on each line, the option on the left stays the same in each row while the option on the right increases as you go down the list.

In each row, you select the option you like by clicking the box next to that option.

If Decision Stage 1 were selected as the one that will be paid at the end of the experiment, ONE row will be selected at random from those in Decision Stage 1 and you will be paid according to your choice on that row. That is, if Decision Stage 1 were selected, a row would be randomly chosen between the first row ($6 in 1 week vs. $0 today) and the last row ($6 in 1 week vs. $6 today) with equal probability. Let's say, for example, the second row were chosen. Then your payment for this Task of the experiment would depend on your choice in the second row. If you had chosen "$6 in 1 week", then that is what you would receive -- $6 transferred to you through VenMo, one week from today. If you had chosen "$0.50 today", then that is what you would receive -- $0.50 transferred to your VenMo account today, immediately after the experiment.

At the start, all boxes will be unchecked. You must check exactly one box in each row. You can change your answer anytime before submitting. Most people start out preferring Option A and then may or may not switch over to preferring Option B. If you switch to Option B, you should not switch back to preferring Option A in later rows.

There are no right or wrong answers to any of these questions. We are simply interested in your preferences, so please consider the options carefully and answer according to what you prefer. In fact, you should answer each question as if it will directly determine your Part 2 earnings, since one of the rows will. If you don't answer according to your actual preferences, you might end up with something you prefer less than the other available option.

There are a few different types of these questions that we will ask, so we will go through them now in a little more detail.

Future Questions:
In this section, you will be asked questions about amounts of money that you may receive in the future. In particular, these questions will concern amounts of money that you may receive after some time delay -- for example, it might be that you receive $10 in 5 weeks.

The amount of money will always be transferred through VenMo directly to you at the date specified. So in the example above, if you were to receive $10 in 5 weeks, we would directly transfer $10 into your VenMo account, 5 weeks from today.

All payments are guaranteed to arrive, certified by the Ohio State Experimental Economics Laboratory. If the question selected involves future payments, I will schedule the payment transfer before you leave the lab today. This way, you can ensure your payment will arrive exactly when I say it will. You have received a slip of paper with my personal phone number and email address on it. Keep this. If, for some reason, you do not receive your payment at the scheduled time, you can call/text/email me and receive payment immediately.

Lottery Questions:

For this questions, you will be asked questions about amounts of money that might be determined by a "lottery." All this means is that there is some chance you will receive a given amount. For example, it might be that you have a 75% chance of receiving $10 and a 25% chance of receiving $2.

If one of these questions is chosen for payment, you will receive the amount determined by the lottery. You will receive the payment today through VenMo.

To help understand the lotteries, here's an example. Imagine a lottery that gives you a 75% chance of receiving $10 and a 25% chance of receiving $2. The computer will draw a random number to determine the lottery outcome. You can think of this in the following way. Imagine there are 100 balls, numbered 1-100, and we're going to randomly draw one of them to determine the lottery outcome. A 75% chance of receiving $10 means that if we draw ball number 1-75, you would earn $10. If we draw 76-100, you would earn $2. Since there are 75 out of 100 balls numbered 1-75, this is exactly a 75% chance of earning $10. There are 25 balls numbered 76-100, so this is a 25% chance of earning $2.

Here is an example of what questions in this section could look like. Remember, you are making a choice for EACH row, and one of the rows could be selected and you will be paid based on your answer in that row:

75% chance of $10, 25% chance of $2	100% chance of $5
75% chance of $10, 25% chance of $2	100% chance of $5.50
75% chance of $10, 25% chance of $2	100% chance of $6
75% chance of $10, 25% chance of $2	100% chance of $6.50
75% chance of $10, 25% chance of $2	100% chance of $7
75% chance of $10, 25% chance of $2	100% chance of $7.50
75% chance of $10, 25% chance of $2	100% chance of $8
75% chance of $10, 25% chance of $2	100% chance of $8.50
75% chance of $10, 25% chance of $2	100% chance of $9
75% chance of $10, 25% chance of $2	100% chance of $9.50
75% chance of $10, 25% chance of $2	100% chance of $10
75% chance of $10, 25% chance of $2	100% chance of $10.50
75% chance of $10, 25% chance of $2	100% chance of $11

Multi-Stage Lottery Questions:

For these questions, you will be asked questions about amounts of money that might be determined by a "lottery." These are similar to the Lottery Questions we just discussed, but the lotteries might have multiple stages. For example, it might be that there is a 50% chance of playing Lottery 1 and a 50% chance of playing Lottery 2, where Lottery 1 gives you a 50% chance of winning $10 and a 50% chance of winning $2 while Lottery 2 gives you a 75% chance of winning $10 and a 25% chance of winning $2.

In this example given above, the computer would first draw a random number 1-100. If the number is 1-50, you would play Lottery 1. If it's 51-100, you would play Lottery 2.

Let's imagine the computer drew number 74, so you're playing Lottery 2. Lottery 2 gives you a 75% chance of winning $10 and a 25% chance of winning $2. So the computer would draw another random number, totally independent from the first number. This is just any number 1-100. If the number is 1-75, you would win $10. If it's 76-100, you would win $2.

This type of question would look like this:

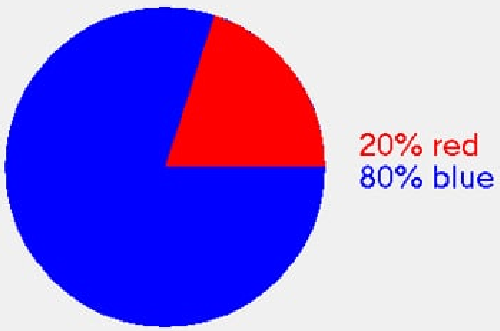
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $5
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $5.50
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $6
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $6.50
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $7
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $7.50
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $8
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $8.50
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $9
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $9.50
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $10
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $10.50
50% chance Lottery 1, 50% chance Lottery 2	100% chance of $11

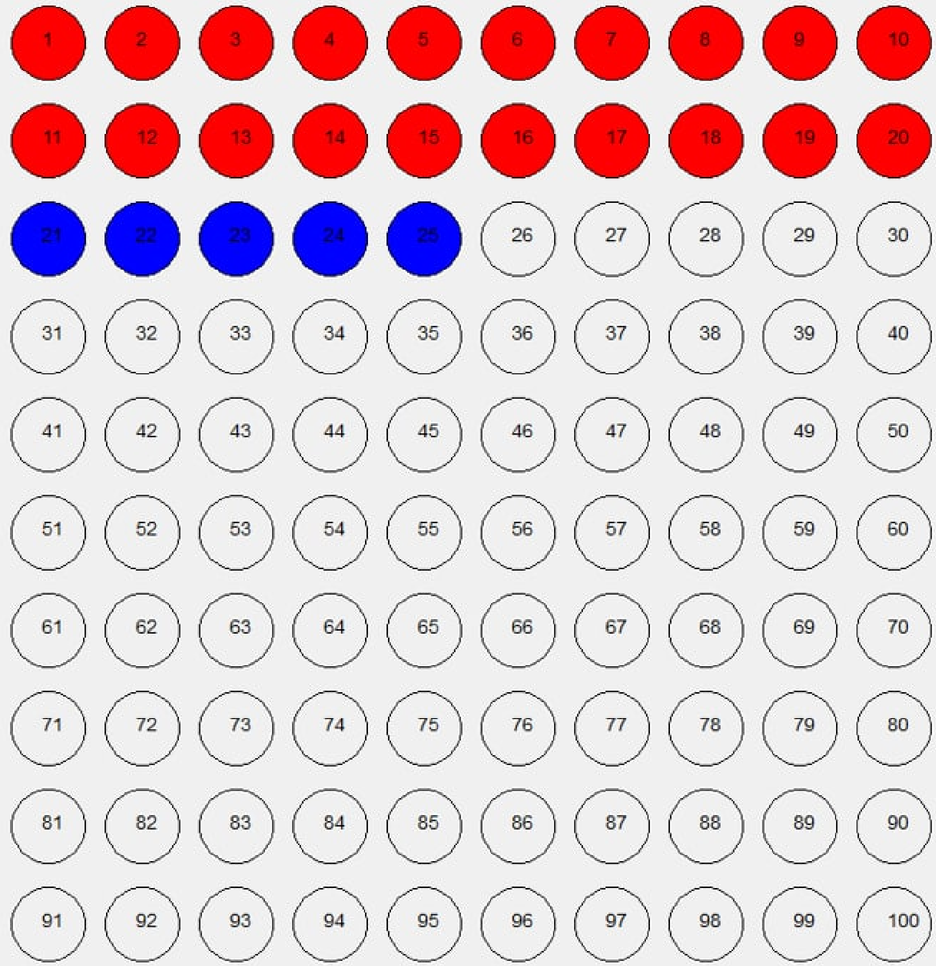
Again, there are no right or wrong answers to any of these questions. We are simply interested in studying your preferences, so please take your time to consider the options and choose which you prefer.


Remaining Time: 115
Lottery 1:
Overall Odds:
(50% red, 50% blue)
Urn 1 will be chosen with probability 63
Urn 2 will be chosen with probability 37
AUTO
RESET
0
100
Urn 1
AUTO
Urn 2
AUTO
0
50
50
100
32% red
68% blue
81% red
19% blue
Done

Remaining Time: 278

Urn 1





The balls numbered less than or equal to 20 are RED, and the balls colored greater than 20 are colored BLUE .

Done