A Note on "When Are Decisions Improvable? An Evaluation of Diagnostic Methods"*

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Abstract

Bernheim, Lucia, Nielsen, and Sprenger (2026) study cognitive uncertainty (*CU*) in binary lottery choice. They argue that experimental subjects misunderstand the elicitation of *CU*—which asks them to report the likelihood that they made the best decision for themselves—as instead asking about the presence of ex-post outcome (payoff) uncertainty. We replicate and amend their survey to disambiguate the interpretation of their results. Subjects may either misconstrue the *CU* elicitation as asking about the presence of outcome uncertainty, or they may report uncertainty about their best decision—in line with the intended meaning of the question—because the presence of outcome uncertainty makes the choice subjectively difficult. Our results strongly support the latter interpretation. This conclusion is reinforced by a review of the literature and by an analysis of large-scale data on choice inconsistencies, both of which show that cognitive difficulty increases with the presence and magnitude of outcome uncertainty. We further discuss Bernheim et al.'s evaluation of *CU* as a mistake-detection technology. First, classic review papers emphasize that subjective confidence is often miscalibrated. Second, Bernheim et al. correlate *CU* with phenomena—small-stakes risk aversion and the common-ratio effect—whose interpretation as mistakes remains contested. We propose an interpretational middle ground: correlations between *CU* and behavioral anomalies may reflect neither mistakes nor non-standard preferences, but rather imperfect information.

1 Cognitive Uncertainty

In our prior work, cognitive uncertainty (*CU*) is defined as people's uncertainty about their best ex-ante decision, given whatever preferences they have (Enke and Graeber, 2023; Enke et al., 2024, 2025). Such uncertainty could have multiple potential origins, including preference uncertainty, uncertainty about how to aggregate problem components into a choice, and others. Introspection provides a simple initial motivation: most people can readily identify economic decisions in which they are uncertain about their best course of action. For instance, we ourselves are not fully certain about what our expected-utility-maximizing equity share is, trading off expected return and risk. Similarly, we are not fully certain that our health insurance plans are actually the best ones from an ex-ante perspective, given our risk profiles, preferences and information.

CU appears to be present not only in high-dimensional field decisions but also in lab experiments. For example, we are not fully certain that we can specify what exactly our certainty equivalents for a lottery are that pays \$80 with probability 75% and nothing otherwise (are you?). Perhaps as a result, multiple authors have measured *CU* or related constructs in experiments or surveys (e.g., Butler and Loomes, 2007; Cubitt et al., 2015; Arts et al., 2024; de Clippel et al., 2024; Yang, 2023; Shubatt and Yang, 2024; Augenblick et al., 2025; Musolff and Zimmermann, 2025).

This note concerns contexts in which experimental subjects choose between a safe payment and a risky, binary lottery. In this context, *CU* is measured as follows (Enke et al., 2024). After subjects make a choice, they are asked: "*How certain are you that choosing X is actually your best decision, given your preferences and the available information?*" Subjects respond by navigating a slider (or selecting a radio button) that specifies a percent chance. Subjects are instructed on the meaning of the question. To check that they correctly understand the question as asking about their best ex-ante decision rather than about the ex-post outcome uncertainty inherent in the binary lottery, subjects need to pass the following comprehension check: "Which one of the following statements is true? (a) When I'm asked to indicate my certainty about my decision, the people running this study are interested in how certain I am that the decision I made is actually my best decision, given my personal preferences and the available information. (b) When I'm asked to indicate my certainty about my decision, the people running this study are interested in how certain I am that I will actually receive the money from the lottery."

2 The Study of Bernheim et al. (2026)

Bernheim et al. (2026) (henceforth BLNS) implement binary lottery choice experiments to study small-stakes risk aversion and the common-ratio effect. This note focuses on

the part of their paper that discusses *CU*. Their main objective is to test whether *CU* is a reliable indicator of improvable decisions / mistakes (we refer readers to BLNS for definitions of these concepts). BLNS's main results are twofold. First, small-stakes risk aversion and the common-ratio effect are both negatively correlated with *CU*. BLNS argue that this casts doubt on the validity of *CU*.

Second, BLNS implement a post-experimental survey to decompose *CU* into multiple potential reasons for being uncertain. The most important reason subjects select from BLNS's pre-defined menu is "Can't Know For Sure What You'll Get: You lack certainty in your decision because, based on the information you've received, you can't be sure what you will receive given your chosen option." BLNS interpret this as showing that subjects misconstrue the *CU* elicitation as asking about ex-post outcome uncertainty rather than uncertainty about one's best ex-ante decision.

We highly appreciate BLNS's interesting contribution to this line of research. To our knowledge, the literature has not proposed *CU* as a general-purpose mistake-detection technique. For instance, the abstract of the widely cited review on metacognition and confidence by Fleming (2024) notes that "Metacognitive judgments are inferential and sometimes diverge from task performance because they are informed by the observer's models of the world and their cognitive system, which may be more or less accurate."

Rather, the central empirical claims in the recent literature are (i) behavioral attenuation, i.e., a link between *CU* and an insensitivity of decisions to fundamentals (e.g., Enke and Graeber, 2023; Enke et al., 2025, 2024; Yang, 2023; Toma and Bell, 2024; Augenblick et al., 2025), and (ii) a link between *CU* and cautious behavior (e.g., de Clippel et al., 2024; Chakraborty and Henkel, 2025). We acknowledge that our own prior work may sometimes have been imprecise about whether high *CU* is necessarily indicative of objective mistakes. We should have articulated more clearly that we intended such conclusions to apply in contexts in which different independent methods provide converging evidence with *CU*. For instance, in the paper that BLNS appear to disagree with (Enke et al., 2025), we concluded that hyperbolic discounting over money is a mistake based on four independent pieces of evidence: strong correlations of hyperbolicity (i) with *CU*; (ii) with across-trial variability in repetitions of the same choice list; and (iii) with behavior in computationally similar atemporal mirror problems; as well as (iv) increased hyperbolicity under experimental complexity manipulations. While we continue to believe that this body of evidence as a whole justifies the conclusions we drew, we note that other work of ours in fact emphasizes and documents empirically that *CU* is not always linked to objective mistakes. For instance, one of the main points of Enke et al. (2023) is to document that the correlation between *CU* and cognitive biases differs widely across different tasks and is sometimes negative, with certain subjects often being objectively wrong and highly uncertain subjects being objectively correct.

Despite the consensus in psychology suggesting the opposite, we agree that BLNS's hypothesis that *CU* may be a sensible mistake-detection technique merits some attention. We also agree that it is valuable to study which precise mechanisms give rise to *CU*, though our prior work notes that these mechanisms will most likely differ across contexts and decision domains.

In this note, we briefly comment on two aspects of BLNS's paper. First, we report on a follow-up experiment using BLNS's methods that disambiguates their results on the *CU* decomposition. Our evidence suggests that subjects do not misunderstand the *CU* elicitation but, instead, report that they exhibit *CU* because the presence of outcome uncertainty makes choice subjectively difficult. In line with this interpretation, we also provide direct evidence that lottery choice appears more error-prone when outcome uncertainty is higher. Second, we briefly provide some context on the literature. We point out that BLNS's focus on the link between *CU* and small-stakes risk aversion and the common-ratio effect is notable (from the perspective of evaluating *CU* as an improvability-detection technique), as it remains an open question whether small-stakes risk aversion and / or the common-ratio effect constitute mistakes. As a result, it is not entirely clear what BLNS's correlational results imply for whether *CU* may be effective in diagnosing improvability.

3   The Decomposition of Cognitive Uncertainty

BLNS's design and results.   BLNS proceed in four steps. First, subjects are instructed on binary lottery choice problems and a *CU* elicitation. Second, they complete a series of binary choices and, for each decision, indicate their *CU* by answering the question: "How certain are you that choosing Option A/B is actually your best decision, given your preferences and the available information?" Third, subjects receive instructions on a potential decomposition of the uncertainty statements. Subjects are familiarized with eight potential reasons, including through examples. Finally, for each of three decisions, subjects are reminded of their choice and their *CU*, and are asked to rate the importance of each potential reason for why they were uncertain on a 1–7 Likert scale.

The potential reasons BLNS asked subjects to rate are:

1. Can't Know For Sure What You'll Get: You lack certainty in your decision because, based on the information you've received, you can't be sure what you will receive given your chosen option.

2. Didn't Think Carefully About What You Want: You lack certainty in your decision because you haven't thought through what you want to achieve as carefully as you could.

3. Not Sure What Each Option Means: You lack certainty in your decision because you're not sure you interpreted the available options correctly or understood their consequences.

4. Worried About Mental Shortcuts: You lack certainty in your decision because you're worried about having used a mental shortcut that might have given the wrong answer.

5. Didn't Apply Your Decision Criterion Correctly: You lack certainty in your decision because you think the criterion you decided to use and any simplifying assumptions you made may actually favor an alternative other than the alternative that you chose.

6. Multiple Views About What You Want: You lack certainty in your decision because, in your view, there's probably more than one right way to think about what you want to achieve.

7. Don't Know How You'll Feel: You lack certainty in your decision because you aren't sure how you will feel about each of the possible outcomes.

8. It's Nearly a Toss-Up: You lack certainty in your decision because you think the choice is close to a toss-up.

9. Other Reasons: You lack certainty in your decision for other reasons.

We note that BLNS's menu did not include what appears to be the perhaps most natural reason given the motivation behind the *CU* elicitation: "You lack certainty in your decision because you find it difficult to think through and determine which option you actually prefer."

BLNS's main result is that a modality of subjects rate the "Can't Know For Sure What You'll Get" reason most highly. Our discussion here centers on interpretation. We also note that BLNS's design involves a substantial time lag between stating *CU* for a given decision and the decomposition exercise, raising the question of whether the decomposition reflects the decision process at the time the choice was made.[1]

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[1]Subjects make multiple other decisions in the meantime, are instructed on an entirely new component of the study, and need to pass comprehension checks. This raises the question whether subjects even remember why they were uncertain in a particular decision 15-20 minutes ago. As a minimal plausibility test, one possible procedure might be to ask subjects to first reproduce their decision and *CU*, yet no such checks are reported in BLNS. One possibility is thus that the decomposition partly reflects subjects' post-hoc reasoning that is not informative about the decision process at the time the decision was taken.

Potential interpretations. BLNS interpret their result as documenting that subjects misconstrue the *CU* elicitation as asking about ex-post outcome uncertainty, contrary to its intended meaning. Under this interpretation, subjects asked about certainty in their best ex-ante decision would instead be reporting certainty about what payoff they would receive. Unfortunately, BLNS provide no indication as to why it should be true that subjects misunderstand the question in this particular way even though the comprehension check we designed (see Section 1) directly solicits their understanding of precisely this aspect. Neither do BLNS explain why the results of their post-experimental survey should be given greater interpretational weight than their own pre-experimental comprehension check, which presumably all subjects in their sample passed. Finally, BLNS do not address how this particular misunderstanding of the *CU* question is consistent with the robust empirical regularity that *CU* predicts strong attenuation in choices, which is exactly the pattern that imperfect-information models in which the decision maker is uncertain about their best ex-ante decision predict.

Nonetheless, we take seriously the possibility that subjects misunderstand the *CU* question in the way BLNS posit. In particular, we agree that such a misunderstanding is a potential interpretation of the specific decomposition survey BLNS implement. However, there is a second interpretation of BLNS's decomposition. This interpretation follows a long line of work on contingent reasoning and randomness in both psychology and economics: that subjects rate this reason ("uncertain because can't be sure how much you'll get") highly because the presence of outcome uncertainty makes subjects uncertain about their best ex-ante decision. In other words, subjects might report that the presence of outcome uncertainty makes the decision subjectively difficult. After all, choosing between $8 for sure and $10 for sure is typically straightforward – decisions are difficult primarily when they involve uncertainty and the need to aggregate and trade off different contingencies. The wording of the BLNS question ("You lack certainty in your decision because [...] you can't be sure what you will receive [...]") appears consistent with such an interpretation.

This argument has at least three antecedents in the literature. First, a voluminous and influential literature on hypothetical or contingent reasoning in economics shows that decision problems are more difficult when they involve the need to reason through multiple contingencies (e.g., Esponda and Vespa, 2014, 2024; Charness and Levin, 2009). Martínez-Marquina et al. (2019) directly show that the presence of outcome uncertainty increases the frequency of decision anomalies. Second, a related literature on lottery choice has documented that choice inconsistencies are considerably more pronounced when the lotteries in the menu are more dissimilar from each other state-by-state (Agranov and Ortoleva, 2017; Enke and Shubatt, 2023; Shubatt and Yang, 2024). In the choice between a non-degenerate lottery and a safe payment (studied by BLNS), this insight im-

plies that choices are more difficult the more uncertain the outcome of the lottery is, because the dissimilarity between a safe payment and a lottery increases in the variance of the lottery. Third, the idea that the presence of outcome uncertainty makes decision problems more difficult and increases information-processing demands is also present in a long line of work in psychology going back at least to Slovic and Lichtenstein (1968) and Lichtenstein and Slovic (1971) who explicitly discuss the cognitive difficulty of processing outcome uncertainty.

While the literature has used various techniques to document the cognitive difficulty of reasoning about outcome uncertainty, we here illustrate this body of work by studying how choice inconsistencies (a potential proxy for choice errors) vary as a function of the magnitude of outcome uncertainty. We leverage the dataset of Peterson et al. (2021), who implement thousands of unique binary lottery choice problems in a large-scale study. Each subject that confronts a given choice problem does so five times (consecutively), allowing for an analysis of across-trial variability (choice inconsistencies) in repetitions of the same choice problem. To make our results directly comparable to BLNS, we restrict the sample of choice problems to problems in which (i) subjects choose between a binary lottery and a safe payment; and (ii) the absolute EV difference is in [0.1,1.9]. This leaves us with 948 unique choice problems, though the results look very similar in the full sample of problems.[2]

We compute—separately for each choice problem—the fraction of subjects who are inconsistent at least once. Following Enke and Shubatt (2023), we then assess how this problem-level measure of choice inconsistencies varies as a function of the magnitude of outcome uncertainty. Figure 1 illustrates the results. The left panel shows that choice inconsistencies strongly increase in the variance of the lottery ($r = 0.53$, $p < 0.01$). The right panel shows that these results are partly driven by the extremity of the probability of the lottery upside, as interior probabilities (more outcome uncertainty) are associated with more frequent choice inconsistencies. These results suggest that greater outcome uncertainty makes decisions more difficult.

These results are a special case of the notions of tradeoff complexity and dissimilarity discussed in the recent literature on lottery choice (e.g., Enke and Shubatt, 2023; Shubatt and Yang, 2024). Intuitively, a safe payment is more dissimilar state-by-state from a binary lottery when the lottery payouts have high variance and / or when the payout probability is more interior. Such dissimilarity means that the tradeoffs involved are more pronounced, making the choice more difficult. The general idea that dimension-by-dimension dissimilarity and the resulting tradeoffs contribute to making choice difficult goes back at least to Tversky and Russo (1969).

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[2]The results also look very similar if we restrict the sample to problems in which all payouts are weakly positive. This may be of interest because Peterson et al. (2021) did not incentivize losses.
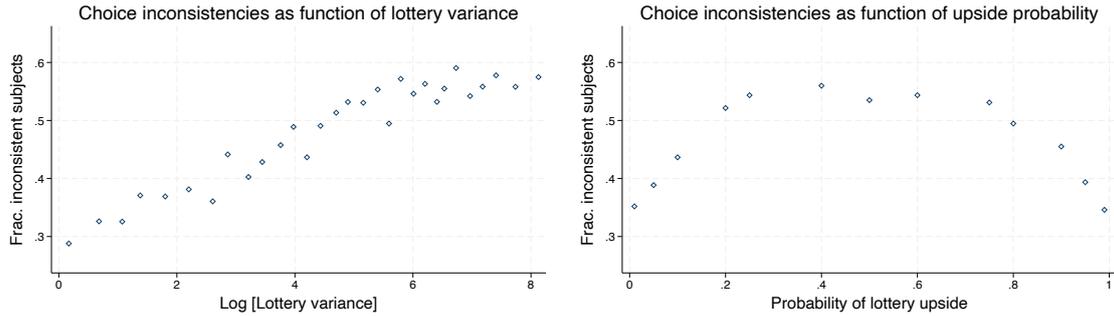
Figure 1: Choice inconsistencies in repeated elicitations of the same binary lottery choice problem in the data of Peterson et al. (2021). The left panel shows a binned scatter plot of the fraction of subjects who are inconsistent at least once as a function of the log variance of the lottery. The right panel shows a binned scatter plot of choice inconsistencies as a function of the payout probability of the lottery upside. For comparability with BLNS, the sample is restricted to choice problems involving a binary lottery and a safe payment, and where the absolute EV difference is in [0.1,1.9], for a total of 948 unique choice sets.

In summary, multiple lines of prior work suggest that outcome uncertainty contributes to making decisions difficult. An alternative interpretation of BLNS's results is thus that subjects exhibit uncertainty about their best ex-ante decision (in line with the question's intended meaning) precisely *because* there is outcome uncertainty.

Experiment to disambiguate interpretations.   To disambiguate these results, we implemented an experiment that replicates BLNS's uncertainty decomposition protocol, see Appendix A for screenshots of the study. We use BLNS's instructions and comprehension checks verbatim to introduce the *CU* decomposition. Moreover, we use the same wording and layout to allow subjects to rate the importance of the different potential reasons for why they reported to be uncertain. Our only tweak is that, after subjects rate the importance of each reason, we ask the simple follow-up question displayed in Figure 2 whenever the "Can't know for sure how much you'll get" reason was rated at least 2 out of 7. This question directly contrasts BLNS's interpretation—that subjects understand their reason as asking about the presence of payoff uncertainty—with the interpretation that subjects are uncertain about their best choice because the lottery involves payoff uncertainty. The order of response options was randomized.

206 subjects completed the experiment on Prolific and made five decisions each, for a total of 1,030 data points on *CU*. 646 observations reflect strictly positive *CU*. Following BLNS, we only collect data on the uncertainty decomposition for these observations. Appendix B provides an analysis of the results. The main results are twofold. First, we replicate BLNS's results on the uncertainty decomposition itself. Subjects, on average, assign the highest ratings to the reason "Can't Know For Sure What You'll Get," and for 315 observations (49%) this is the most important reason, almost exactly as in BLNS's data[3]

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[3]Of these 315 observations, 12 rated all reasons as 1/7, meaning that they were not asked our follow-up
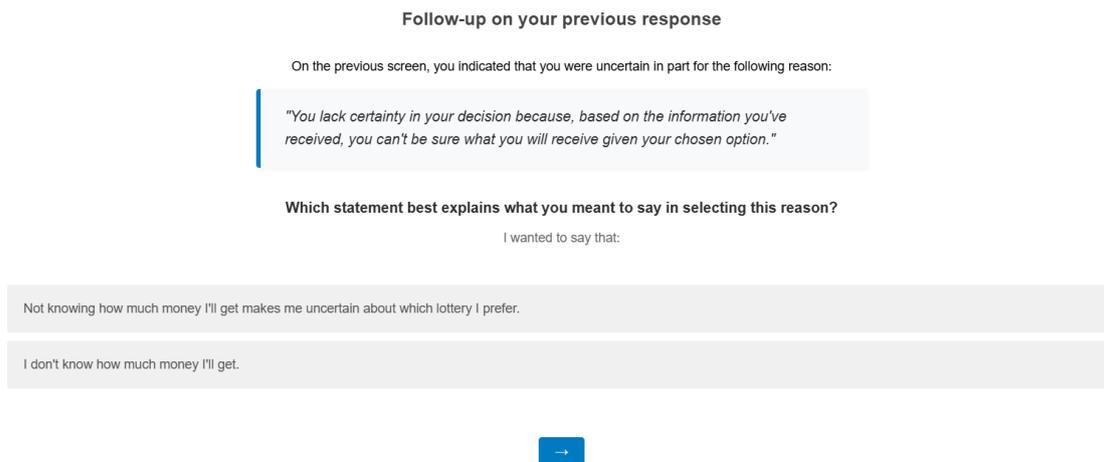
Figure 2: Screenshot of follow-up survey question

Second, in our follow-up question, focusing on the sample of 303 observations in which "Can't Know For Sure What You'll Get" is the most important reason (BLNS's preferred sample), 74% select the reason suggesting decision rather than outcome uncertainty. If we instead look at the sample of all observations who rated this reason at least 2/7 ($N = 443$), the corresponding number is 75%. Taking into account that inattention, measurement noise and rushed answers mechanically push response fractions towards 50%, these results suggest that subjects do not misunderstand the *CU* elicitation as asking about ex-post outcome uncertainty but that, instead, the presence of outcome uncertainty makes subjects uncertain about their best ex-ante decision.[4]

4 Correlations Between *CU* and Choices

BLNS correlate *CU* with small-stakes risk aversion and the common-ratio effect. As far as we understand BLNS's line of argument, this analysis of *CU* as a diagnostic measure of improvability relies on the idea that small-stakes risk aversion and / or the common-ratio effect are improvable / mistakes. However, there does not appear to be a consensus in

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question (which required a rating of at least 2).

[4]To assess robustness against changes in wording, we also ran the following variant with 100 subjects:

You indicated that you were uncertain because based on the information you've received, you can't be sure what you will receive given your chosen option. You rated the importance of this reason as 5 out of 7 (where 7 is 'Very Much').
Regarding this reason, which statement best clarifies what you meant?

- *This reason was relevant for me because I wanted to say that I don't know how much money I'll get.*
- *This reason was relevant for me because I wanted to say that not knowing how much money I'll get makes me uncertain about how much I value an option.*

80% of BLNS's preferred sample select the second reason.

the behavioral economics or psychology communities that either of these two phenomena reflect mistakes rather than preferences (see Alós-Ferrer et al., 2024, for a recent paper suggesting the opposite). Consider the recent paper "Connecting Common Ratio and Common Consequence Preferences" that is coauthored by two of BLNS's authors (McGranaghan et al., 2024). One of the main aims of this paper is to measure true common ratio *preferences* rather than merely common ratio *effects* ("our work reinforces the fundamental benefits of identifying patterns of preferences using valuation tasks"). The authors conclude that such common ratio preferences sometimes exist and speculate that these preferences are driven by "a preference for upside potential," rather than by mistakes (McGranaghan et al., 2024). Given this state of the literature, we are unsure what the presence or absence of a correlation between *CU* and small-stakes risk aversion or the common-ratio effect reveals about whether *CU* is a valid improvability-detection method.

Second, beyond the specific question of whether small-stakes risk aversion and the common-ratio effect constitute mistakes, BLNS's null hypothesis that *CU* may reliably diagnose mistakes differs markedly from the perspective taken in the literature. In both economics and psychology, several authors have pointed out that even high *CU* (or low decision confidence in psychology) need not coincide with objective mistakes. BLNS assert that "This literature [in psychology] establishes that self-reported confidence often provides a good indicator of performance in objective perceptual tasks...Whether low confidence is actually a good proxy for perceived improvability in ...settings [without objective performance benchmarks] is an open question." We disagree with BLNS's characterization that self-reported confidence is generally a reliable indicator of improvability in objective tasks, and that the main open question is whether it is also a good proxy in subjective tasks. Rather, psychologists have known for decades that there are objective tasks in which people exhibit low decision confidence yet perform pretty well (see Green and Swets, 1966, for a classic reference). As a result, the recent review by Fleming (2024) emphasizes that metacognitive performance and confidence often diverge from performance even in objective tasks, see for example the quote from Fleming's abstract above. Also see Fleming and Lau (2014). Within economics, Enke et al. (2023) provide direct evidence that *CU* is often miscalibrated even in objective decision problems. Also see the many references in Enke et al. (2023) on similar results in the psychology literature on meta-cognition and confidence.

Given this state of the literature, we are uncertain about the origins of BLNS's null hypothesis that confidence is indicative of performance in objective tasks but not in subjective ones. A more accurate summary of the existing evidence may be that the relationship between confidence and performance is task-dependent in both objective and subjective settings, with well-documented cases of miscalibration in both.

5   Conclusion: What Does Cognitive Uncertainty Capture?

Interpretation of *CU*.   A growing body of evidence shows that *CU* partly reflects the strength of tradeoffs across dimensions or payout states. For instance, Shubatt and Yang (2024) show that across three domains—multi-attribute choice, lottery choice and intertemporal choice—*CU* strongly increases in a formal measure of the strength of tradeoffs. Related, Enke et al. (2024) document across many different applications that *CU* systematically increases away from points at which no tradeoffs are present. The pattern encountered by BLNS—that *CU* increases in ex-post outcome uncertainty—appears to be one special case of this general phenomenon because higher outcome uncertainty can make it subjectively more difficult to navigate tradeoffs.

At the same time, *CU* does not reliably diagnose objective improvability in general, and—to our knowledge—has not been proposed to serve such a purpose.

A related question is whether *CU* may reliably diagnose *subjective* improvability. Answering this question requires taking difficult stances on what counts as improvable. To illustrate, suppose that people are literally endowed with CRRA utility functions and attempted to maximize them. Consider two cases. First, the individual knows their CRRA coefficient but does not know how to identify the option that maximizes expected utility. Second, the individual has imperfect information about their CRRA coefficient but, conditional on this uncertainty, acts in a fully Bayesian and maximizing fashion. Suppose that both individuals express cognitive uncertainty. Does this reflect subjective improvability? In the first case, it unambiguously does. Yet in the second case, it isn't obvious in which sense the decision is subjectively improvable. After all, if the individual exhibits irreducible uncertainty about their CRRA coefficient, even the most sophisticated social planner who has access to the same information set will not make different choices. We thus do not view *CU* as a reliable measure of subjective improvability, either.

Links between *CU* and decision anomalies.   The preceding discussion offers what we believe is a sensible middle ground in the debate about the interpretation of the robust correlations between *CU* and behavioral 'anomalies' such as probability weighting in the elicitation of certainty equivalents, inverse probability weighting in the elicitation of probability equivalents, hyperbolic discounting over money, insensitive effort supply, scope insensitivity in public policy evaluations, and others (e.g., Enke and Graeber, 2023; Enke et al., 2024, 2025; Shubatt and Yang, 2024; Toma and Bell, 2024).

One strand of the literature has attributed the existence of these 'anomalies' to nonstandard preferences. According to this perspective, correlations with *CU* are spurious. A second strand of the literature has instead sometimes attributed the 'anomalies' to mistakes. According to this perspective, correlations with *CU* are suggestive evidence.

BLNS's contribution has clarified to us that the terminology of mistakes is sometimes unhelpful and imprecise. Instead, a more helpful interpretation may be that CU and the associated 'anomalies' reflect imperfect information. For instance, various imperfect-information models show that preference uncertainty in combination with 'Bayesian' updating (broadly understood) can produce phenomena such as probability weighting, hyperbolic discounting over money, and other special cases of behavioral attenuation.[5] If CU partly captures such preference uncertainty, then the 'anomalies' may not reflect choices that maximize latent true preferences, yet neither would they reflect suboptimal behavior. Instead, akin to the influential literature on the 'Bayesian brain' in cognitive science, they would reflect 'reasonable' responses to uncertainty in the mind.

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[5]This perspective is also consistent with outcome uncertainty producing higher CU. For instance, Shubatt and Yang (2024) show in a model that preference uncertainty is less relevant for decisions when the choice options involve less pronounced tradeoffs.

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Appendix

A   Screenshots of Experiment

Instructions 1/2

Please read these instructions carefully. There will be comprehension checks.

In this study, you will make multiple decisions.

Your payment will consist of two components:

- Completion fee:
    If you **complete the study**, you will receive a **completion fee**.

- Additional bonus:
    On each of 5 decision screens, you will make a decision. One of the decision screens will be selected at random by the computer, with equal probability, and will determine your **bonus**. The **maximal bonus** you can earn in this study is **$30**. One in five participants will be paid a bonus.

Instructions 2/2

Your task

In this study, you will decide which of two lotteries you prefer.

In total, you will complete 5 rounds of this task. Across these rounds, the lotteries you can choose between will vary. These rounds are completely independent from one another. If one of the rounds is selected to determine your bonus, only your choice in this one round will determine your bonus.

Example screen:

Which lottery do you choose?
Please select one.

Lottery A	Lottery B
Probability 50% Get $30 Probability 50% Get $0	Probability 100% Get $14

How certain are you that choosing Lottery A is actually your best decision, given your preferences and the available information?

| Very uncertain | | | | | | | | | Fully certain |

| 50% | 55% | 60% | 65% | 70% | 75% | 80% | 85% | 90% | 95% | 100% |

Here is how your bonus would be determined in this example:
- If you chose **Lottery A** on the selected decision, the computer will **play that lottery for real** to determine your bonus (for example, $30 with the shown probability, $0 otherwise).
- If you chose **Lottery B**, you receive the **sure amount** shown for B as your bonus.
- Each participant has the same chance to be paid. If you are selected, you receive the **full bonus amount** determined above (in addition to the completion fee).

Your choices always matter: if you are selected for payment, the selected decision is paid exactly as described.

Your certainty

In each round, we will ask you two questions:
1. You will decide which lottery you prefer.
2. We will ask you how certain you are about your decision. Specifically, we are interested in how likely you think it is (in percentage terms) that the decision you made is actually your best decision, given your personal preferences and the available information.

Once you click the next button, the comprehension check questions will start!

16

Comprehension check

To verify your understanding of the instructions, please answer the comprehension questions below. You have to get all questions right before you're allowed to proceed. In each question, exactly one response option is correct.

You can review the instructions here .

1. Which one of the following statements is true?

I will choose between the same lotteries in each round.

The lotteries I can choose between will vary across rounds.

2. Which one of the following statements is true?

When I'm asked to indicate my certainty about my decision, the people running this study are interested in how certain I am that the decision I made is actually my best decision, given my personal preferences and the available information.

When I'm asked to indicate my certainty about my decision, the people running this study are interested in how certain I am that I will actually receive the money from the lottery.

→

Please focus now! The main part of the study begins on the next page.

On each screen, you will choose a lottery and indicate your certainty.

Click "Next" when you read all the above text carefully and are ready to start.

→

Which lottery do you choose?
Please select one.

Lottery A	Lottery B
Probability 90% Get $30 Probability 10% Get $0	Probability 100% Get $26

How certain are you that choosing this lottery is actually your best decision, given your preferences and the available information?

Very uncertain		Completely certain
50	75	100

63

Understanding Your Overall Certainty

We asked you to report your level of certainty in each of the tasks you have completed so far in this study. In some tasks, you reported a certainty level of less than 100%, indicating less-than-complete certainty in your decisions.

Next, we will ask you to explain some possible reasons for your less-than-complete certainty in your previous choices.

Understanding Your Overall Certainty

In the next pages, we list nine possible reasons for having less-than-complete certainty in your decisions. For each reason, we also provide an illustration. It's important to keep in mind that these are just illustrations. In a few minutes we will ask you to classify similar examples, so please review these reasons carefully.

All these examples concern an individual named Chris who must choose between attending two social events with two different groups of friends.

Understanding Your Overall Certainty

1. **Can't Know For Sure What You'll Get:** You lack certainty in your decision because, based on the information you've received, you can't be sure what you will receive given your chosen option.

Here's an example of why Chris might report less-than-complete certainty for this reason:

> Some of Chris's friends told him they might attend his chosen event or they might just stay home. He might express less-than-complete certainty in his decision because he can't be sure what his chosen option will yield since he doesn't know which friends will actually turn up to the event.

→

2. **Didn't Think Carefully About What You Want:** You lack certainty in your decision because you haven't thought through what you want to achieve as carefully as you could.

Here's an example of why Chris might report less-than-complete certainty for this reason:

> Chris values experiences with different friends for different reasons but hasn't seriously considered whether one set of reasons is more important than another. He might express less-than-complete certainty in his decision because he hasn't carefully thought through what he wants from this social event.

→

3. **Not Sure What Each Option Means:** You lack certainty in your decision because you're not sure you interpreted the available options correctly or understood their consequences.

Here's an example of why Chris might report less-than-complete certainty for this reason:

> Chris was told weeks ago which friends were attending which event, but he found some of their messages confusing and isn't sure he understood them properly. He might express less-than-complete certainty in his decision because he isn't sure he understands the consequences of choosing to attend one event vs. the other.

→

Understanding Your Overall Certainty

4. **Worried About Mental Shortcuts:** You lack certainty in your decision because you're worried about having used a mental shortcut that might have given the wrong answer.

Here's an example of why Chris might report less-than-complete certainty for this reason:

> Chris' enjoyment of social events depends on who else is there, but it's hard for him to think through the pluses and minuses of being with one large group of friends rather than another. Instead, he makes his decision based entirely on which event his friend Parker plans to attend. He might express less-than-complete certainty in his decision because he's worried that the mental shortcut he used — to only think about Parker — isn't a good one.

→

5. **Didn't Apply Your Decision Criterion Correctly:** You lack certainty in your decision because you think the criterion you decided to use and any simplifying assumptions you made may actually favor an alternative other than the alternative that you chose.

Here's an example of why Chris might report less-than-complete certainty for this reason:

> To simplify his choice, Chris assumed he would have the most fun at the event with the largest number of friends, so he listed the friends planning to attend each event and counted them. Right after committing to the event with the larger count, he worried that he might have miscounted. He might express less-than-complete certainty in his decision because he now thinks the criterion he decided to use and the simplifying assumption he made might actually favor an alternative other than the one he chose.

→

Understanding Your Overall Certainty

6. **Multiple Views About What You Want:** You lack certainty in your decision because, in your view, there's probably more than one right way to think about what you want to achieve.

Here's an example of why Chris might report less-than-complete certainty for this reason:

> Chris values experiences with different friends for different reasons and, after careful consideration, doesn't think one set of reasons is necessarily more or less important than another. He might express less-than-complete certainty in his decision because he doesn't think there's just one right way to think about what he wants from either social event.

→

Understanding Your Overall Certainty

7. **Don't Know How You'll Feel:** You lack certainty in your decision because you aren't sure how you will feel about each of the possible outcomes.

Here's an example of why Chris might report less-than-complete certainty for this reason:

> Chris enjoys different friends in different moods and is uncertain what his mood will be when the event arrives. He might express less-than-complete certainty in his decision because he isn't sure how he will feel about being with each group of friends.

→

Understanding Your Overall Certainty

8. **It's Nearly a Toss-Up:** You lack certainty in your decision because you think the choice is close to a toss-up.

Here's an example of why Chris might report less-than-complete certainty for this reason:

> After assessing the desirability of each event, Chris concludes that he would enjoy them about the same. However, because he is slightly unsure about each assessment, either one might be slightly better. He might express less-than-complete certainty in his decision because he thinks it is nearly a toss-up.

→

Understanding Your Overall Certainty

9. **Other Reasons:** You lack certainty in your decision for other reasons.

Here's an example of why Chris might report less-than-complete certainty for this reason:

> Chris may have other reasons for expressing less-than-complete certainty in his decision that we haven't mentioned.

→

Explaining the Reasons for your Overall Certainty

When you reported your overall certainty in each choice, any answer below 100% indicated that you had less-than-complete certainty. We want to understand your reasons for reporting less-than-complete certainty.

For each reason on the previous screens, you will indicate the degree to which it accounted for your less-than-complete certainty. For example, if you rated your certainty as 60%, we want to know the extent to which each reason was responsible for you answering 60% rather than 100%.

In each case, you will answer on a scale of **1 (Very Little) to 7 (Very Much)**. So if you rated your overall certainty as 60%, you would give a 1 for a particular reason if it had very little to do with saying your certainty was 60% rather than 100%, and you would give a 7 if it had a great deal to do with saying your certainty was 60% rather than 100%.

Please proceed to see an example of how the questions will look.

→

Imagine your overall certainty in a choice was 60% rather than 100%. You would then face the following question:

*Your overall certainty was 60% rather than 100%. For each reason listed below, please indicate the degree to which it accounted for your less-than-complete certainty (in other words, the fact that you reported 60% rather than 100%). In each case, select a number from **1 (Very Little)** to **7 (Very Much)**.*

---

1. **Can't Know For Sure What You'll Get:** You lack certainty in your decision because, based on the information you've received, you can't be sure what you will receive given your chosen option.

Click **here** to reread a clarifying example.

	1	2	3	4	5	6	7	
Very Little	○	○	○	○	○	○	○	Very Much

2. **Didn't Think Carefully About What You Want:** You lack certainty in your decision because you haven't thought through what you want to achieve as carefully as you could.

Click **here** to reread a clarifying example.

Very Little	○	○	○	○	○	○	Very Much

3. **Not Sure What Each Option Means:** You lack certainty in your decision because you're not sure you interpreted the available options correctly or understood their consequences.

Click **here** to reread a clarifying example.

Very Little	○	○	○	○	○	○	Very Much

4. **Worried About Mental Shortcuts:** You lack certainty in your decision because you're worried about having used a mental shortcut that might have given the wrong answer.

Click **here** to reread a clarifying example.

Very Little	○	○	○	○	○	○	Very Much

5. **Didn't Apply Your Decision Criterion Correctly:** You lack certainty in your decision because you think the criterion you decided to use and any simplifying assumptions you made may actually favor an alternative other than the alternative that you chose.

Click **here** to reread a clarifying example.

Very Little   ○ ○ ○ ○ ○ ○ ○   Very Much

6. **Multiple Views About What You Want:** You lack certainty in your decision because, in your view, there's probably more than one right way to think about what you want to achieve.

Click **here** to reread a clarifying example.

Very Little   ○ ○ ○ ○ ○ ○ ○   Very Much

7. **Don't Know How You'll Feel:** You lack certainty in your decision because you aren't sure how you will feel about each of the possible outcomes.

Click **here** to reread a clarifying example.

Very Little   ○ ○ ○ ○ ○ ○ ○   Very Much

8. **It's Nearly a Toss-Up:** You lack certainty in your decision because you think the choice is close to a toss-up.

Click **here** to reread a clarifying example.

Very Little   ○ ○ ○ ○ ○ ○ ○   Very Much

9. **Other Reasons:** You lack certainty in your decision for other reasons.

Click **here** to reread a clarifying example.

Very Little   ○ ○ ○ ○ ○ ○ ○   Very Much

→

Check your Understanding

We will now check your understanding of the different reasons for expressing less-than-complete certainty, and of how you should report the importance of different reasons.

> **If you answer at least 3 of 4 questions correctly, you will receive an extra $1 payment, so it is in your interest to take them seriously!**

→

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Test your Understanding

Question 1:

Susan is deciding between two options. Option A is an apple. Option B is either a pear or an orange depending on whether Yellow comes before Blue on the color spectrum (i.e., the order of the rainbow). If Yellow comes before Blue then Option B is definitely a pear. If Yellow comes after Blue then Option B is definitely an orange.

Susan doesn't recall the color spectrum precisely but remembers learning the acronym "ROY G BIV" for the colors of the rainbow. She thinks the "Y" stands for Yellow and the "B" stands for Blue, which would imply that Yellow comes before Blue. But she really isn't sure. She makes her decision as if Option B is a pear. She likes pears much more than apples so she chooses the pear.

However, she reports an overall certainty in her decision of less than 100% because she is not that sure about the accuracy of the "ROY G BIV" acronym she used when making her choice.

Which of the following reasons should Susan mark as contributing "Very Much" to her less-than-complete certainty?

Didn't Think Carefully About What You Want: You lack certainty in your decision because you haven't thought through what you want to achieve as carefully as you could.

It's Nearly a Toss-Up: You lack certainty in your decision because you think the choice is close to a toss-up.

Worried About Mental Shortcuts: You lack certainty in your decision because you're worried about having used a mental shortcut that might have given the wrong answer.

→

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Test your Understanding

Question 2:

Edward is deciding between two options. Option A is a box of oatmeal cookies, while Option B is a box of assorted chocolates. For Option B, he won't know which types of chocolates are in the box until he opens it.

He knows he likes all types of chocolate more than oatmeal cookies, so he chooses Option B. He expresses an overall certainty in his decision of less than 100% because there's no way for him to know which chocolates are in the box.

Which of the following reasons should Edward mark as contributing "Very Much" to his less-than-complete certainty?

Can't Know For Sure What You'll Get: You lack certainty in your decision because, based on the information you've received, you can't be sure what you will receive given your chosen option.

Didn't Apply Your Decision Criterion Correctly: You lack certainty in your decision because you think the criterion you decided to use and any simplifying assumptions you made may actually favor an alternative other than the alternative that you chose.

Worried About Mental Shortcuts: You lack certainty in your decision because you're worried about having used a mental shortcut that might have given the wrong answer

→

Test your Understanding

Question 3:

Samantha is deciding between two boxes. Box A contains either an apple or a pear, while Box B contains either one dollar or ten cents. The boxes are labeled with their exact contents, but the labels are written in a foreign language that Samantha has not studied.

She does her best to guess what the words mean based on similarities to words in languages she knows. She concludes that Box A probably contains an apple while Box B probably contains one dollar. She chooses Box A because she prefers an apple to one dollar. She expresses an overall certainty in her decision of less than 100% because she's not sure she correctly translated the labels on the boxes.

Which of the following reasons should Samantha mark as contributing "Very Much" to her less-than-complete certainty?

Didn't Think Carefully About What You Want: You lack certainty in your decision because you haven't thought through what you want to achieve as carefully as you could.

Not Sure What Each Option Means: You lack certainty in your decision because you're not sure you interpreted the available options correctly or understood their consequences.

Worried About Mental Shortcuts: You lack certainty in your decision because you're worried about having used a mental shortcut that might have given the wrong answer.

→

Test your Understanding

Question 4:

Jude is deciding between the same two boxes as Samantha in the previous problem. Box A contains either an apple or a pear, while Box B contains either one dollar or ten cents. The boxes are labeled with their exact contents but the labels are written in a foreign language.

Unlike Samantha, Jude can read the language and is fairly certain Box A contains an apple while Box B contains one dollar. An apple is worth more than a dollar to him, so he intends to select Box A. But after making his choice, he thinks he may have accidentally recorded his selection as Box B, containing the dollar. For that reason, he expresses an overall certainty in his decision of less than 100%.

Which of the following reasons should Jude mark as contributing "Very Much" to his less-than-complete certainty?

Not Sure What Each Option Means: You lack certainty in your decision because you're not sure you interpreted the available options correctly or understood their consequences

Didn't Apply Your Decision Criterion Correctly: You lack certainty in your decision because you think the criterion you decided to use and any simplifying assumptions you made may actually favor an alternative other than the alternative that you chose.

It's Nearly a Toss-Up: You lack certainty in your decision because you think the choice is close to a toss-up.

→

Explaining the Reasons for your Overall Certainty

We will now ask you to provide the reasons for your overall certainty in the decisions that you made in this study.

→

On the next screen you will explain your certainty in **round 1/5**.

→

On a previous screen you faced the following decision:

Lottery A	Lottery B
Probability 50 % Get $30 Probability 50 % Get $0	Probability 100% Get $14

You selected **Lottery B** and reported a **67%** certainty in your decision.

---

*For each reason listed below, please indicate the degree to which it accounted for your less-than-complete certainty (in other words, the fact that you reported 60% rather than 100%). In each case, select a number from **1 (Very Little) to 7 (Very Much)**.*

	Very Little						Very Much
Multiple Views About What You Want: You lack certainty in your decision because, in your view, there's probably more than one right way to think about what you want to achieve.	●	○	○	○	○	○	○
Not Sure What Each Option Means: You lack certainty in your decision because you're not sure you interpreted the available options correctly or understood their consequences.	○	●	○	○	○	○	○
Worried About Mental Shortcuts: You lack certainty in your decision because you're worried about having used a mental shortcut that might have given the wrong answer.	○	●	○	○	○	○	○
Don't Know How You'll Feel: You lack certainty in your decision because you aren't sure how you will feel about each of the possible outcomes.	○	○	○	○	●	○	○
Didn't Think Carefully About What You Want: You lack certainty in your decision because you haven't thought through what you want to achieve as carefully as you could.	●	○	○	○	○	○	○
It's Nearly a Toss-Up: You lack certainty in your decision because you think the choice is close to a toss-up.	○	○	○	●	○	○	○
Didn't Apply Your Decision Criterion Correctly: You lack certainty in your decision because you think the criterion you decided to use and any simplifying assumptions you mead may actually favor an alternative other than the alternative that you chose.	●	○	○	○	○	○	○
Can't Know For Sure What You'll Get: You lack certainty in your decision because, based on the information you've received, you can't be sure what you will receive given your chosen option.	○	○	○	○	●	○	○
Other Reasons: You lack certainty in your decision for other reasons.	○	○	○	○	○	●	○

Follow-up on your previous response

On the previous screen, you indicated that you were uncertain in part for the following reason:

> *"You lack certainty in your decision because, based on the information you've received, you can't be sure what you will receive given your chosen option."*

Which statement best explains what you meant to say in selecting this reason?

I wanted to say that:

Not knowing how much money I'll get makes me uncertain about which lottery I prefer.

I don't know how much money I'll get.

→

You are almost at the end of the survey.

Before you finish, please share a few details about yourself.

What is your sex?

Male
Female

How old are you?

What is your annual household income before taxes?

Less than $10,000
$10,000 to $19,999
$20,000 to $29,999
$30,000 to $39,999
$40,000 to $49,999
$50,000 to $59,999
$60,000 to $69,999
$70,000 to $79,999
$80,000 to $89,999
$90,000 to $99,999
$100,000 to $149,999
$150,000 or more

What is your highest level of education?

Less than high school degree
High school graduate (high school diploma or equivalent including GED)
Some college but no degree
Associate degree in college (2-year)
Bachelor's degree in college (3-year or 4-year)
Master's degree
Doctoral degree
Professional degree (JD, MD)

→

Congratulations! You earned the following bonuses:

- Decision Bonus: $30
- Quiz Reward: $

Total Bonus: 30

→

Thank you for your participation! You have completed this study entirely, and you will receive a completion payment.

If you were eligible for a bonus it will be paid out to you once all the responses are collected.

→

B   Results of Experiment

B.1   Replication of BLNS's Results

206 subjects completed the experiment on Prolific and made five decisions each, for a total of 1,030 data points on *CU*. Figure A.1 shows the distribution of reported certainty in the full sample of decisions. 646 observations reflect strictly positive *CU*.

Figure A.2 shows the average importance of each of the BLNS reasons and Figure A.3 the fraction of decisions (pooled across subjects and rounds) for which a reason was the most highly rated one (including ties). Our results are very similar to those reported in BLS, with around 50% of all data points suggesting that the most important reason for being uncertain is "Can't know for sure what you'll get."
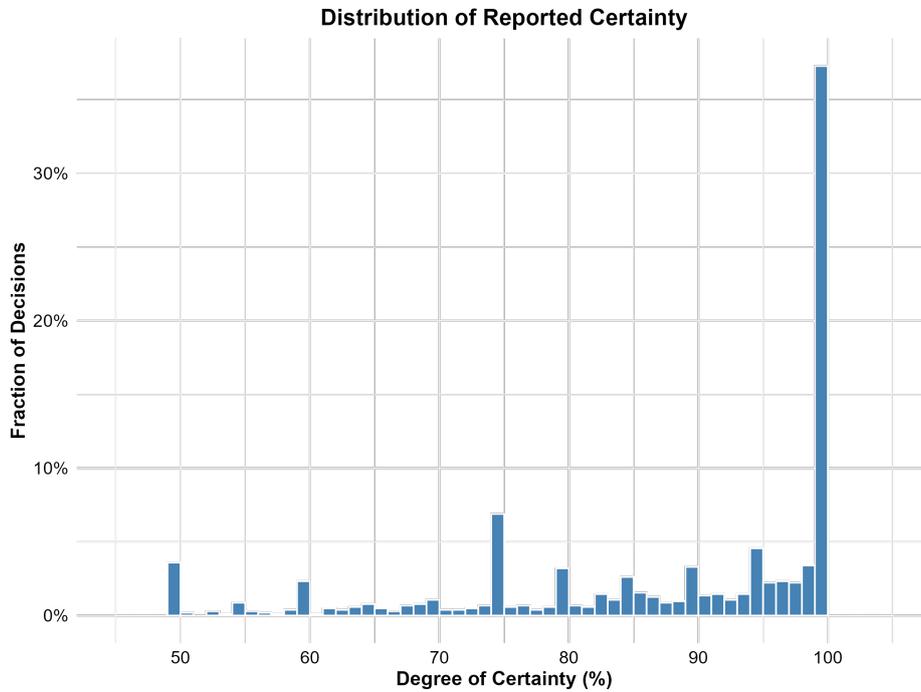

Figure A.1: Distribution of self-reported certainty across all decisions (pooled). The histogram displays the fraction of total decisions falling into each certainty bin (bin width = 1).

Average Importance of Reasons (Pooled Decisions)
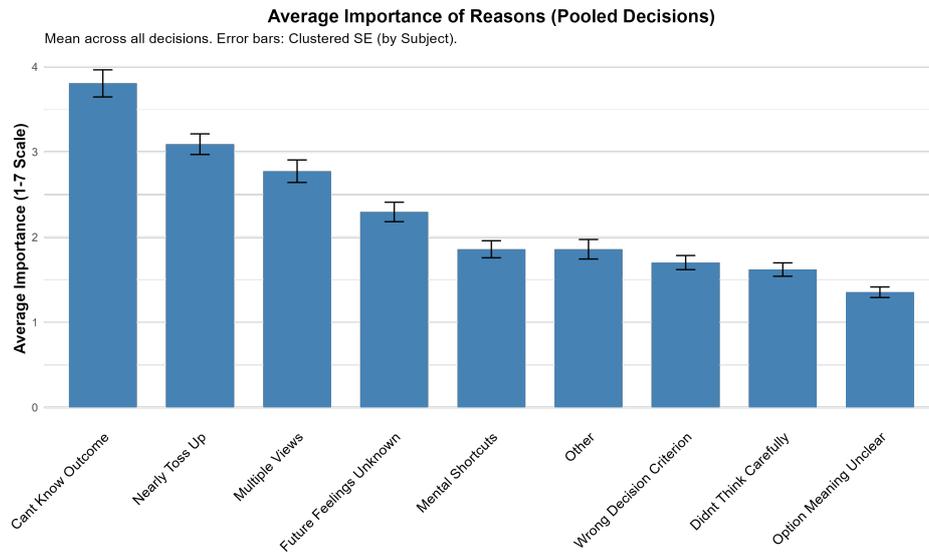Mean across all decisions. Error bars: Clustered SE (by Subject).

Figure A.2: Average importance ratings for each potential BLNS reason for being uncertain. The means are calculated by pooling all decisions across all subjects. Error bars represent ±1 standard error (SE), clustered at the subject level.

Frequency of Being the Most Important Reason
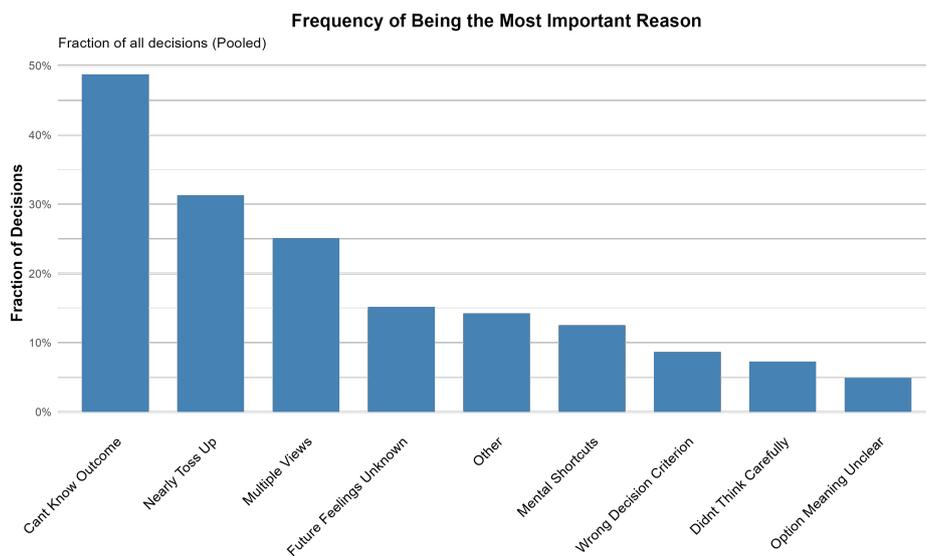Fraction of all decisions (Pooled)

Figure A.3: Fraction of decisions for which each reason was rated as most important (including ties). Fractions are calculated by pooling all decisions across all subjects.

B.2   Follow-Up Question to Disambiguate Interpretations

Figures A.4 and A.5 show the results for our follow-up question. Focusing on the sample of 303 observations in which "Can't Know For Sure What You'll Get" is the most important reason (BLNS's preferred sample), 74% select the reason suggesting decision rather than outcome uncertainty. If we instead look at the sample of all people who indicated non-zero importance for this reason ($N = 443$), the corresponding number is 75%.

Finally, Figure A.6 provides a subject-level analysis (rather than decision level analysis as in the other figures). We classify subjects according to how consistently they answered in our follow-up question. We see that a large majority of subjects either always or mostly selects the reason that indicates cognitive uncertainty in line with the question's intended meaning.
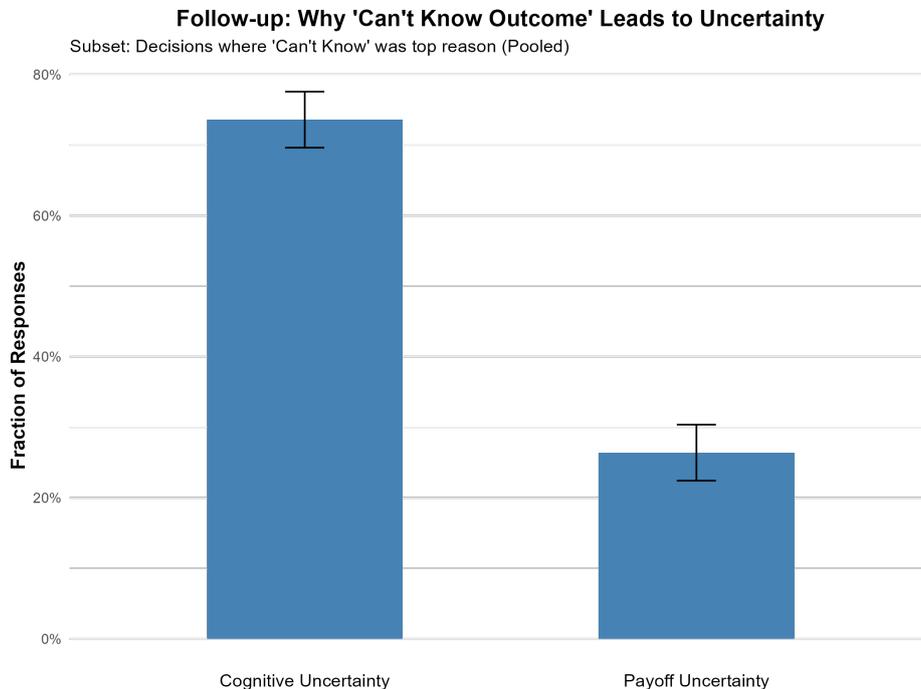
Follow-up: Why 'Can't Know Outcome' Leads to Uncertainty

Subset: Decisions where 'Can't Know' was top reason (Pooled)

Figure A.4: Interpretation of "Can't know for sure what I will get" (Top Reason Subset). This figure displays the distribution of responses to the follow-up question across the sample of observations for which the "Can't know for sure what you'll get" reason was the top reason (including ties). "Cognitive Uncertainty" refers to the response: *"Not knowing how much money I'll get makes me uncertain about which lottery I prefer."* "Payoff Uncertainty" refers to: *"I don't know how much money I'll get."* Fractions are calculated by pooling decisions. Error bars represent ±1 standard error (SE), clustered at the subject level.
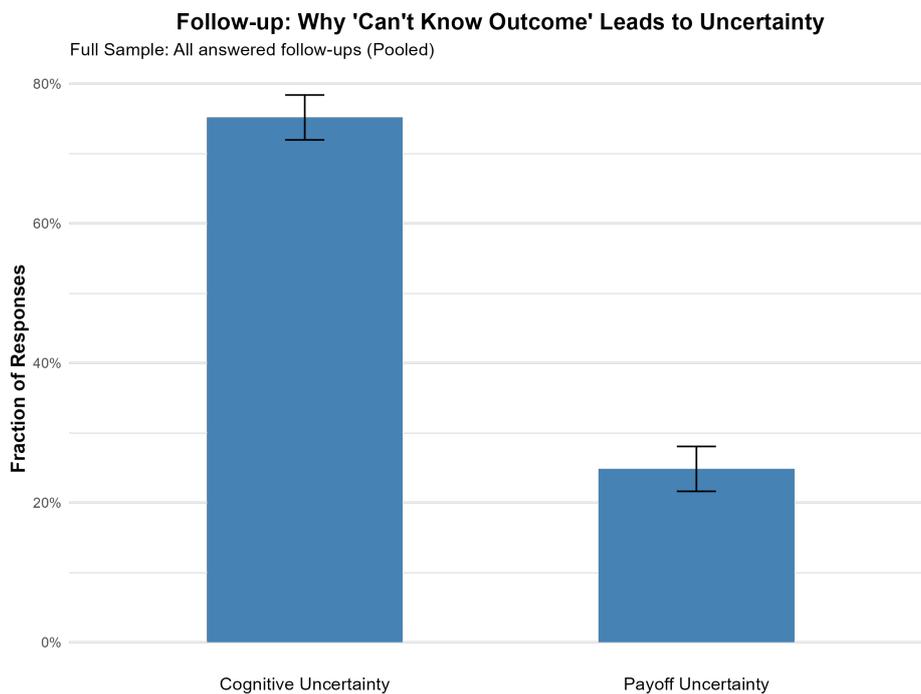
Follow-up: Why 'Can't Know Outcome' Leads to Uncertainty

Full Sample: All answered follow-ups (Pooled)

Figure A.5: Interpretation of "Can't know for sure what I will get" (Full Sample). This figure displays the distribution of responses to the follow-up question across the full sample of observations who reported that the importance of the "Can't know for sure what you'll get" reason was at least 2/7. "Cognitive Uncertainty" refers to the response: *"Not knowing how much money I'll get makes me uncertain about which lottery I prefer."* "Payoff Uncertainty" refers to: *"I don't know how much money I'll get."* Fractions are calculated by pooling decisions. Error bars represent ±1 standard error (SE), clustered at the subject level.

Consistency of Follow-up Reasons Across Rounds

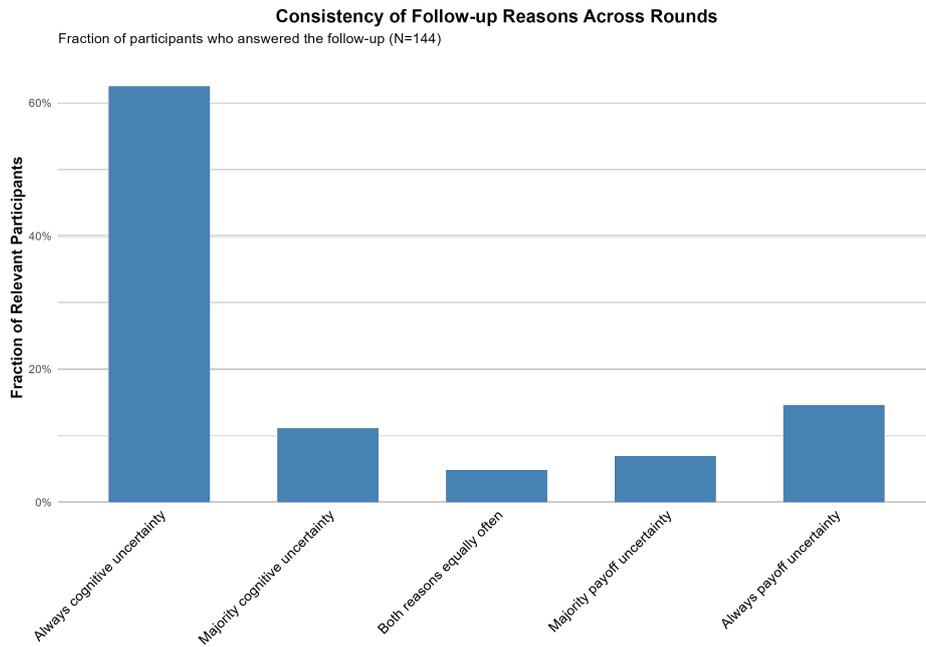Fraction of participants who answered the follow-up (N=144)

Figure A.6: Consistency of follow-up interpretations across rounds. This figure classifies participants based on the consistency of their follow-up responses across the 5 rounds. "Always" indicates that the participant chose that interpretation in all rounds in which they encountered the follow-up question. "Majority" indicates the participant chose that interpretation in the majority of rounds. The y-axis shows the fraction of relevant participants (those who answered the follow-up question at least once). "Cognitive Uncertainty" refers to the response: *"Not knowing how much money I'll get makes me uncertain about which lottery I prefer."* "Payoff Uncertainty" refers to: *"I don't know how much money I'll get."*