Magic Mirror on the Wall, Who Is the Smartest One of All?*

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Abstract

In the canonical model of bounded rationality each player best-responds to their belief that other players reason to some finite level. We propose a novel behavior that reflects the player's belief that while other players may be rational, the player cannot model and hence predict the behavior of others. This encompasses a situation where a player believes that their opponent can reason to a higher level than they do. We propose an identification strategy for such behavior, and evaluate it experimentally.

JEL Classification: C72, C92, D91.

Keywords: Bounded rationality, higher-order rationality, level-k, cognitive-hierarchy, epistemic game theory, laboratory experiment.

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To be honest, my head is hurting from this back-and-forth thinking ad infinitum.

Participant #230

1 Introduction

The canonical model of bounded rationality in games, as level-k and cognitive hierarchy, is an iterative 'top-down' model of reasoning: a player with a finite level of reasoning believes others can reason to a strictly lower level and best responds to that belief. This restriction is critical in how the model is operationalized – it ensures that a player requires only a finite number of steps of reasoning to optimally respond to their belief. Importantly, a player who can do k steps of iterated reasoning (i.e., k steps of "I think, you think, I think, ...") can only model others as being capable of doing at most $k - 1$ steps of iterated reasoning.[1] This ability to model the behavior of others, and hence predict it, is a key assumption in these models. This, however, leads to natural and interesting questions: what happens if a player believes others may reason to a higher level than they are capable of? For example, how will a player respond if they believe that their opponent is more sophisticated than them? Will they no longer be capable of modeling their opponent's behavior and hence predicting their actions?

Consider a player, Ann, who is playing a game with Bob. We propose a behavior that reveals to an analyst that Ann is not able to model, and hence predict, Bob's behavior. We then implement a novel experimental design that allows us to identify this behavior experimentally and evaluate its pervasiveness in the population. We also investigate whether Ann's behavior is a feature of her thought process or depends on Bob's observed characteristics such as being either an undergraduate student or a Ph.D student in Economics.

To understand the intuition behind the identification strategy and experimental design, recall that in iterative 'top-down' models of reasoning players' beliefs are anchored in the behavior of a non-strategic L0 type, and types are heterogenous in their level of reasoning. The L1 type performs one level of reasoning and best responds to the L0 type. In turn, the L2 type performs two levels of reasoning and best responds to some belief over L0 and L1 types, and so on with the Lk type best responding to some belief over L0, ..., L($k - 1$) types. In these models, the lack of predictability of the opponent is captured by the L0 type, which is typically assumed to play uniformly random. The only other source of unpredictability in these models stems from the uncertainty over the level of reasoning of others.

The uncertainty associated with non-strategic play (L0) could be controlled for by designing a game that permits the analyst to identify if a player "believes other players are rational."[2] We introduce a judiciously designed game – which we refer to as the *large* game ("*LG*") – in which the lack of predictability in iterative 'top-down' models of reasoning is limited. In particular, if Ann

[1] Any player who can reason about their opponent doing m steps must necessarily be able to do at least $m + 1$ steps of reasoning themselves.

[2] We use rationality here in the game-theoretic sense of playing a best response to beliefs. Further, in the iterative 'top-down' model of reasoning, all Lk types with $k \geq 1$ play a best response and hence are rational.

believes that Bob is rational *and* has the ability to model Bob's behavior, then her payoff in the game is bounded from below by a strictly positive number.

Now consider the possibility that Ann thinks that Bob may be *more* sophisticated than her but cannot model, and hence predict, Bob's behavior. In such a situation, it might be reasonable for Ann to believe that Bob is rational, since Ann herself is rational and thinks that Bob may be more sophisticated than herself. However, she might not be able to model Bob's behavior beyond that. In many games, the assumption that Bob is rational will not leverage much predictability, as in the case of our carefully designed *large* game.[3] In this game, even if Ann believes that Bob is rational – *but* cannot model and predict Bob's behavior – her payoff might not respect the lower bound that was constructed for the case in which she was able to model his behavior.

We contrast the *large* game with a *dominance-solvable* game ("*DS*"), in which Bob has a strictly dominant strategy. If Ann believes that Bob is rational, she will believe that Bob will play the strictly dominant strategy. Thus, she can guarantee herself a certain payoff, which is below the lower bound on her payoff in the *large* game if she is able to model Bob's behavior.

Observing Ann's preferences over the two games will allow an observer to infer whether Ann can model Bob's behavior or not. If Ann can model Bob's behavior she will strictly prefer the *large* game. Hence, if she weakly prefers the *dominance-solvable* game, then she reveals that she *cannot* model Bob's behavior. Importantly, these inferences do not depend on Ann's risk or social preferences.

One reasonable concern with the proposed identification strategy may arise if Ann's inability to model Bob's behavior is due to her concern that Bob may not be rational. To control for this possibility, the *large* game includes a "safe" action, which guarantees Ann a strictly higher expected utility in the *large* game than in the *dominance-solvable* game for *any* belief that Bob may not be rational.[4] Consequently, although our design makes the starkest predictions for a player that believes their opponent is rational, any deviation from this benchmark biases the identification in one direction only. Put differently, those that can model the behavior of others will prefer the *large* game regardless. This results in the proportion of participants that is identified as not having the ability to model the behavior of others being a conservative estimate of this behavior in the population.

The novel experimental design we employ has four components. The first are the two diagnostic games: *LG* and *DS*. The second are two control games that rule out other confounding factors that can contribute to prefer *DS* over *LG*. Third, we investigate whether participants' reasoning process ('top-down' as in iterative reasoning models or prioritizing rationality as an organizing principle) depends on their opponents' observed characteristics. To achieve this, we exogenously vary the participants' opponent type: they face either a Ph.D. student in Economics or an undergraduate student of any discipline. The fourth component is a preference-elicitation mechanism over the games. Rather than directly eliciting a choice between the two diagnostic games, participants first choose their actions in each game (and against each potential opponent), and then we elicit their respective *valuations*.[5] This allows an observer to infer both participants' preferences between the two diagnostic games and participants' (confidence in their) beliefs about their opponents' behavior. Moreover, we can exploit the valuation data to isolate those participants who believe that their

[3]The assumption of rationality will only ensure that Bob will not play any strictly dominated strategy.

[4]This statement is robust to arbitrary degree of risk aversion, see Section 5 for details.

[5]To allow participants to recall their reasoning in the valuation stage, we encouraged them to write it down in a text box. We use this information to gather further qualitative evidence on their choice process.

opponent is rational as the predictions in our games are the starkest for this subset of participants.

We find that approximately half of the choices made by participants are consistent with difficulty of predicting others' behavior. This is true especially if they believe that their opponents are rational. Among those, 64% behave as though they are not able to model the behavior of others. Moreover, roughly 70% of participants exhibit a stable model of reasoning irrespective of the opponent's characteristics. Among the remainder, the results are split: roughly 12% can model the behavior of undergraduate students but not of Ph.D. students, while roughly 18% can model the behavior of Ph.D. students but not of undergraduate students.

This paper is closely related to the literature on iterative reasoning. Pioneering scholarly contributions in the level-k literature include Stahl and Wilson (1994; 1995), Nagel (1995), Costa-Gomes, Crawford, and Broseta (2001), Camerer, Ho, and Chong (2004), and Costa-Gomes and Crawford (2006). More recently, Gill and Prowse (2016) investigated how cognitive ability and character skills influence the evolution of play in repeated strategic interactions and estimate a structural model of learning based on level-k reasoning. For a survey of this literature, see Crawford, Costa-Gomes, and Iriberri (2013).

Arad and Rubinstein (2012a) and Kneeland (2015) developed novel experimental designs to identify levels of reasoning in an iterative model. Moreover, in the former design, the authors explicitly asked participants about their thought process when making their choices to gain a better understanding of participants' behavior. Arad (2012) proposed a new allocation game to study iterative reasoning and the performance of the level-k model, and showed that level-k thinking accounts for a smaller number of choices made by participants than in other experiments. Further, Arad and Rubinstein (2012b) studied how participants reason iteratively on few dimensions, or features, in an allocation game (Colonel Blotto). Subsequently, Arad and Penczynski (2020) studied a few other environments of resource allocation with communication between participants, and confirmed that many participants engage, in fact, in multi-dimensional iterative reasoning.

Most closely related to our work is Agranov, Potamites, Schotter, and Tergiman (2012) who manipulated participants' beliefs about the cognitive levels of the players they are playing against, and Alaoui and Penta (2016) who studied a model of iterative reasoning where player's depth of reasoning is endogenously determined. More recently, Alaoui, Janezic, and Penta (2020) further developed an experimental design strategy to distinguish level-k behavior driven by subjects' beliefs from their cognitive bounds, and found an interaction between participants' own cognitive bound and reasoning about the opponent's reasoning process.

The paper proceeds as follows. Section 2 introduces the design and the set of diagnostic games as well as the two control games. It builds the theoretical background necessary for our experiment – discussed in Section 3 – and the identification strategy used in the analysis conducted in Section 4. Section 5 offers a more formal analysis. Finally, Section 6 concludes with a brief discussion of the results. The Appendix contains further analyses, details on participants' individual behavior, the experimental instructions, and screenshots of the experimental interface.

2 The Design

We employ both an iterative 'top-down' model of reasoning, based on level-k and cognitive hierarchy, and the concept of 2-rationalizability to guide our experimental design, identification strategy, and analysis. We provide a brief description of the model and the concept here and engage in a discussion on how these interact with our setup in the next subsection. A more formal and general analysis will be provided in Section 5.

2.1 Building Intuition: Model and Solution Concept

Iterative 'top-down' model of reasoning In this model, players anchor their beliefs in a naïve model of others' behavior and adjust their beliefs by a finite number of iterated best-responses. The model is anchored in the behavior of the level-0 ("L0") type, which is exogenously given and is typically assumed to be uniformly random. A level-1 ("L1") player is not strategic and does not believe others are rational, but does choose a strategy that maximizes their expected utility (given the level-0 play).[6] A level-2 ("L2") player assumes that all other players are either L0 or L1 types and chooses a strategy that maximizes their expected utility under some probability distribution on L0 and L1 strategies. This process continues for higher-level players and, more generally, with Lk types choosing a strategy that is expected-utility maximizing given beliefs over play of strictly lower types.[7]

2-*rationalizability* This concept can be intuitively understood via its relationship with the notion of rationality and reasoning about rationality. A player is *rational* if they play a best-response (maximize expected utility) given their subjective belief about how the game is played. A player *believes in rationality* if they believe others play a best-response given their subjective beliefs about how the game is played. The solution concept of 2-rationalizable strategies incorporates both the assumption of rationality and belief in rationality.[8]

Iterative 'top-down' model of reasoning and 2-*rationalizability* Now we highlight the relationship between the model and the concept introduced above. First notice that the iterative 'top-down' model of reasoning implicitly imposes assumptions about how types reason about rationality. We highlight two facts. First, all Lk types with $k \geq 1$ are rational as they play a best response given their belief about others' play. Second, any Lk type that places zero weight on the L0 type believes in rationality.

Further notice that the iterative 'top-down' model of reasoning imposes an additional assumption *beyond* reasoning about rationality. It imposes the assumption that beliefs are anchored in L0-play. Put differently, a rational L1-type cannot hold any belief about the play of the game.

[6]Most iterative reasoning applications assume that players are risk-neutral and hence maximize expected-payoffs. In this paper, instead, we will allow for *any* expected-utility preferences.

[7]This 'top-down' model of iterative reasoning nests both the level-k and cognitive hierarchy models. In the level-k model, a Lk type assumes that all other players are L$(k-1)$ types. In the cognitive hierarchy model, a Lk type places positive weight over L0, …, L$(k-1)$ types where the weight is determined according to a conditional Poisson model. The iterative 'top-down' model was first formalized in Strzalecki (2014).

[8]The relationship between reasoning about rationality and k-rationalizable strategies follows from standard results, e.g., among others, Bernheim (1984), Brandenburger and Dekel (1987) and Tan and da Costa Werlang (1988).

Rather, they must hold beliefs consistent with L0-play. The same holds true similarly for higher levels. A L2-type (that believes others are L1-type) cannot hold any belief about others' rational play, but rather must hold beliefs consistent with L1-play, etc. Therefore, one can view the iterative 'top-down' model of reasoning as assuming that players *can*, in fact, model the play of others.

This is in sharp contrast to the concept of 2-rationalizability. This approach is grounded in the assumption that players can hold *any* beliefs about the play of others, and only requires those beliefs to be consistent with the assumption that others are rational. In this sense, one can think of 2-rationalizable strategies as relaxing the assumption of the ability to model the play of others, relative to iterative reasoning models.

Key design assumptions In what follows, we will assume that players are rational. For the iterative 'top-down' model of reasoning, this means that we will focus on the behavior of Lk-types for $k \geq 1$.[9] Moreover, players that are rational and believe in rationality will also play a special role in our design. As we assume that players themselves are rational, a natural assumption if they believe others may be more sophisticated than them, is to at least believe others are rational – even if they cannot model the behavior of others. As such, our design will make stark predictions for those participants who are rational and believe in rationality of others.

2.2 The Games

In order to identify behavior that reflects the player's belief that while other players may be rational, they cannot model the behavior of others, we judiciously designed *two* diagnostic games. One where the ability to model the opponents' behavior is important for how the participant values the game, and the other where such an ability is less important.

The strategic form of these games is depicted in Figure 1.

LG

Player 1 \ Player 2	A	B	C	D
a	12 / 0	14 / 12	12 / 13	8 / 11
b	0 / 4	0 / 14	16 / 0	4 / 6
c	16 / 10	5 / 0	0 / 11	0 / 12
d	7 / 13	11 / 8	10 / 6	12 / 0

DS

Player 1 \ Player 2	A	B	C
a	6 / 0	3 / 12	4 / 11
b	15 / 5	8 / 13	13 / 0
c	10 / 12	9 / 8	9 / 0

Figure 1: The Large Game (LG) and the Dominance-Solvable Game (DS)

The large game "LG" We begin with the large game denoted *LG*, which is a 4×4 bimatrix game. The iterative 'top-down' model of reasoning predicts that players choose actions in $\{a, b\}$ and in

[9] There are two interpretations of a L0-player in the literature. One is that the player does not reason at all, but chooses a mixed strategy that corresponds to the anchor. The second is that the player does not exist but, instead, serves as a way to anchor the beliefs of other players.

$\{B, C\}$. To see why this is the case, let us first consider the simpler level-k model. For simplicity, we assume that all players maximize expected payoffs.[10]

To build intuition, we first consider the behavior of the L1 type of Player 1 who is maximizing their own payoff but does not take any strategic considerations of their opponent into account (as they do not believe that their opponent is rational). This type plays actions a or b as actions c and d induce payoffs that are dominated by action a's payoffs. Notice that a is naturally a best response to the belief that Player 2 is the L0 type and plays actions in $\{A, B, C, D\}$ with equal chance.

We can carry out the analogous thought experiment for Player 2's behavior to find that the L1 type plays action C. This action delivers the highest Player 2 payoffs and is therefore a natural focal action.[11] Any new iteration ("the next level") is a best response to the opponent's behavior. For example, the L2 type of Player 1 plays a and the L2 type of Player 2 plays B. Then, the L3 type of Player 1 plays b and the L3 type of Player 2 plays B. This process continues *ad infinitum*. Player 1's best responses are always in $\{a, b\}$ and Player 2's best responses are always in $\{B, C\}$.

The iterative 'top-down' model of reasoning is a more general model than the level-k model. It explicitly allows players to hold arbitrary risk preferences within expected utility. Moreover, players may hold *any* belief about the expected-utility preferences of other players as well as over lower types L0, ..., L($k-1$) of other players.

We first consider Player 1's behavior of L1 type and begin with the observation that each action induces a lottery through the player's belief about the play of others. For example, the lottery induced by action a, in which Player 1 receives with equal chance the monetary payoffs of 13, 12, 11, and 0. Playing a first-order stochastically dominates the lotteries induced by playing actions c or d. Notice, however, that the lotteries induced by actions a and b do not first-order stochastically dominate each other. Further, if Player 1 is extremely risk-seeking, then action b is their best response. Thus, the best response to such beliefs are actions a and b. Making analogous arguments for Player 2, we can show that the L1 type plays action C.

We now consider Player 1's behavior of L2 type. This type can hold any beliefs that take the following form: $(1-p)\cdot\{1/4, 1/4, 1/4, 1/4\} + p\cdot\{0, 0, 1, 0\}$ for any $p \in (0, 1]$. The best-response to such beliefs are actions a and b (but not c or d). Again, making analogous arguments for Player 2, we can show that the L2 type plays either action B or action C. This type's behavior is characterized by any belief about Player 1's behavior that is a mixture of Player 1 playing actions in $\{a, b, c, d\}$ with equal chance and the two degenerate beliefs that Player 1 plays action a or action b with certainty.

Lastly, consider the L3 type of Player 1. This type can hold any beliefs that take the following form: $(1-p_1-p_2)\cdot\{1/4, 1/4, 1/4, 1/4\} + p_1\cdot\{0, 0, 1, 0\} + p_2\cdot\{0, 1, 0, 0\}$ for any $p_1, p_2 \in [0, 1]$ such that $0 < p_1 + p_2 \leq 1$. The best response to such beliefs is either action a or action b. The behavior of the L3 type of Player 2 is characterized by playing actions B or C. The reasoning for higher-order types follows similarly and no new actions are played by these types.

A special case of the iterative 'top-down' model of reasoning arises when we restrict attention to types that are rational and believe in rationality. This implies that we focus on types that place

[10] This can be generalized to allow for any expected-utility preferences and it will still be true that the iterative 'top-down' model of reasoning predicts that players will play actions in $\{a, b\}$ and in $\{B, C\}$. For details, see Section 5.

[11] The attractiveness of action C for the L1 type of Player 2 is particularly salient in our experiment design, which we will discuss in Section 3. Notice that this behavior is also a best response to the belief that Player 1 is the L0 type and plays actions in $\{a, b, c, d\}$ with equal chance.

zero weight on others being the L0 type. If this is true, then the expected payoff for any such type must be *strictly greater than 12*.[12]

Moving to payoffs when applying the concept of 2-rationalizability. Any action can be played by a rational player. For any action there exists some belief about the other player's behavior such that the action is a best response.[13] Thus, if Player 1 has difficulty predicting the behavior of others, they might reasonably hold any beliefs over the distribution $\{A, B, C, D\}$. For example, a player who plays action a could plausibly assign positive probability to Player 2 playing action A. In such a case, one might reasonably expect the payoff to be less than 12 in *LG*.

The dominance-solvable game "DS" The other diagnostic game is *DS* – a 3×3 bimatrix game that is dominance-solvable in a single iteration. Player 2 has a strictly dominant strategy. This means that any rational Player 2 must play the dominant action A in either the level-k model or any 'top-down' model of reasoning. To give some guidance, we first consider the behavior in the level-k model of the L1 type of Player 1, who plays action a that maximizes their expected payoff (the payoffs induced by action c are dominated by those induced by action a). Such behavior is also a best response to the belief that Player 2 is the L0 type and plays actions in $\{A, B, C\}$ with equal chance. As Player 2 has a strictly dominant strategy, it is obvious that all Lk types' behavior with $k \geq 1$ is characterized by always playing A. For Player 1, any type $k > 1$ best responds by playing c.

Behavior in the iterative 'top-down' model of reasoning is more nuanced for Player 1 (but not for Player 2). Because players can hold any expected utility preference, it is possible that Player 1 chooses, in fact, actions in $\{a, b, c\}$.

We begin with Player 1's behavior of L1 type. Playing a first-order stochastically dominates playing action c, however, the lotteries induced by actions a and b do not first-order stochastically dominate each other. If the L1 type of Player 1 is extremely risk-seeking, then action b is their best response.

Consider again a special case of the iterative 'top-down' model of reasoning by restricting attention to types that are rational and believe in rationality. If this is true, then the expected payoff for any such type will be *exactly 12*.

In contrast to the large game *LG*, however, any player who is rational and believes in rationality – yet falls outside the iterative 'top-down' model of reasoning – must still behave exactly the same as in the iterative 'top-down' model of reasoning. Thus, any 2-rational player chooses action c and has an expected payoff of *exactly 12* irrespective of being an iterative-reasoner or not.

Player 1's preferences over LG and DS All players that are rational and believe that their opponents are rational prefer playing *LG* over *DS* in the iterative 'top-down' model of reasoning. The expected payoff of 12 in *DS* is strictly lower than the expected payoff of *LG*. That is, a 'top-down' iterative-reasoner should strictly prefer to play *LG* over *DS*.

When we relax the assumption of belief in rationality it permits players to assign positive weight on the L0 type in the 'top-down' model of reasoning. Importantly, allowing for dispersed beliefs

[12] Player 1 may value *LG* exactly at 12. This, however, can only occur with an extreme form of ambiguity aversion coupled with the player's set of prior including degenerate priors. We elaborate on this point in Section 5.

[13] c is a best response to Player 2 playing D and d is a best-response to Player 2 playing A. Likewise, A is a best-response to Player 1 playing c and D is a best response to Player 1 playing d.

does not alter the ranking of *LG* over *DS*. Put differently, any 'top-down' iterative-reasoner should strictly prefer to play *LG* over *DS* regardless of risk preferences.

Lastly, the comparative statics also hold in Nash equilibrium.[14] *LG* has a Nash equilibrium in mixed strategies where the equilibrium actions coincide with the actions prescribed by the iterative 'top-down' model of reasoning. The equilibrium payoff is also strictly greater than 12 and strictly dominates the equilibrium payoff of *DS*, which is exactly 12. The Nash equilibrium of *LG* is $\big((8/9, 1/9, 0, 0), (0, 13/15, 2/15, 0)\big)$ with payoffs of $\big(182/15, 112/9\big)$. *DS* has a Nash equilibrium in pure strategies: $\big((0, 0, 1), (1, 0, 0)\big)$ with payoffs of $(12, 10)$.

The control games Now we are ready to introduce the control games. The objective of our study is to detect whether players value the predictability of their opponents' actions. The two control games are designed to rule out other confounding factors that can contribute to prefer *DS* over *LG*.

The strategic form of the two games is depicted in Figure 2.

MS

Player 1 \ Player 2	*A*	*B*	*C*
a	6 0	10 12	8 11
b	16 5	3 13	10 0
c	9 12	8 8	10 0

NE

Player 1 \ Player 2	*A*	*B*	*C*
a	13 0	14 12	6 11
b	5 5	3 13	16 0
c	10 12	9 8	9 0

Figure 2: The controls: The Mixed-Strategy (MS) Game and the Nash-Equilibrium (NE) Game

Our controls serve two purposes: First, we want to control for the size of the game, that is, whether players prefer any smaller game over *LG per se*. To do so, we introduce *MS*, which is a 3×3 bimatrix game with the iterative 'top-down' model of reasoning prescribing a player's actions $\in \{a, b, c\}$. Notice that the payoffs in *MS* can be greater than 12, and thus above those in *DS*. In addition, *MS* also has a Nash equilibrium in mixed strategies similar to *LG* where players mix over the actions $\in \{a, b\}$ (but not c), and the equilibrium payoff is strictly dominated by *LG*'s equilibrium payoff.[15]

Second, we want to control for Nash equilibrium. Thus, we consider *NE* – a 3×3 bimatrix game with a unique Nash equilibrium in pure strategies. In contrast to *DS*, however, this game is not dominance-solvable. Here too, the iterative 'top-down' model of reasoning prescribes player's action $\in \{a, b, c\}$.[16] The payoffs in *NE* can be greater than 12, and thus above those of *DS* as well. Once again, the equilibrium payoff in *NE* is strictly dominated by *LG*'s equilibrium payoff. The Nash equilibrium of the *NE* control game is $\big((0, 0, 1), (1, 0, 0)\big)$ with equilibrium payoffs of $(12, 10)$, which coincides with the equilibrium payoff prediction of *DS*.

As we are solely interested in participants' behavior in the role of Player 1, all 3×3 games (*DS*, *MS*, and *NE*, respectively) are judiciously chosen to share common features. All payoffs for Player

[14] This is also true in logit Quantal Response Equilibrium.

[15] The Nash equilibrium of the *MS* control game is $\big((7/9, 2/9, 0), (0, 11/12, 1/12)\big)$ with payoffs of $\big(143/12, 76/9\big)$.

[16] Strictly speaking, a player's action $\in \{a, b\}$ is consistent with the standard level-k model, whereas dispersed beliefs are required for action $\in \{a, b, c\}$ – which is consistent with the iterative 'top-down' reasoning model.

1 are kept constant across these smaller games to improve control and ease of comparison. We only altered the payoffs associated with actions $\in \{A, B, C\}$ for Player 2. Naturally, each action's minimum payoff with the corresponding action pairs $((a, A), (b, C), (c, C))$ is zero in the two control games as in *DS*. Lastly, notice that in the control games, like the *LG* game, all actions are iteratively undominated. Thus, game *DS* stands alone as being the unique game where reasoning about rationality alone is enough to predict the opponent's play.

3 The Experiment

3.1 Implementation

We divided the experiment into two parts. In each part, participants faced four decision-making problems in random order. We told participants that they would be randomly matched with another participant, who already made their choices in a previous auxiliary session. The purpose of this design feature was to collect all data online in an individual decision-making setting and to ameliorate any form of social preferences when choosing actions.

We told participants that this other participant, whom we called "Player *Z*," is either an undergraduate student from any year or discipline at The University of Toronto or a Ph.D. student in Economics who took several advanced courses that are highly relevant for this experiment. Participants would not learn their opponent type until the conclusion of the experiment. Therefore, participants made always two choices: one if Player *Z* is an undergraduate student from any year or discipline and another if they are a Ph.D. student in Economics.

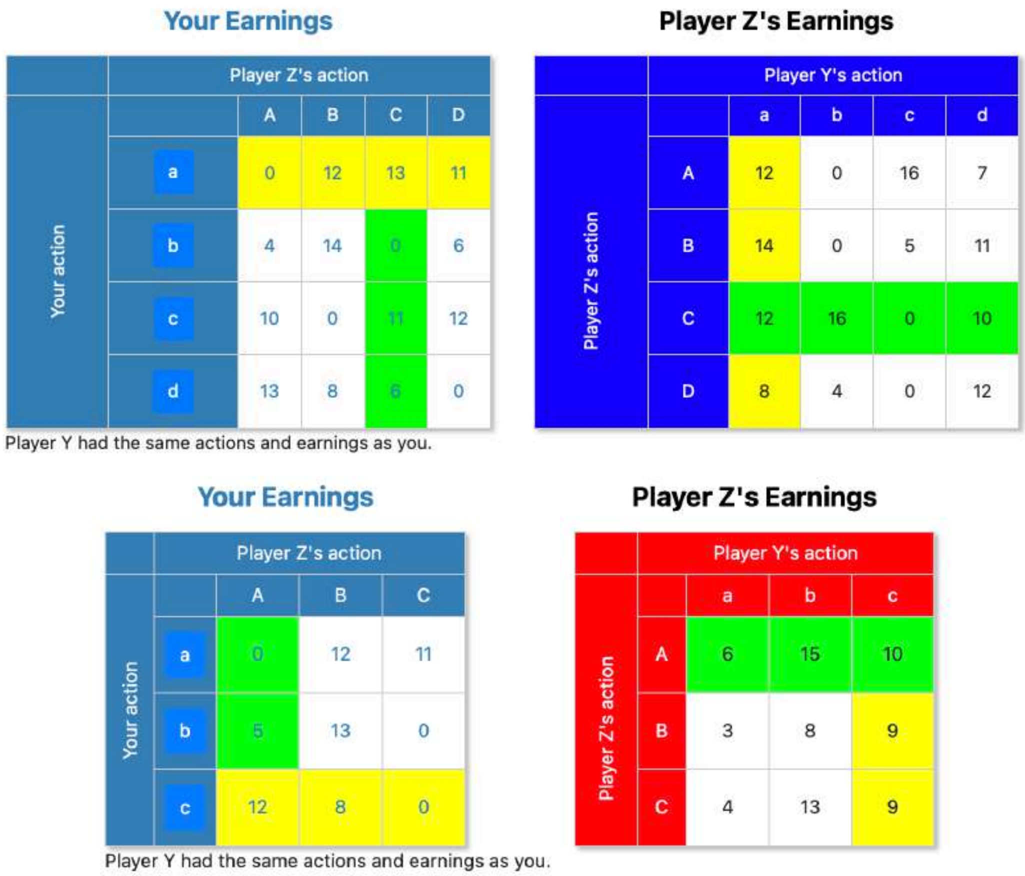
Figure 3 visualizes the implementation of the games.

The matrices on the left represent participants' payoffs in the *LG* game (top) and the *DS* game (bottom). The matrices on the right represent Player *Z*'s payoffs in *LG* and *DS*, respectively. The opponent type was visualized via color (red = undergraduate and blue = Ph.D. student).

Our experimental implementation of the games makes it particularly salient for participants that Player *Z* has a strictly dominant strategy in *DS*. Moreover, in *LG*, it highlights the attractiveness of action *C* for the L1 type of Player *Z*, even though it is more nuanced compared to *DS*. As this type is non-strategic and does not take the other player's incentives into account, visualizing each player's payoffs in a separate matrix directs attention to the sequence of numbers that is the highest.

To improve participants' experience and to assist in selecting an action, we implemented a highlighting tool that used two colors: yellow and light green. When a participant moved their mouse over a row in their matrix ("Your Earnings"), the action was highlighted in yellow color in both matrices: a row in their matrix, and a column in Player *Z*'s matrix ("Player *Z*'s Earnings"). By left clicking the mouse over a row it remained highlighted, and participants could unhighlight it by clicking their mouse again or clicking another row. Similarly, when participants moved their mouse over a row that corresponds to an action of Player *Z* in "Player *Z*'s Earnings," the row was highlighted in light green and the corresponding column was highlighted in light green in "Your Earnings." Clicking the mouse over the row kept it highlighted, and clicking it again (or clicking another action) unhighlighted it.

We further told participants that Player *Z* participated in a previous auxiliary experimental session in which (s)he was matched with another participant, called "Player *Y*," who participated in


Your Earnings

Your action	Player Z's action: A	B	C	D
a	0	12	13	11
b	4	14	0	6
c	10	0	11	12
d	13	8	6	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

Player Z's action	Player Y's action: a	b	c	d
A	12	0	16	7
B	14	0	5	11
C	12	16	0	10
D	8	4	0	12

Your Earnings

Your action	Player Z's action: A	B	C
a	0	12	11
b	5	13	0
c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

Player Z's action	Player Y's action: a	b	c
A	6	15	10
B	3	8	9
C	4	13	9

Figure 3: Game Implementation: *LG* (top) and *DS* (bottom)

the same session and played their role. When Player Z was an undergraduate student from any year or discipline, so was Player Y; and when Player Z was a Ph.D. student in Economics, so was Player Y. We used Player Z's decisions from the auxiliary sessions to determine participants' earnings in the main experiment.

In addition, we gave participants the opportunity to write notes to their "future self." Below each decision problem participants could write down the reasoning behind their choice of action in a text box. What they typed was displayed later on in the experiment. We told participants that these notes would help them when making choices in the second part of the experiment.

To account for possible order effects, we gave participants another opportunity to revisit their choices and confirm them.[17] We displayed their notes and participants were able to modify these. Afterwards, participants advanced to the next part of the experiment.

In the second part of the experiment, we elicited participants' approximate valuations via choice lists. We asked them to make a series of choices between playing the four decision problems against both Player Z types with their action choices from the first part of the experiment and sure amounts. For example, suppose that in the first part of the experiment a participant chose action c in any given 3×3 game, as highlighted in Figure 4. The payoff from the decision problem depends on the action chosen by Player Z and is either \$12, \$8, or \$0 if Player Z chose A, B, or C, respectively.

The choice problems were organized in four pairs ($4 \times 2 = 8$ lists), where Option A changed

[17] We find no evidence of order effects, using both parametric and non-parametric tests.

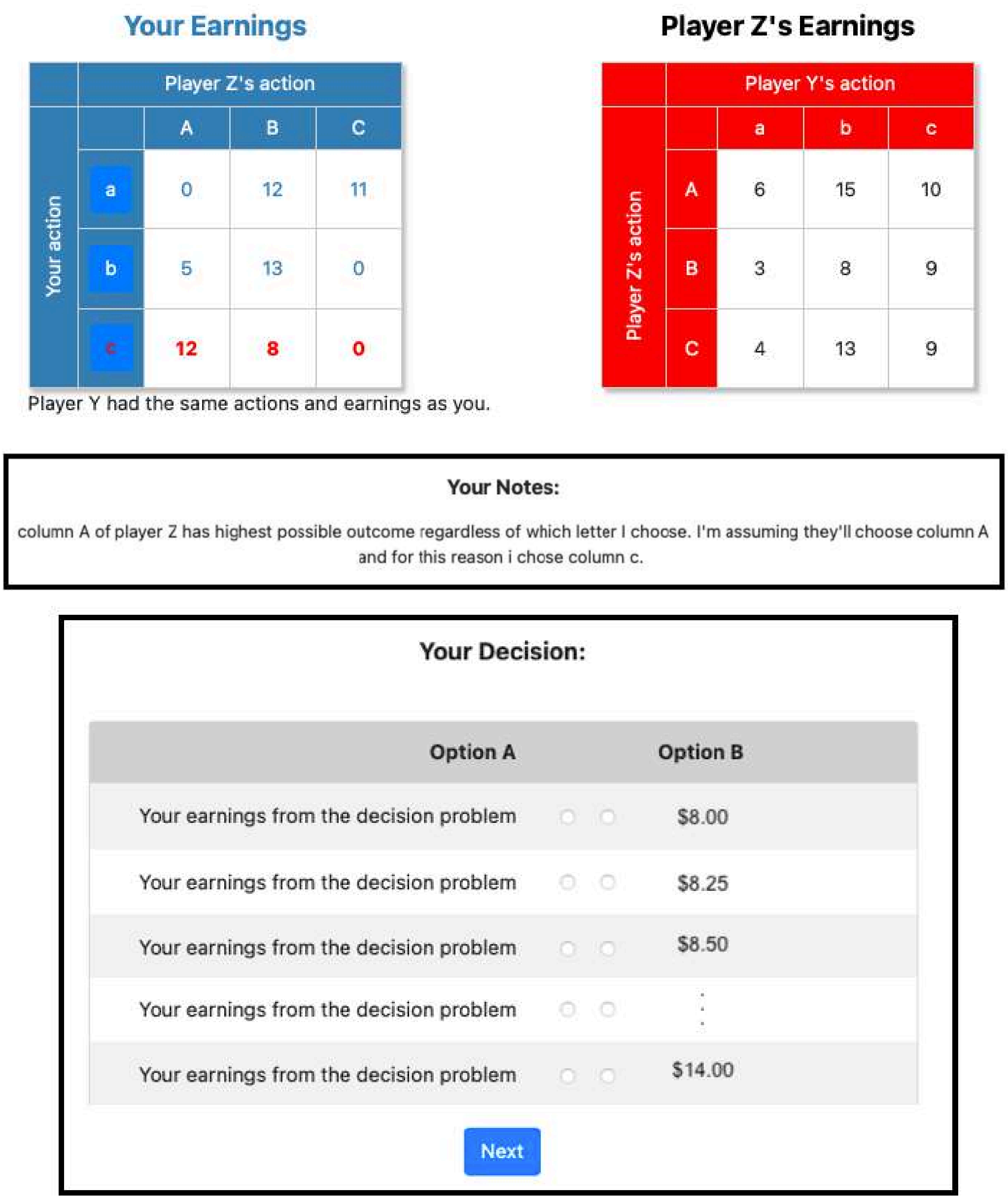


Figure 4: Valuation Task

across lists and represented participants' payoffs from each of the four decision problems against both opponent types from the first part of the experiment. Option B paid with certainty and started at \$8 in the decision of the choice list, and increased by \$0.25 as the participant moved from one line to the next until \$14. For each decision problem, we showed participants their notes from the first part of the experiment to remind them of their reasoning behind their action choices.

Finally, one of the choice problems in one of the choice lists was randomly selected, and the participants' choice in that choice problem determined their payment. If a participant chose the sure amount in Option B, then they received the payment specified in Option B in that choice problem. If a participant opted for Option A, then their payment depended on the action chosen in the decision problem in the first part of the experiment, if their Player Z was an undergraduate student from any year or discipline or a Ph.D. student in Economics, and on the action chosen by Player Z. Figure 5 highlights the timeline of the experiment and summarizes the key features.

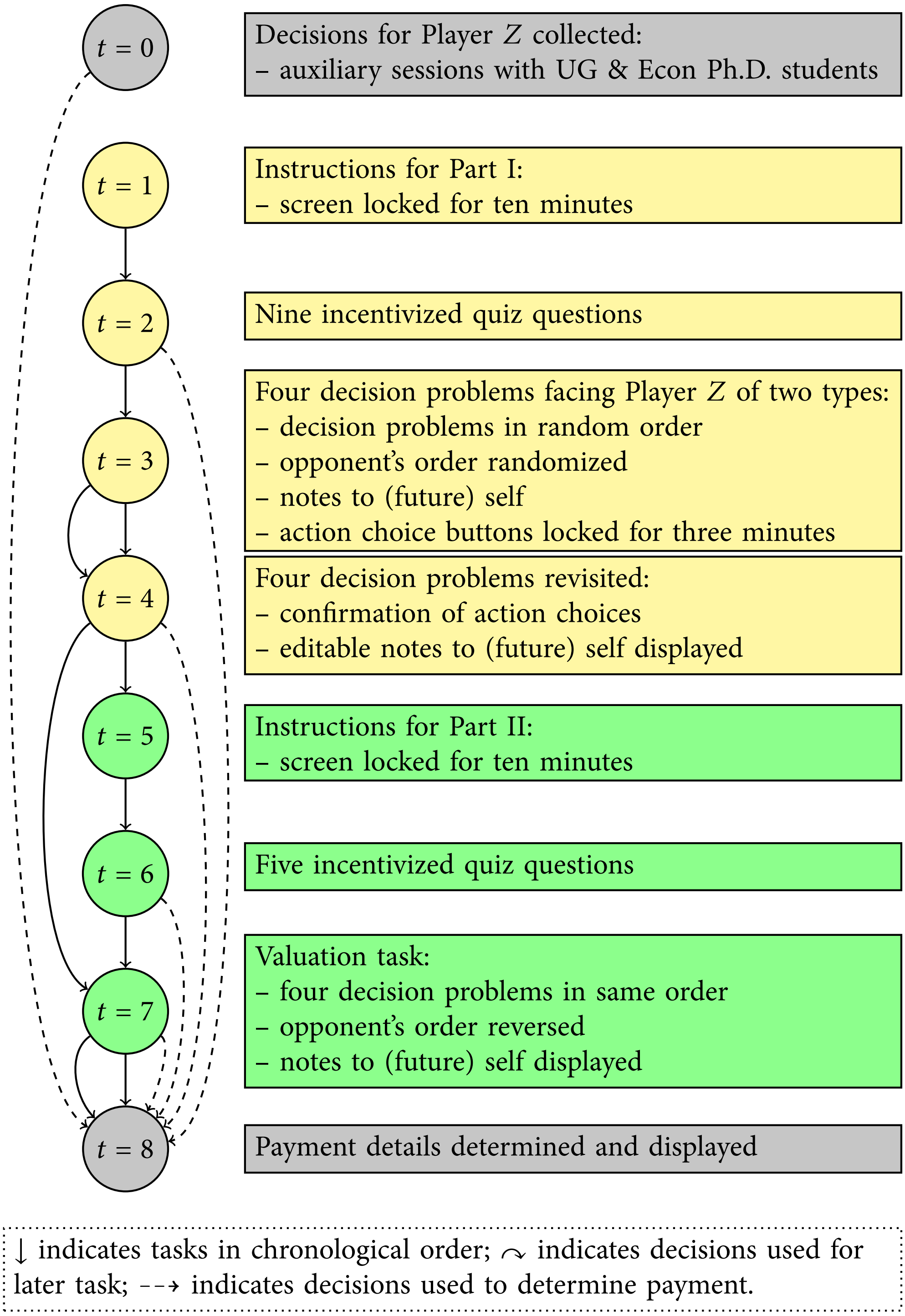


Figure 5: Timeline of the Experiment

3.2 Participants and Procedure

We conducted the experiment online due to the COVID-19 pandemic in April 2020 with students enrolled at The University of Toronto. Participants were recruited from Toronto Experimental Economics Laboratory's (TEEL) pool using ORSEE (Greiner 2015). No subject participated in more than one session. Participants signed up ahead of time for a particular day, either the 4^{th} or 5^{th}

of April 2020 for the auxiliary part of the experiment; or the 11^{th}, 13^{th}, and 15^{th} to 20^{th} of April 2020 for the main experiment. On the day of the experiment, we sent participants an electronic link at 8 AM EDT, and they had to complete the tasks by 8 PM EDT. During this time window, participants could contact an experimenter via cell phone or Skype for assistance. After reading the instructions, participants had to correctly answer nine incentivized comprehension questions before starting the first task, and further five incentivized comprehension questions before starting the second task. We paid $0.25 for answering each question correctly on their first trial. If participants made a mistake, no payment was made for that question, but they had to answer it correctly in order to move to the next question. The experiment was programmed in oTree (Chen, Schonger, and Wickens 2016). We recruited a total of 244 (9 for the auxiliary sessions and 235 for the main experiment) participants and all payments were made via Interac e-transfer, a commonly used payment method by Canadian banks that only requires an e-mail address and a bank account. The average participant earned approximately $18 (maximum payment was $22.50 and minimum payment was $5.50), including a show-up payment of $5. All payments were in Canadian dollars. The instructions and experimental interface are reproduced in the Online Appendix.[18]

3.3 Discussion of the Implementation and Procedure

The core idea of this paper is to identify a novel behavior that reflects the participants' belief that while other participants may be rational, they cannot model the behavior of them and hence predict it. Thus far, we developed an identification strategy for such behavior and before presenting the results on the evaluation of its pervasiveness, we briefly discuss some aspects of the experimental implementation and its procedure. We collected Player Z's decisions on action choices in the four games in two separate auxiliary sessions. This has the following advantages: First, we were able to match participants (Player Y and Player Z) with the same sophistication level. Second, we could collect all decisions in the main experiment in an "individual decision-making" framework. As we collected the data during the COVID-19 pandemic, we could not run any experiment sessions in the laboratory. Instead, undergraduate students enrolled at The University of Toronto participated remotely. Thus, we were able to avoid any coordination issues stemming from simultaneous strategic decision-making in an online context. Lastly, as payments in the auxiliary sessions had materialized already, this design can ameliorate utilitarian choices of the participants in the main experiment. As alluded to above, all experiment sessions took place online. To avoid quick heuristic-based decision-making, we forced participants to spent at least 10 minutes on each set of instructions and at least 3 minutes on each of the four games against either opponent type before buttons were activated. Further, we presented all four games in random order to avoid any order effects, and, in addition, gave participants the opportunity to revise their decisions after they were exposed to all four games and had selected an action choice. Remaining conscious of possible order effects, we also reversed the opponent order between the two parts of the experiment. That is, if participants faced always an undergraduate student before a Ph.D. student in Economics when choosing an action, then they always faced a Ph.D. student in Economics before an undergraduate student in the valuation task and *vice versa*. A possible downside of our online experiment – though not a characteristic that is unique to our experiment – is the reduction of control. As such,

[18] A live version with all dynamic elements displayed to participants can be accessed upon request.

we may expect noisier data relative to "standard" laboratory experiments. Nevertheless, there is no reason to expect behavioral deviations in any systematic way.

4 Results

We break the analysis into four sections. We begin with presenting the aggregate experimental results focusing first on preferences between *LG* and *DS* and then explore the valuation data across all four games. Third we will focus on behavior conditional on the opponent's identity: whether Player Z was an undergraduate student or a Ph.D. student in Economics. Last we consider non-choice data embedded in the subject's notes.

4.1 Aggregate Choices

In total, we collected data of $N = 235$ participants. We impose two exclusion restrictions at the subject-level for the *LG* and *DS* choices. First, we include only participants in our analysis whose valuations are consistent with them being rational. That is, we exclude participants from our analysis whose valuations are inconsistent with best-responding.[19] Second, we exclude participants from our analysis who played b in *DS*, as it is inconsistent with the iterative 'top-down' model of reasoning and would require a large deviation from 'belief in rationality' to be a best response. We are carefully removing these participants as we do not want to confound a preference for the predictability of the opponent's behavior with participants holding "eccentric" beliefs and hence resulting in *DS* being valued at $v = 13$. Since we are interested in participants that satisfy these exclusion restrictions against both opponent types (the intersection), we restrict attention to $n = 161$ participants.[20] Table 1 provides an overview of the frequency of actions choices in *LG* and *DS*.

Table 1: Frequency of Action Choices in the Diagnostic Games

Action	*LG*	*DS*
a	230/322	20/322
b	28/322	—
c	39/322	302/322
d	25/322	—

All choices made irrespective of opponent type.

In *LG*, approximately 71% of choices are concentrated on action a, and the remainder is roughly equally distributed among actions b, c, and d. In *DS*, roughly 94% of choices fall on action c with the remaining 6% playing action a.

As a first pass, we summarize choice behavior and the ranking of *DS* and *LG* irrespective of the opponent type. Table 2 lists these results.

The observed choices are clearly at odds with the predictions of the iterative reasoning model or Nash equilibrium. While players are predicted to strictly prefer *LG* over *DS*, less than half of all

[19] More precisely, we exclude subjects whose valuations exceed the maximum possible payoff given their action choice (e.g., playing action a with a valuation $v = 14$ in *DS*) and those playing a in *DS* with a valuation $v \geq 12$.

[20] All analyses reported in the main text are replicated for all participants in our sample. These results are reported in Appendix A.

Table 2: Aggregate Results

	$DS \succsim LG$	$DS \prec LG$
$I - R$ Prediction	*nil*	*all*
Ratio	170/322	152/322
Percentage	52.8%	47.2%

All choices made irrespective of opponent type.
$I - R \equiv$ Iterative 'top-down' model of reasoning.

observed choices are in line with the prediction. This is the first evidence at the aggregate choice-level that suggests that participants may value the predictability of their opponents' actions. Put differently, the majority of choices suggest that participants are not able to model, and hence predict, the behavior of others in *LG*.

Introducing controls As a next step, we include the two control games in our aggregate-choice analysis. We are interested in those participants who weakly prefer the dominance-solvable game *DS* over the more complex game *LG*, and not those who may have a preference for smaller games or Nash equilibrium in pure strategies *per se*. To do so, we first extend the requirement that participants make choices consistent with best-responding to both *MS* and *NE* games[21] As a result, we are now focussing on 121 participants facing an undergraduate student and 119 participants facing a Ph.D. students in Economics, respectively. Table 3 lists these results of 240 choices irrespective of opponent type. As is evident, controlling for best-response inconsistency at the aggregate choice level does not make a substantial dent on participants' overall ranking of *DS* and *LG*.

Table 3: Aggregate Results – Controlling for Best-Response Inconsistency and Equal Valuations of All Smaller Games

	$DS \succsim LG$	$DS \prec LG$
$I - R$ Prediction	*nil*	*all*
Control #1	117/240	123/240
B-R Inconsistency	48.8%	51.2%
Control #2	110/225	115/225
Equal Valuations	48.9%	51.1%

All choices made irrespective of opponent type excluding all choices that C#1: inconsistent with best-responses; C#2: value *DS*, *MS*, and *NE* equally.
$I - R \equiv$ Iterative 'top-down' model of reasoning.

Next, we leverage *MS* and *NE* and, in this step, exclude only those choices that value all small games equally, i.e., $v_{DS} = v_{MS} = v_{NE}$ (Control #2 in Table 3). This allows us to control for those participants who have high valuations in *DS* relative to *LG* not because it is easier to predict behavior in this game, but rather because of a preference for smaller games or Nash equilibrium in pure strategies. This results in concentrating on 116 participants playing against an undergraduate student and 109 participants playing against a Ph.D. students in Economics, respectively.

[21] In particular, in this step, we remove participants who play a with a valuation $v \geq 12$, and further exclude those whose valuations exceed the maximum possible payoff given their action choice in either of the two control games.

This control does not make a substantial dent on the overall ranking of *DS* and *LG* either. The conclusion remains qualitatively the same when allowing for one line difference (±0.25) in valuations across all small games with 106/213 weakly preferring *DS* over *LG* and 107/213 strictly preferring *LG* over *DS*, respectively. Overall, the inclusion of the controls does not alter the results. While the ratio of those who weakly prefer *DS* over *LG* somewhat decreases, the big picture still suggests that participants may value the predictability of their opponents' actions.[22]

Aggregate choices – belief that opponent is rational This is also true – and even more strongly pronounced – if participants believe that their opponents are rational. This means that the player is confident that Player Z is rational. Our design allows us to identify these participants by exploiting the valuation data collected in the second part of our experiment. Table 4 summarizes the choice behavior by the ranking of *DS* and *LG* irrespective of the opponent type but conditional on believing in the opponent's rationality.

Table 4: Aggregate Results – Belief that Opponent Is Rational

	$DS \succsim LG$	$DS \prec LG$
$I - R$ Prediction	*nil*	*all*
Ratio	113/177	64/177
Percentage	63.8%	36.2%

All choices made irrespective of opponent type conditional on believing in opponent's rationality.
$I - R \equiv$ Iterative 'top-down' model of reasoning.

4.2 Empirical Value Distributions

We revert to the (unconditional) aggregate results as summarized in Table 2. Moving beyond summary statistics, we now turn to the empirical distribution of valuations by the ranking of *DS* and *LG* induced by the valuations. Thus far we only discussed the ordinal information gathered in our experiment. Now we enrich our discussion by leveraging the cardinal information obtained in the valuation task. Figure 6 visualizes the empirical distributions of the valuations of the two diagnostic games, *DS* and *LG*, as well as the two control games, *MS* and *NE*.

For the diagnostic games, the value distribution for *DS* (*LG*) is significantly higher (lower) in stochastic dominance when $DS \succsim LG$ than $DS \prec LG$: two-sample Kolmogorov-Smirnov test produces $p < 0.001$.[23] While differences between how the two groups value *DS* and *LG* are expected given how the groups are defined, the value distributions provide further support for the idea that the $DS \succsim LG$ group prioritizes reasoning about rationality as an organizing principle. First, the large differences between the empirical value distributions in *LG* indicates that the $DS \succsim LG$ participants face difficulties in modeling and predicting the opponents' behavior in *LG* – a game where

[22] A potential concern may arise because we used choice lists to elicit participants' approximate valuation for each game. As these lists are discrete we could potentially misclassify participants. Those participants who valued both *LG* and *DS* *exactly* at 12.25 could be classified as ranking *DS* weakly above *LG* even though being consistent with the iterative 'top-down' model of reasoning. Of the 322 choices presented in Table 2, only 24 choices value both games exactly at 12.25. For the controls, this number reduces further to 9 of 240 and 8 of 225 choices.

[23] In this discussion of empirical value distributions, all reported p-values are associated with two-sample Kolmogorov-Smirnov tests.

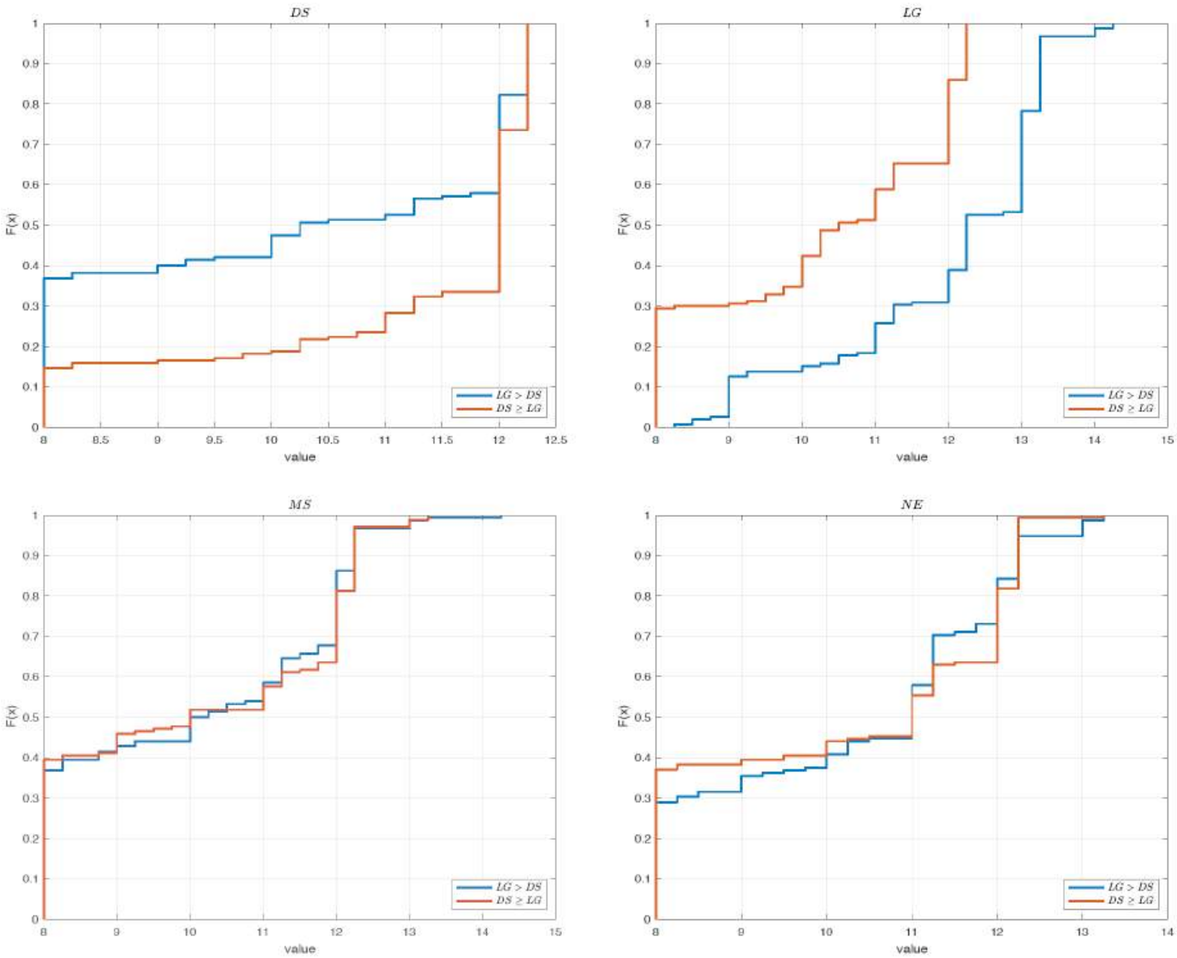


Figure 6: Empirical Value Distributions of All Games by the Ranking of *DS* and *LG* for All $n = 322$ Choices. Top Row: The diagnostic games. Left: *DS*; Right: *LG*; Bottom Row: The control games. Left: *MS*; Right: *NE*.

reasoning about rationality plays no predictive role. Second, participants' valuation in *DS* allows us to infer their (confidence in their) beliefs about rationality: we can infer that participants with $12 \leq v \leq 12.25$ believe that their opponents are rational. Thus, the large differences between the empirical value distributions in *DS* indicates that the $DS \succsim LG$ group is more likely to believe in rationality relative to the $DS \prec LG$ group.

For the two control games, the empirical value distributions by ranking of *DS* and *LG* (the two groups) overlap and cross each other several times as well. Thus, it is not surprising that no statistically significant differences can be detected ($p \geq 0.412$). This also supports the hypothesis that the relative preference for *DS* over *LG* between the two groups is not driven by a preference for small games or Nash equilibrium in pure strategies as these two groups value *MS* and *NE* similarly. Comparing the empirical value distributions across all small games also sheds some light on how participants value *DS* relatively to *MS* and *NE*. Irrespective of the the ranking of our diagnostic games, a significantly larger mass of choices concentrates at $12 \leq v \leq 12.25$ compared to the two control games. We interpret this as an indication that for our participants the opponents' behavior in *DS* is indeed easier to model and choices easier to predict.

So far we only visualized the empirical value distributions separately for each game by the ranking of the set of diagnostic games. The novel behavior we propose is rooted in the player's belief that while other players may be rational, they cannot model the behavior of others and hence predict it. In Figure 7, we show the empirical value distributions for all games by the ranking of *DS* and *LG*.

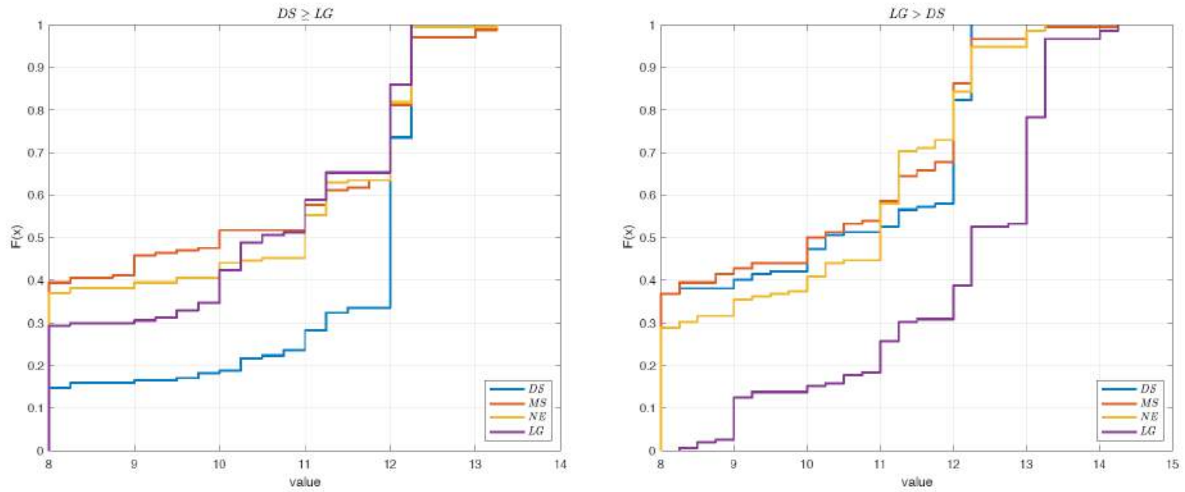


Figure 7: Empirical Value Distributions of *DS*, *MS*, and *NE* by Ranking of *DS* and *LG*

For the $DS \succsim LG$ group, the valuation distribution for *DS* first-order stochastically dominates the valuation distributions of the two control games (both $p < 0.001$). Further, no statistical differences are observed when comparing the distributions of the two control games ($p = 0.657$). By contrast, when $DS \prec LG$, the valuation distributions of all small games overlap and are statistically indistinguishable from each other with the exception of *DS* and *NE* ($p = 0.047$).[24] We interpret these findings as further evidence that for approximately half of our participants, *DS* is indeed very attractive because it permits easier modeling and hence predicting the opponent's choices. The other half of participants, however, appear not to distinguish between the small games and, *inter alia*, have strictly higher valuations for *LG* than *DS*.

Empirical value distributions – belief that opponent is rational We have established that a large fraction of choices weakly prefer *DS* over *LG*. This observation is even starker for those believing in the opponent's rationality – behavior that our identification strategy aims to capture by concentrating on those who played c in *DS* with $12 \leq v \leq 12.25$. In other words, now we emphasize observed choices by participants who believe that their opponents are rational. Below, we highlight the empirical value distributions for all games by preference relation over *DS* and *LG*, as shown in Figure 8.

Differences in empirical value distributions are even more distinct for those who rank *DS* over *LG* when holding the belief that their opponent is rational. That is, the player being confident that their opponent is rational. The valuation distribution for *DS* clearly first-order stochastically dominates the valuation distributions of the two control games as well as *LG* (all $p < 0.001$).[25] Similarly to the unconditional empirical value distributions depicted in Figure 6, when $DS \prec LG$,

[24] Differences in valuation distributions are not significant: $p = 0.397$ from comparing games *DS* vs. *MS* and *MS* vs. *NE*, respectively.

[25] Differences in valuation distributions are only significant for *LG* vs. *MS* with $p = 0.290$. By contrast, $p = 0.487$ and $p = 0.830$ from comparing *LG* vs. *NE* and *MS* vs. *NE*, respectively.

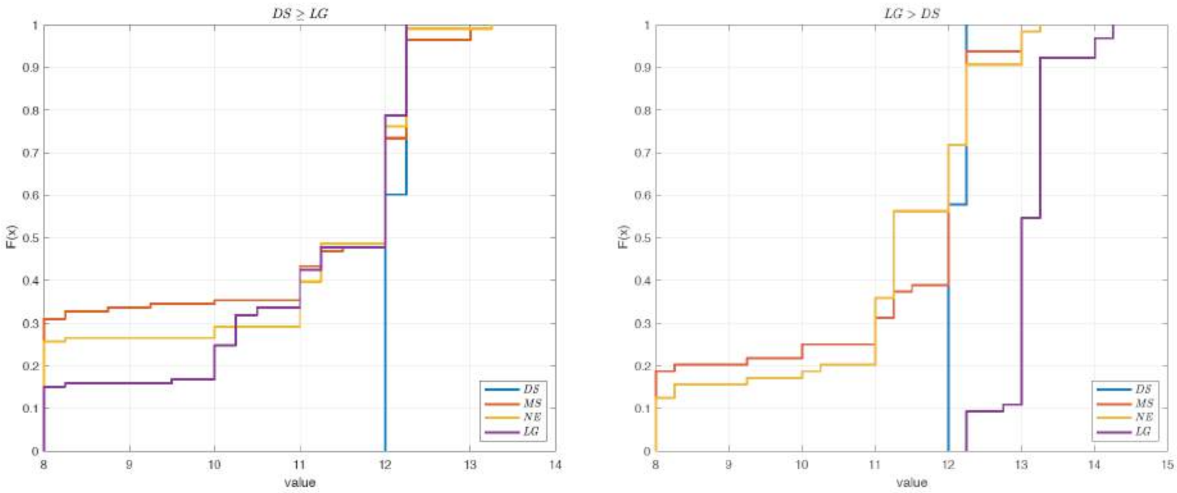


Figure 8: Empirical Value Distributions of *DS*, *MS*, and *NE* by Preference Relation

the valuation distributions of the two control games overlap and are statistically indistinguishable from each other ($p = 0.160$). Clearly, the difference between *LG* and the remaining games as well as the difference between *DS* and both *MS* and *NE* is statistically significant (all $p < 0.001$).

4.3 Opponent Type

We now turn to choices at the subject-level and discuss differences in behavior by opponent type. As before, we maintain all our exclusion restrictions discussed above and thus concentrate on $n = 161$ participants. We have established that approximately half of the choices made by these participants are consistent with difficulty of predicting others' behavior. Recall that this turns out to be true even if they believe their opponents are rational. Among this subset of participants, approximately 68% behave as though they are not able to model the behavior of others.

Table 5: Ranking of *DS* and *LG* by Opponent Type

			Undergraduate	
			$DS \succsim LG$	$DS \prec LG$
Ph.D.	$DS \succsim LG$	$I - R$ Prediction	*nil*	*nil*
		Ratio	61/161	19/161
		Percentage	37.9%	11.8%
	$DS \prec LG$	$I - R$ Prediction	*nil*	*all*
		Ratio	29/161	52/161
		Percentage	18.0%	32.3%

$I - R \equiv$ Iterative 'top-down' model of reasoning.

Table 5 shows the comparative statics of the ranking over the set of diagnostic games conditional on the opponent's identity, that is, whether participants played against an undergraduate student or a Ph.D. student in Economics.

As can be easily seen, the choices made by these participants are consistent with difficulty of modeling and hence predicting others' behavior. These numbers are not overly sensitive to the opponent's type: roughly 70% of participants exhibit a stable model of reasoning irrespective of the opponent's characteristics. That is, the majority of participants respond similarly to both undergraduates and economic Ph.D. students. Specifically, about 32% of participants can predict the choices of both undergraduate and Ph.D. students in *LG* and about 38% find it challenging to predict the choices of either. Among the remainder, of those who respond to the opponent's type, the results are split. Roughly 12% can predict the choices of undergraduates and not Ph.D. students, while 18% can predict the choices of Ph.D. students and not undergraduates.

By exploiting the cardinal information collected in the valuation task, we are able to detect not only ordinal differences in the ranking over the diagnostic games but also more nuanced differences: whether *DS* becomes relatively more or less attractive conditional on both the preference relation over *DS* and *LG* as well as the opponent's sophistication. The corresponding difference in differences of valuations ($v_{LG} - v_{DS}$) by opponent type are depicted in Figure 9.

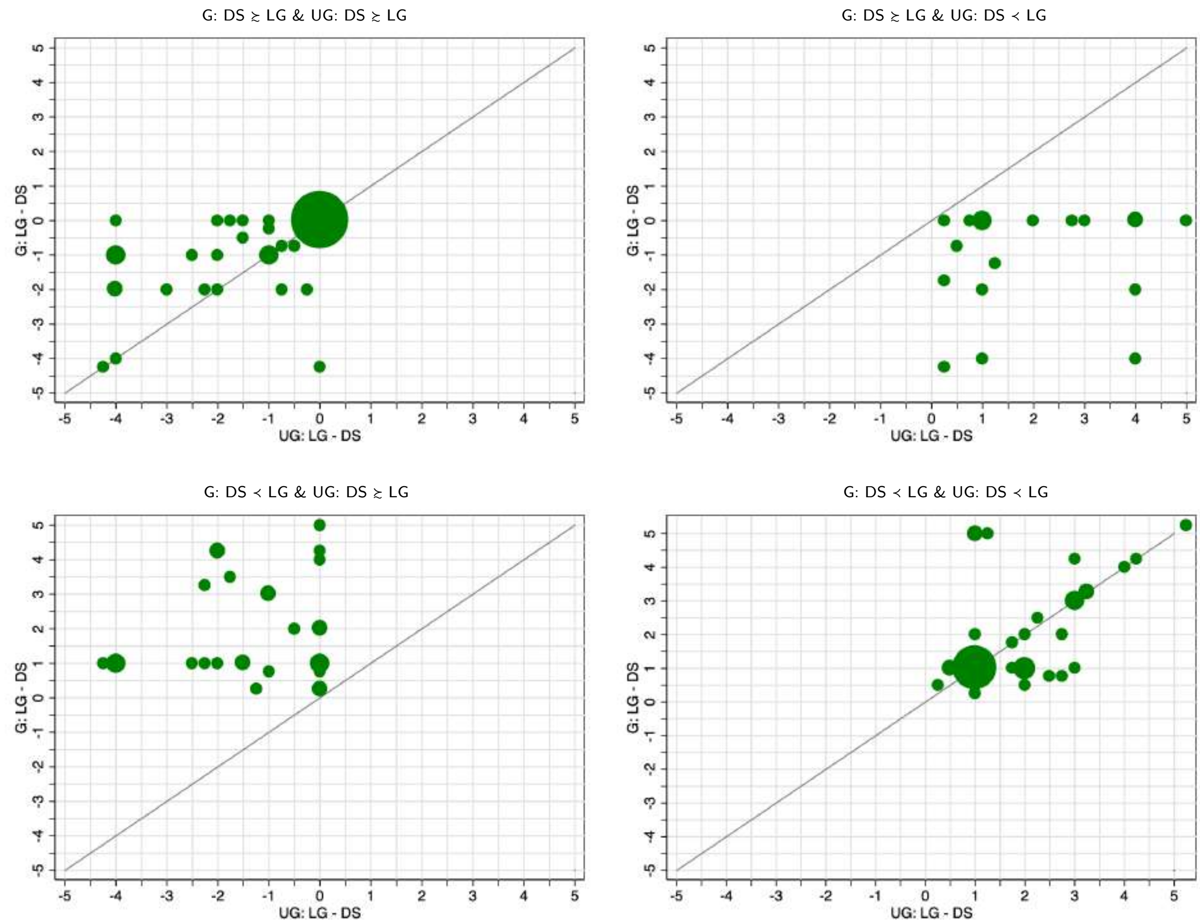


Figure 9: Difference in Differences of Valuations of *LG* and *DS* by Ranking of *DS* and *LG* and by Opponent Type

As visualized in Figure 9, depending on the preference relation over the games by opponent type, participants indeed value the games differently when facing either an undergraduate student or a Ph.D. student in Economics. On one hand, when $DS \succsim LG$ against both types, *DS* becomes relatively *less* valuable when playing against a Ph.D. student in Economics. This difference is statistically significant at the 5%-level using both t-test and Wilcoxon's signed-rank test ($p < 0.026$). On the other hand, when $DS \prec LG$, *DS* becomes relatively *more* valuable when facing a Ph.D. student in Economics. This difference, however, is not statistically significant ($p > 0.257$ for both tests). Naturally, whenever $DS \prec LG$ against one opponent type but not the other, the differences are statistically significant at the 1%-level (all $p < 0.001$). Overall, around 32% of participants can predict the choices of both opponent types and roughly 38% cannot predict the choices of either. Both groups, however, display stark asymmetries by type: *DS* becomes relatively more (less) attractive when facing a Ph.D. student in Economics whenever the participant is able (unable) to predict the choices of both (either) opponent types. The direction of these asymmetries in the observed choices by opponent type firmly surprised us. If anything, we conjectured *DS* becoming relatively *more* attractive when playing against a Ph.D. student in Economics conditional on experiencing difficulties in predicting the opponent's choices. While these findings indeed surprised us, there are obvious explanations for such behavior. To begin with, we conjectured that the – carefully designed – attractiveness of *DS* relative to *LG* would be relatively more important for Ph.D. students in Economics than undergraduate students. Put differently, we conjectured participants to be more (less) likely to hold the belief that the opponent is rational when playing against (undergraduate) Ph.D. students; which in turn dominates the potential increased unpredictability of Ph.D. students in *LG*. However, the reverse occurred in our data with the unpredictability of Ph.D. students in *LG* dominating the "rationality-impact" in *DS*. The findings do not qualitatively change when we restrict attention to those participants who hold the belief that their opponent is rational. Participants face more difficulties when predicting the opponent's choices in *LG* against Ph.D. students relative to undergraduate students. When *DS* is ranked above *LG* against both types, *DS* still becomes relatively *less* enticing when playing against a Ph.D. student in Economics. This difference is statistically significant at the 5%-level using both t-test and Wilcoxon's signed-rank test ($p < 0.034$). When *DS* is ranked below *LG*, *DS* still becomes relatively more alluring when facing a Ph.D. student. It is not statistically significant ($p > 0.160$ for both tests), as in the aggregate-choice analysis. As above, when *DS* is ranked above *LG* against one opponent type but not the other, the differences are also statistically significant at the 1%-level (all $p < 0.008$).

Robustness test As a further robustness test and to complement the non-parametric analysis and key elements discussed so far in this section, we ran ordinary least-square regressions with random effects controlling for order effects as well as the opponent order. In particular, we regressed the difference in valuations of *LG* and *DS* ($v_{LG} - v_{DS}$) on the opponent dummy *Ph.D.*, which is 0 when facing an undergraduate student and 1 when playing with a Ph.D. student in Economics, and the valuations for both *MS* and *NE*. Further, we include the game order dummy *DS before LG*, which is 0 if *LG* is displayed before *DS* and 1 if *DS* is displayed before *LG*. In addition, we also include the opponent order dummy *G before UG*, which is 0 if participants played first against an undergraduate student and afterwards against a Ph.D. student in Economics in the first part of the experiment and 1 if the order is reversed.

To account for the fact that we observe each participant repeatedly and behavior across games for the same participant is not independent, we treat each participant as our units of statistically independent observations. We first split our sample by preference relation over the set of diagnostic games and opponent type ($= 2 \times 2$) as in Table 5 and then estimate the model using the full sample. As above, we exclude participants from our analysis whose valuations exceed the maximum possible payoff given their action, those who played *b* in *DS*, and those who are inconsistent with best-responding in *DS*.[26] Table 6 lists the results from this analysis.

Table 6: OLS Estimations with Random Effects of Difference in Valuations of *LG* and *DS*

Ranking by Opponent	UG: $DS \gtrsim LG$ G: $DS \gtrsim LG$	UG: $DS \gtrsim LG$ G: $DS \prec LG$	UG: $DS \prec LG$ G:$DS \gtrsim LG$	UG: $DS \prec LG$ G: $DS \prec LG$	*All*
	$v_{LG} - v_{DS}$	$v_{LG} - v_{DS}$	$v_{LG} - v_{DS}$	$v_{LG} - v_{DS}$	$v_{LG} - v_{DS}$
Intercept	-0.649	-0.046	4.692^{**}	3.311^{***}	0.322
	(1.198)	(1.546)	(1.994)	(0.877)	(0.969)
Ph.D.	0.463^{**}	3.196^{***}	-2.810^{***}	-0.112	0.367^{*}
	(0.220)	(0.407)	(0.609)	(0.129)	(0.197)
v_{MS}	0.016	-0.221^{*}	-0.192	-0.216^{***}	-0.084
	(0.081)	(0.126)	(0.205)	(0.081)	(0.076)
v_{NE}	-0.082	0.079	-0.114	0.065	0.073
	(0.096)	(0.140)	(0.184)	(0.090)	(0.084)
DS before LG					-0.152
					(0.298)
G before UG					0.048
					(0.303)
σ_ϵ	0.972	1.253	1.369	0.599	1.483
σ_u	0.982	0.288	0.475	1.102	1.292
N	83	42	25	90	240
(Between) R-squared	0.001	0.228	0.611	0.080	0.004

***Significant at the 1 percent level; **Significant at the 5 percent level; *Significant at the 10 percent level

We find a strong effect of the observed characteristic of the opponent, *Ph.D.*, on the difference in valuations of *LG* and *DS* for all ranking as long as $DS \gtrsim LG$ against at least one opponent type. This is also mildly true for the full sample, irrespective of the ranking over the set of diagnostic games. As expected, we do not find a strong of type when $DS \prec LG$. These estimation results are in line with the difference in differences of valuations by opponent type and by ranking of *LG* and *DS*, as depicted in Figure 9. We do not find any indication of order effects, either due to presenting participants *LG* or *DS* before the other as well as playing each of the four games first against an undergraduate student or a Ph.D. student in Economics in the first part of the experiment.

4.4 Non-Choice Data

Recall that we gave participants the opportunity to write notes to their "future-self." Below each of the two diagnostic games as well as two control games against either opponent type, participants could write down the reasoning behind their choice of action in a text box. If participants decided to type anything in these text boxes, then it was displayed later on again in the experiment: the first time when participants were prompted to confirm their choice of action and a second time when facing the valuation task. We did not force participants to write anything in these text boxes, however, we told them that these notes would help them when making choices in the second part of the experiment. As expected, not all participants made use of this opportunity. Those who did,

[26]We replicated the same analysis on the entire sample and report the results in Appendix A.

however, give us the opportunity to use their notes as "the window of the strategic soul."[27] Using both action choice and valuation data, we documented evidence at the aggregate choice-level that suggests that participants may value the predictability of their opponents' behavior. Moreover, we showed that this observation is even starker if participants believe that their opponents are rational with 63.8% of choices ranking *DS* higher than *LG*. Among this subset of participants, we are curious to see whether there is any suggestive evidence of participants indicating that the opponents' actions are predictable in *DS* and *LG*, and if there is any difference by the ranking of *DS* and *LG*. We have established that 177 choices are consistent with holding the belief that their opponent is rational, meaning that the player is confident that Player Z is rational. In 106 (134) of these choices, participants decided to write notes in *DS* (*LG*). Table 7 provides summary statistics for this subset of choices by the ranking of the set of diagnostic games.

Table 7: Notes – Belief that Opponent Is Rational

Indication that Player Z's Action Is Predictable

		DS		*LG*	
		yes	*no*	*yes*	*no*
$DS \succsim LG$	Ratio	45/67	22/67	29/86	57/86
	Percentage	67.2%	32.8%	33.7%	66.3%
$DS \prec LG$	Ratio	16/39	23/39	22/48	26/48
	Percentage	41.0%	59.0%	45.8%	54.2%

Clearly, those who rank *DS* above *LG* indicate *more* frequently that the opponents' action is predictable in *DS* relative to those who rank *DS* below *LG*. Those with $DS \succsim LG$ indicate *less* frequently that Player Z's action is predictable in *LG* compared to those with $DS \prec LG$. Although participants' notes cannot be quantified in a strict sense, they nevertheless provide further qualitative support for the idea that the $DS \succsim LG$ group prioritizes reasoning about rationality as an organizing principle.

5 Theoretical Analysis

In Section 2, we provided intuitive explanations for our identification strategy. In this section, we elaborate and present a formal analysis.

5.1 Theory

Let $G = (S_1, S_2, u_1, u_2)$ be a finite 2-player game where S_i is player i's strategy set and $\pi_i : S_1 \times S_2 \to \mathbb{R}$ is player i's pecuniary payoff function, which depends on player i and the other player's $(-i)$ strategies. We allow for general expected-utility preferences over monetary payoffs. Let $\mathfrak{U}$ be the set of von Neumann-Morgenstern utility functions, which are strictly increasing functions mapping $\mathbb{R}$ to $\mathbb{R}$. For any $u_i \in \mathfrak{U}$, the function $u_i \circ \pi_i : S_i \times S_{-i} \to \mathbb{R}$ represents the utility of player i. Denote

[27] Vincent Crawford coined this term in Crawford (2008).

by $\mu_{-i} \in \Delta(S_{-i})$ player i's beliefs over player $-i$'s strategies. Extend $u_i(\pi_i(S_i, S_{-i}))$ to $u_i(\pi_i(S_i, \mu_{-i}))$ in the usual way to represent player i's expected utility.

Throughout this paper we assume that players are rational. That is, all players best respond to their beliefs about the play of others. Let $\mathbb{BR}_i$ be the best response set for each player i. This set specifies the strategies that are a best response for player i given both player i's preferences, $u_i \in \mathcal{U}$, and the belief they hold about the play of the other player, μ_{-i}. Formally, for $u_i \in \mathcal{U}$ and $\mu_{-i} \in \Delta(S_{-i})$,

$$\mathbb{BR}_i[u_i, \mu_{-i}] := \{s_i \in S_i : u_i(\pi_i(s_i, \mu_{-i})) \geq u_i(\pi_i(r_i, \mu_{-i})), \text{ for each } r_i \in S_i\}.$$

We will be interested in two solution concepts. First, the iterative 'top-down' model of reasoning, which captures how players reason when they can model the behavior of others. Second, the concept of 2-rationalizable strategies, which incorporates the assumption that player i is rational and believes player $-i$ is rational. This concept captures how players reason when they cannot model the behavior of others. We define both below.

Iterative 'top-down' models of reasoning These models are anchored in the exogenously specified L0 behavior: $\mu^0 = \mu_1^0 \times \mu_2^0 \in \Delta(S_1) \times \Delta(S_2)$. Throughout this paper we impose a standard assumption that the L0 type plays uniformly random: $\mu_i^0(s) = \frac{1}{|S_i|}$ for all $s \in S_i$. A common assumption in the literature is that L0 type exists only in the minds of others, and anchors the beliefs of all higher types. Here too, we focus on the behavior of the latter.

Before we define the behavior of an Lk type in the general 'top-down' model of reasoning, it may help to consider the simpler level-k model. This model imposes two restrictive assumptions. First, it assumes risk-neutrality which implies that u_i is the identity function I. Second, it assumes that Lk types believe that others are L$(k-1)$ types.

The behavior of all Lk types can be defined recursively, anchored on the behavior of the L0 type. Denote by $L_i^{k,levelk}$ the set of actions consistent with k iterations of reasoning by player i in the level-k model. Then $L_i^{1,levelk} = \mathbb{BR}_i[I, \mu_{-i}^0]$. This set includes any actions that maximize player i's expected payoffs given belief μ_{-i}^0. In other words, player i believes that player $-i$ is playing according to behavior prescribed by the L0 type.

Next, assume the set $L_i^{k,levelk}$ has been defined. Then we can readily define the behavior for L$(k+1)$. Let $L_i^{k+1,levelk}$ be the set of strategies s_i so that $\mu_{-i}(L_{-i}^k) = 1$ and $s_i \in \mathbb{BR}_i[I, \mu_{-i}]$. The former condition guarantees that player i's beliefs about player $-i$'s play place positive probability only on actions in L_i^k. The latter condition ensures that s_i maximizes player i's expected payoffs given beliefs. Moving forward, for player i, we will refer to any action $a_i \in L_i^{k,levelk}$ as *an action played by the Lk type*.

The behavior of an Lk type in the general 'top-down' model of reasoning generalizes the simpler level-k model to allow for three key features. First, a player may hold arbitrary risk preferences within expected-utility. Second, a player may hold any beliefs about the expected-utility preferences of other players. Third, a player of Lk type may hold *any* beliefs over lower types L0, ..., L$(k-1)$.

As in the level-k model, all Lk types' behavior is anchored in L0 and can be defined recursively. The definition of the L_i^1 set is analogous to the level-k model, except allowing for arbitrary risk preferences. Therefore, L_i^1 is the set of strategies s_i such that $s_i \in \mathbb{BR}_i[u, \mu_{-i}^0]$ for some $u \in \mathcal{U}$. The L_i^1 set then naturally includes any actions that maximize player i's expected-utility for some von

Neumann-Morgenstern utility function u given the belief μ^0_{-i}. That is, player i's belief that player $-i$ behaves according to the L0 type.

Further, assume the sets L^m_i have been defined for all $m \in \{1, \dots, k\}$. Then we can define the behavior for L$(k+1)$. Denote by R^k_i the set of strategies that can potentially be played by levels $1, \dots, k$ of player i: $R^k_i = \{\cup_{m \in \{1,\dots,m\}} L^k_i\}$. Let L^{k+1}_i be the set of strategies s_i such that there exists some $u \in \mathcal{U}$ and $\mu_{-i} \in \Delta(S_{-i})$ that satisfies the following two conditions. First, let $\mu_{-i} = p \cdot \mu^0_{-i} + (1 - p) \cdot \mu_{-i}(R^k_{-i})$ with $p \in [0, 1)$. That is, player i may assign probability $p < 1$ that player $-i$ is L0, and probability $(1 - p)$ that player $-i$ is rational but can reason at most k iterations. This ensures that player i's beliefs about player $-i$'s behavior are consistent with the assumption that players' reasoning is organized in a 'top-down' fashion. Put differently, player i can only assign positive probability on actions played by types with levels strictly less than $(k+1)$. Second, $s_i \in \mathbb{BR}_i[u, \mu_{-i}]$. This condition ensures that player i's strategy s_i maximizes their expected utility given player i's preferences u, and the belief that player $-i$ plays according to μ_{-i}. We will refer to any action a_i in L^k_i as *an action played by the Lk type* for player i. We abuse notation slightly by referring to either $a_i \in L^{k,levelk}_i$ or $a_i \in L^k_i$ as an action played by the Lk type, but make it clear in our discussion whether we refer to the simpler level-k model or the more general iterative 'top-down' model of reasoning.

2-rationalizability The solution concept of 2-rationalizable strategies incorporates both the assumption of rationality and belief in rationality. We can define this solution concept recursively in the following way. Let S^1_i be the set of strategies s_i such that there exists some $u \in \mathcal{U}$ and $\mu_{-i} \in \Delta(S_{-i})$ with $s_i \in \mathbb{BR}_i[u, \mu_{-i}]$. The set S^1_i includes all rational strategies for player i. These are a best response for player i given their preference u and beliefs μ_{-i} about player $-i$'s play. We refer to any action a_i in S^1_i as a *1-rationalizable strategy*. Given this, we can define S^2_i as the set of strategies s_i so that there exists some $u \in \mathcal{U}$ and $\mu_{-i} \in \Delta(S_{-i})$ that satisfies the following conditions. First, $s_i \in \mathbb{BR}_i[u, \mu_{-i}]$, which ensures that s_i maximizes player i's expected utility given the belief that player $-i$ behaves according to μ_{-i}. Second, $\mu_{-i}(S^1_{-i}) = 1$, which guarantees that player i believes rationality. That is, player i can only place positive probability on 1-rationalizable strategies, which are the strategies consistent with the assumption that player $-i$ is rational. We will refer to any action s_i in S^2_i as a *2-rationalizable strategy*.

5.2 Revisiting the Diagnostic Games

The large game "LG" To set the stage, we first consider the simpler level-k model. First, note that we can denote any probability measure $p \in \Delta(S_1)$ (and $p \in \Delta(S_2)$, respectively) as a 4-tuple (p_1, p_2, p_3, p_4). This represents the probabilities over $\{a, b, c, d\}$ (and $\{A, B, C, D\}$, respectively). Then in this game, L0 behavior is given by $\mu^0 = (1/4, 1/4, 1/4, 1/4)$ for both players. Moreover, the $L^{k,levelk}_i$ sets can then be calculated recursively given the anchor μ^0:

$$L^{k,levelk}_1 = \begin{cases} \{a\} & \text{if } k \bmod 4 = 1, 2 \\ \{b\} & \text{if } k \bmod 4 = 0, 3 \end{cases} \qquad L^{k,levelk}_2 = \begin{cases} \{C\} & \text{if } k \bmod 4 = 0, 1 \\ \{B\} & \text{if } k \bmod 4 = 2, 3 \end{cases}$$

The L1 type of Player 1 plays actions a or b as this type is agnostic about the other player's action choice as they do not believe that their opponent is rational. Therefore, the L1 type plays a or b as actions c or d induce payoffs that are dominated action a's payoffs. Notice that a is naturally a best response to the belief that Player 2 is the L0 type and plays actions in $\{A, B, C, D\}$ with equal chance. Similarly, the L1 type of Player 2 plays action C as this action delivers the highest payoffs.[28] The L2 types then best respond to L1 behavior: the L2 type of Player 1 plays a and the L2 type of Player 2 plays B. The L3 types then best respond to L2 behavior: the L3 type of Player 1 plays b and the L3 type of Player 2 plays B. This process continues for higher types *ad infinitum*. Thus, the level-k model predicts that Player 1 plays actions in $\{a, b\}$ (and Player 2 plays actions in $\{B, C\}$).

The more general iterative 'top-down' model of reasoning delivers identical predictions as the level-k model: Player 1 plays actions in $\{a, b\}$ (and Player 2 plays actions in $\{B, C\}$). The L_i^k sets can then be calculated recursively given the anchor μ^0:

$$L_1^k = \{a, b\} \text{ if } k \geq 1 \qquad\qquad L_2^k = \begin{cases} \{C\} & \text{if } k = 1 \\ \{B, C\} & \text{if } k \geq 2 \end{cases}$$

Recall that the L1 type can play any strategy $s_i \in L_i^1$. A strategy s_i is in L_i^1 if there exists some $u \in \mathcal{U}$ such that $s_i \in \mathbb{BR}_i[u, \mu^0]$. Clearly, action a is in L_1^1 as it maximizes the expected payoff under the player's belief μ^0. Importantly, we also need to ensure that a is the only choice that maximizes expected utility for every von Neumann-Morgenstern utility function u.[29] We begin with the observation that a strategy $s_i \in S_i$ induces a lottery through the belief $p \in \Delta(S_{-i})$, which we denote $s_{i,p}$. For example, the lottery $a_{\mu^0} = (13, 1/4; 12, 1/4; 11, 1/4; 0, 1/4)$, in which Player 1 receives with equal chance the pecuniary payoffs of 13, 12, 11, and 0. This lottery first-order stochastically dominates the lotteries c_{μ^0} and d_{μ^0}. Thus, actions c and d cannot maximize the player's expected utility. The remaining action to consider is b. Notice that neither lotteries a_{μ^0} nor b_{μ^0} first-order stochastically dominate each other. This means that we can find some $u_b \in \mathcal{U}$ where $u_b(\pi(b, \mu^0)) \geq u_b(\pi(a, \mu^0))$. It follows that $b \in \mathbb{BR}_i[u_b, \mu^0]$. In fact, if player i is extremely risk-seeking, then action b is their best response. To summarize, $L_1^1 = \{a, b\}$. Analogous arguments can be made for Player 2 to show that $L_2^1 = \{C\}$.

The L2 type of Player 1 can hold any belief about the play of Player 2 that takes the form of a mixture between μ^0 and $(0, 0, 1, 0)$. That is, beliefs take the form $\mu_2 = (p_0/4, p_0/4, p_0/4 + (1 - p_0), p_0/4)$ for some $p_0 \in [0, 1)$. The lottery a_{μ_2} still first-order stochastically dominates the lotteries c_{μ_2} and d_{μ_2} for any $p_0 \in [0, 1)$. Thus, $L_1^2 = \{a, b\}$.

For Player 2, the L2 type can hold any belief about Player 1's behavior that is a mixture between μ^0 and the two degenerate beliefs: $(1, 0, 0, 0)$ and $(0, 1, 0, 0)$. In other words, beliefs take the form $\mu_1 = (p_0/4 + p_a, p_0/4 + p_b, p_0/4, p_0/4)$ for some $p_0, p_a, p_b \in [0, 1]$ with $p_0 + p_a + p_b = 1$ and $p_0 < 1$. Consider the case where $p_a \neq 1$, then the lottery C_{μ_1} first-order stochastically dominates the lotteries A_{μ_1} and D_{μ_1}. Next, consider the case where $p_a = 1$, then the lottery B_{μ_1} first-order stochastically dominates the lottery x_{μ_1} for $x \in \{A, C, D\}$. Thus, we conclude that $L_2^2 = \{B, C\}$. Moreover, for both

[28] Notice that actions a and C maximize the expected payoff under the players' belief μ^0 as well. Further, our qualitative data provides suggestive evidence that L1 types' behavior is consistent with selecting the row that contains the highest sequence of numbers.

[29] In what follows we will rely on the the following equivalence: a lottery p first-order stochastically dominates lottery q if and only if p is preferred to q for all $u \in \mathcal{U}$.

players and using arguments analogous to those made above, it can be shown that $L_1^k = \{a, b\}$ and $L_2^k = \{B, C\}$ for all $k \geq 3$.

We now turn to the predictions when Player 1 only believes that Player 2 is rational, and nothing beyond that. This includes the scenario where Player 1 believes that Player 2 may be more sophisticated than Player 1. We are interested specifically in the 2-rationalizable set for Player 1, which captures the case of a player who is rational and believes that Player 2 is rational. Here, Player 1 believes that Player 2 plays a 1-rationalizable strategy. The 2-rationalizable set for Player 1 and the 1-rationalizable set for Player 2 are:

$$S_1^2 = \{a, b, c, d\} \qquad\qquad S_2^1 = \{A, B, C, D\}$$

It is straightforward to see that all actions for Player 2 are 1-rationalizable. This is the case as each action maximizes expected payoffs under some degenerate belief about the play of Player 1. It follows that all actions are 2-rationalizable for Player 1 as each action for Player 1 maximizes expected payoffs under some degenerate belief about Player 2's behavior.

Lastly, we elicited participants' valuation for each game, i.e., their certainty equivalent. Since player's utility function is monotone, the analyst can infer their ranking over the games. Moreover, the valuations reveal important information about participants' beliefs. As such, we can learn whether the level-k model or the more general iterative 'top-down' model of reasoning is an accurate predictor of participants' behavior.

In the iterative 'top-down' model of reasoning, restricting attention to types that are rational and believe that their opponent is rational confines attention to types that assign zero weight on others being the L0 type. The expected payoff in the *LG* game must be *strictly greater than 12* for these types. It is straightforward to confirm this claim by setting $p_0 = 0$ in the above arguments. This means that any type holds a belief that is a mixture of $(0, 1, 0, 0)$ and $(0, 0, 1, 0)$. For any such belief $\mu_2 = p(0, 1, 0, 0) + (1 - p)(0, 0, 1, 0)$, the lottery $a_{\mu_2} = \big(12, p; 13, (1 - p)\big)$ delivers a payoff strictly above 12 whenever $p \neq 1$ and the lottery $b_{\mu_2} = \big(14, p; 0(1 - p)\big)$ delivers a payoff of 14 whenever $p = 1$. To summarize, players who are rational and hold the belief that their opponents are rational believe that they can guarantee themselves a payoff that is strictly greater than 12. It follows that the certainty equivalent of *LG* for any expected utility player who believes that their opponent is rational is strictly higher than 12.

Caution is potentially warranted if Player 1 is ambiguity averse as they may value *LG* at 12. This, however, can only occur under an extreme form of ambiguity aversion coupled with the player holding degenerate beliefs. It requires Player 1 to play the "safe" action a, to have maxmin expected-utility preferences *and* their set of priors must include beliefs that Player 2 plays B with certainty and a prior that assigns a probability strictly less than $6/7$ that Player 2 plays B.[30]

Moving to payoffs when applying the concept of 2-rationalizability. A player that believes others are rational can hold any belief over Player 2 choosing a 1-rationalizable action. This means that in

[30] Whether this is an important concern is an empirical question. We can exploit participants' actions and valuations in the control games to evaluate if ambiguity aversion dominates participants' valuations. If we allow for for maxmin expected utility preferences, and allow that the set of priors of a player of level $(k + 1)$ includes all degenerate priors consistent with the strategies in L_2^k in the control games, then (for any action in) *MS* has to be valued at 8 and *NE* at 11 (when playing action a). In our data, of all choices, only 2 choices exhibit such extreme form of ambiguity aversion.

the *LG* game Player 1 can hold any belief about the play of Player 2. In this case, such players may *not* believe that they can guarantee themselves any certain payoff. Moreover, one might reasonably conjecture these expected payoffs to be less than 12.

The dominance-solvable game "DS" As in *LG*, we first introduce the predictions of the level-k model. In this game, the L0 behavior is given by the 3-tuple $\mu^0 = (1/3, 1/3, 1/3)$ for both players. Consequently, the $L_i^{k,levelk}$ sets can then be calculated recursively given the anchor μ^0:

$$L_1^{k,levelk} = \begin{cases} \{a\} & \text{if } k = 1 \\ \{c\} & \text{if } k \geq 1 \end{cases} \qquad\qquad L_2^{k,levelk} = \{A\} \text{ if } k \geq 1$$

The L1 type of Player 1 plays action a that maximizes their expected payoff as the payoffs induced by action c are dominated by those induced by action a. Similarly, the L1 type of Player 2 plays action A.[31] As action A is strictly dominant for Player 2, all Lk types with $k \geq 1$ play A. In turn, the L2 type of Player 1 plays c and the L2 type of Player 2 plays the strictly dominant action. This processes continues *ad infinitum*, however, no new actions are being played. Thus, the level-k model predicts that Player 1 plays actions in $\{a, c\}$ (and Player 2 plays the unique action in $\{A\}$).

In this game, the predictions of the level-k model and the iterative 'top-down' model of reasoning are *not* identical. In the more general model, allowing players to hold arbitrary expected utility preference expands the set of actions that could be played by Player 1. The iterative 'top-down' model of reasoning predicts that Player 1 chooses actions in $\{a, b, c\}$ (and Player 2 plays actions in $\{A\}$). The L_i^k sets are shown below. These can be calculated recursively given the anchor μ^0.

$$L_1^k = \begin{cases} \{a, b\} & \text{if } k = 1 \\ \{a, b, c\} & \text{if } k \geq 2 \end{cases} \qquad\qquad L_2^k = \{A\} \text{ if } k \geq 1$$

We begin with the behavior of the L1 type and consider Player 1. Action a is in L_1^1 as it maximizes expected payoffs under the belief μ^0. The lottery a_{μ^0} first-order stochastically dominates the lottery c_{μ^0} and neither a_{μ^0} nor b_{μ^0} first-order stochastically dominate each other. In fact, if Player 1 is extremely risk-seeking, then action b is their best response. Therefore, $L_1^1 = \{a, b\}$. As above, analogous arguments can be made for Player 2 to show that $L_2^1 = \{A\}$.

Turning to the behavior of the L2 type of Player 1, action c maximizes expected payoffs under the degenerate belief $(1, 0, 0)$, and thus $L_1^2 = \{a, b, c\}$. As action A is strictly dominant for Player 2, $L_2^k = \{A\}$ for $k \geq 1$.

Lastly, we briefly discuss the 2-rationalizable predictions. Again, since A is strictly dominant for Player 2, it is the unique 1-rationalizable action. It follows that the only 2-rationalizable action for Player 1 is c.

$$S_1^2 = \{c\} \qquad\qquad S_2^1 = \{A\}$$

[31] Actions a and A also maximize the expected payoff under the players' belief μ^0.

In this game, a rational type who believes that their opponent is rational must hold beliefs of the form $(1,0,0)$. Such players believe that they can guarantee themselves a payoff of *exactly 12* with certainty. Notice that reasoners who cannot model, and hence predict, Player 2's behavior – beyond the belief that Player 2 should play a 1-rationalizable strategy – might reasonably rank *DS* over *LG*.

If Player 1 plays *c* and values the game less that 12 it reveals to the analyst that the participant is not confident that Player 2 is rational. Further, such valuations shed light on whether the simpler level-*k* model or the more general iterative 'top-down' model of reasoning that explicitly allows for dispersed beliefs predicts participants' behavior more accurately.

Player 1's preferences over LG and DS We first restrict attention to players that are rational *and* believe that their opponents are rational. Consider the preferences of such types over the two diagnostic games: *LG* and *DS*. Although *DS* has a smaller strategy space compared to *LG* and is dominance-solvable, the game's expected payoff of 12 is strictly lower than the expected payoff of *LG* in the iterative 'top-down' model of reasoning. In other words, a 'top-down' iterative-reasoner should strictly prefer to play *LG* over *DS*.

We now relax the assumption of belief in rationality. When considering the 'top-down' model of reasoning, this means that we allow players to place positive weight on the L0 type. Fix $p_0 \in [0,1)$ as the probability assigned to the L0 type. In *LG*, the belief of a 'top-down' reasoner takes the following form: $\mu_2^{LG} = p_0(1/4, 1/4, 1/4, 1/4) + p_B(0,1,0,0) + p_C(0,0,1,0)$ for some $p_B, p_C \in [0,1]$ with $p_0 + p_B + p_C = 1$. In *DS*, the belief of such reasoner is $\mu_2^{DS} = p_0(1/3 1/3, 1/3) + (1-p_0)(1,0,0)$.

First, notice that the lottery $a^{LG}_{\mu_2^{LG}} = \left(0, p_0/4; 12, p_0/4 + p_B; 13, p_0/4 + p_C; 11, p_0/4\right)$ first-order stochastically dominates the lottery $a^{DS}_{\mu_2^{DS}} = (0, p_0/3 + p_A; 12, p_0/3; 11, p_0/3)$ for all p_0, p_B and p_C. Further, the lottery $a^{LG}_{\mu_2^{LG}}$ also first-order stochastically dominates the lottery $c^{DS}_{\mu_2^{DS}} = (12, 1 - 2p_0/3; 8, p_0/3; 0, p_0/3;)$ for all p_0, p_B and p_C. Thus, any iterative 'top-down' reasoner prefers to play the *LG* game over actions *a* or *c* in the *DS* game, regardless of risk preferences.[32]

6 Concluding Remarks

In iterative reasoning models, each player best-responds to belief that other players reason to some finite level. In this paper, we propose a novel behavior that captures players holding the belief that their opponent could be rational but they cannot model their behavior. Reverting to our example from the introduction, it encompasses a situation where a player believes that their opponent can reason to a higher level than they do. We developed a novel experimental design that permits us to identify such behavior, and evaluate it experimentally.

We find that approximately half of the choices made by participants are consistent with difficulty of predicting others' behavior. This is true especially if they believe their opponents are rational.

[32] The only potential caveat here is that there may be an iterative 'top-down' reasoner who is extremely risk seeking *and* at the same time very pessimistic about the rationality of others (high p_0), and as such prefers the lottery $b^{DS}_{\mu_2^{DS}} = (5, p_0/3; 13, 1 - 2p_0/3; 0, p_0/3)$ over any lotteries induced by the *LG* game. Such choices are extremely rare in our data. Of 470 choices in total, only 8 participants choose to play *b* in *DS* and value the game at $13 \leq v \leq 13.25$. As in the analysis presented in Section 4, if we control for such players by focusing on those who play *a* or *c* in the *DS* game, the iterative 'top-down' model of reasoning makes the unambiguous prediction that such players rank *LG* over playing *a* or *c* in *DS*.

Among those, 64% behave as though they are not able to model the behavior of others.

Interestingly, approximately 70% of participants exhibit a stable model of reasoning irrespective of the opponent's characteristics. Among the remainder, the results are split: around 12% can model the behavior of undergraduate students but not of Ph.D. students, while around 18% can model the behavior of Ph.D. students but not of undergraduate students.

To conclude, we document evidence that players may value predictability of their opponents behavior.

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Magic Mirror on the Wall,
Who Is the Smartest One of All?
Online Appendix: Experimental Results

Yoram Halevy Johannes Hoelzemann Terri Kneeland

December 9, 2021

A Experimental Results of All Participants

In this section, we replicate and report all results reported in the main text. We begin by summarizing choice behavior and the preference relation over *DS* and *LG* irrespective of the opponent type. Table A.1 lists these results.

Table A.1: Aggregate Results

	$DS \succsim LG$	$DS \prec LG$
$I - R$ Prediction	*nil*	*all*
Ratio	258/470	212/470
Percentage	54.9%	45.1%

All choices made irrespective of opponent type.
$I - R \equiv$ Iterative 'top-down' model of reasoning.

As a next step, we control for participants whose behavior is inconsistent with best-responding across all games and either types. For example, we now remove participants who play a with a valuation $v \geq 12$, and further exclude those whose valuations exceed the maximum possible payoff given their action choice: b with a valuation $v > 13.25$ or c with a valuation $v > 12.25$ in either of the two control games, *MS* and *NE*. As a result, we are now focussing on 173 participants playing against an undergraduate student and 164 participants playing against a Ph.D. students in Economics, respectively. Table A.2 lists these results of $n = 337$ choices irrespective of opponent type.

Table A.2: Aggregate Results – Controlling for Best-Response Inconsistency

	$DS \succsim LG$	$DS \prec LG$
$I - R$ Prediction	*nil*	*all*
Ratio	179/337	158/337
Percentage	53.1%	46.9%

All choices made irrespective of opponent type excluding
all choices that are inconsistent with best-responses in *MS* and *NE*.
$I - R \equiv$ Iterative 'top-down' model of reasoning.

Next, we leverage *MS* and *NE* and, in this step, exclude only those choices that value all small games equally, i.e., $v_{DS} = v_{MS} = v_{NE}$. This results in concentrating on 173 participants playing against an undergraduate student and 165 participants playing against a Ph.D. students in Economics, respectively. Table **??** lists these results.

Table A.3: Aggregate Results – Controlling for Equal Valuations of All Smaller Games

	$DS \succsim LG$	$DS \prec LG$
$I-R$ Prediction	*nil*	*all*
Ratio	229/338	109/338
Percentage	68.2%	32.2%

All choices made irrespective of opponent type excluding all choices that value DS, MS, and NE equally.
$I - R \equiv$ Iterative 'top-down' model of reasoning.

Overall, the inclusion of the controls does not alter the results. Similar to the results reported in the main text, while the ratio of those who weakly prefer DS over LG increases to some extent, using the entire sample also suggests that participants may value the predictability of their opponents' actions.

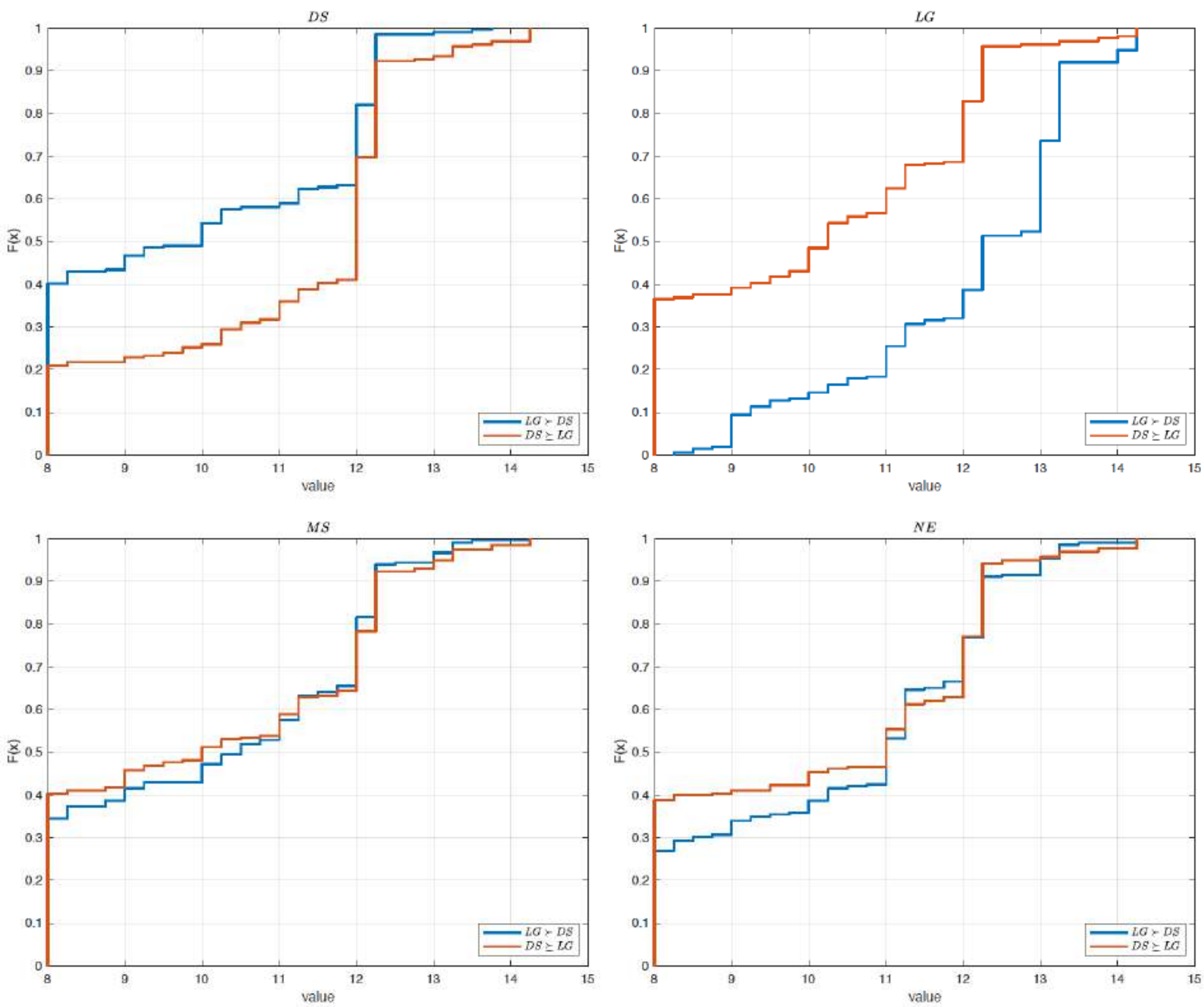

Figure A.1: Empirical Value Distributions of All Games by the Ranking of DS and LG for all N = 470 Choices. Top Row: The diagnostic games. Left: DS; Right: LG; Bottom Row: The control games. Left: MS; Right: NE.

As in the main text, we move beyond summary statistics and turn to the empirical distribution of valuations by the ranking of *DS* and *LG* induced by the valuations for the aggregate results presented in Table A.1. We leverage again the cardinal information obtained in the second part of the experiment – the valuation task. Figure A.1 visualizes the empirical distributions of the valuations of the two diagnostic games, *DS* and *LG*, as well as the two control games, *MS* and *NE*.

Next, we show the empirical value distributions for all games by the ranking of *DS* and *LG* in Figure A.2.

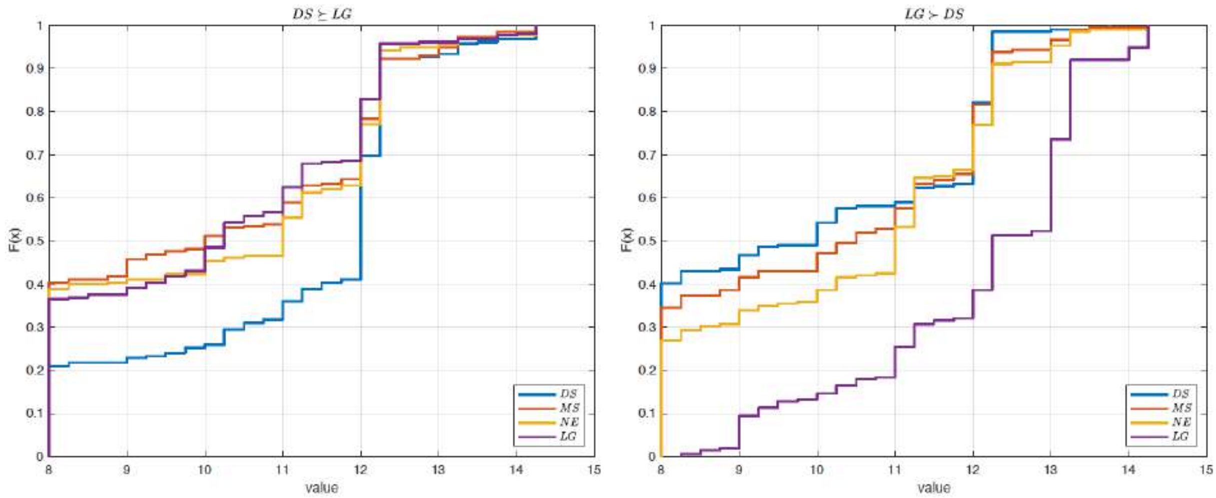

Figure A.2: Empirical Value Distributions of *DS*, *MS*, and *NE* by Ranking of *DS* and *LG*

Turning to choices at the subject-level and a brief discussion of differences in behavior by opponent type. We have established that approximately half of the choices made by these participants are consistent with difficulty of predicting others' behavior. On the full sample, this turns out to be even stronger when we control for valuing all smaller games equally as highlighted above. Table A.4 shows the comparative statics of the ranking over the set of diagnostic games conditional on the opponent's identity (i.e., either an undergraduate student or a Ph.D. student in Economics).

Table A.4: Ranking of *DS* and *LG* by Opponent Type

			Undergraduate	
			$DS \succsim LG$	$DS \prec LG$
Graduate	$DS \succsim LG$	$I - R$ Prediction	*nil*	*nil*
		Ratio	90/235	29/235
		Percentage	38.3%	12.3%
	$DS \prec LG$	$I - R$ Prediction	*nil*	*all*
		Ratio	49/235	67/235
		Percentage	20.9%	28.5%

$I - R \equiv$ Iterative 'top-down' model of reasoning.

Lastly, we ran ordinary least-square regressions with random effects controlling for order effects as well as the opponent order. In particular, we regressed the difference in valuations of *LG* and *DS* ($v_{LG} - v_{DS}$) on the opponent dummy *Ph.D.*, which is 0 for facing an undergraduate student and 1 for playing against a Ph.D. student in Economics, and the valuations for both *MS* and *NE*. Further, we include the game order dummy *DS before LG*, which is 0 if *LG* is displayed before *DS* and 1 if *DS* is displayed before *LG*. In addition, we also include the opponent order dummy *G before UG*, which is 0 if participants played first against an undergraduate student and afterwards against a Ph.D. student in Economics in the first part of the experiment and 1 if the order is reversed.

We first split our sample by preference relation over the set of diagnostic games and opponent type (= 2×2) as in Table A.4 and then estimate the model using the full sample. Unlike in the main text, we do not exclude participants from our analysis whose valuations exceed the maximum possible payoff given their action, those who played *b* in *DS*, and those who are inconsistent with best-responding in *DS*. Table A.5 lists the results from this analysis.

Table A.5: OLS Estimations with Random Effects of Difference in Valuations of *LG* and *DS*

Ranking by Opponent	UG: $DS \succsim LG$ G: $DS \succsim LG$	UG: $DS \succsim LG$ G: $DS \prec LG$	UG: $DS \prec LG$ G:$DS \succsim LG$	UG: $DS \prec LG$ G: $DS \prec LG$	*All*
	$v_{LG} - v_{DS}$	$v_{LG} - v_{DS}$	$v_{LG} - v_{DS}$	$v_{LG} - v_{DS}$	$v_{LG} - v_{DS}$
Intercept	-1.597^{**}	-1.075	2.498^{*}	2.474^{***}	0.069
	(0.685)	(1.101)	(1.379)	(0.831)	(0.682)
Ph.D.	0.206	3.642^{***}	-3.418^{***}	-0.190	0.360^{*}
	(0.148)	(0.290)	(0.350)	(0.186)	(0.170)
v_{MS}	0.037	-0.043	0.007	-0.116	-0.039
	(0.054)	(0.090)	(0.111)	(0.076)	(0.055)
v_{NE}	0.030	0.019	-0.007	0.070	0.067
	(0.057)	(0.094)	(0.115)	(0.078)	(0.058)
DS before LG					0.009
					(0.215)
G before UG					-0.225
					(0.219)
σ_ϵ	0.995	1.435	1.286	1.059	1.839
σ_u	0.961	0.750	0.812	0.897	1.002
N	180	98	58	134	470
(Between) R-squared	0.013	0.019	0.009	0.009	0.010

***Significant at the 1 percent level; **Significant at the 5 percent level; *Significant at the 10 percent level

We find a strong effect of the observed characteristic of the opponent, *Ph.D.*, on the difference in valuations of *LG* and *DS* for all ranking as long as $DS \succsim LG$ against at one opponent type only. This is also mildly true for the full sample, irrespective of the ranking over the set of diagnostic games. As expected, we do not find a strong of type when $DS \prec LG$. Here, we also do not find a strong of type when $DS \succsim LG$. Overall, these estimation results for all $N = 235$ are in line with the difference in differences of valuations by opponent type and by ranking of *LG* and *DS* too. Using the full sample, we also do not find any indication of order effects, either due to presenting participants *LG* or *DS* before the other as well as playing each of the four games first against an undergraduate student or a Ph.D. student in Economics in the first part of the experiment.

Magic Mirror on the Wall, Who Is the Smartest One of All?

Online Appendix: Experimental Interface — Main Experiment —

Yoram Halevy Johannes Hoelzemann Terri Kneeland

December 9, 2021

Instructions

Welcome. This is an experiment in the economics of decision-making. If you pay close attention to these instructions, you can earn a significant amount of money that will be paid to you at the end of the experiment via interac e-transfer.

To participate in this online experiment, you will need to use Chrome or Safari on your notebook or personal computer (other browsers and mobile phones are not supported). If you are using a browser or device that is not supported, please copy the experiment link, open one of these supported browsers on a notebook or pc and paste the link into the address bar.

Your computer screen will display useful information. Remember that the information on your computer screen is PRIVATE. To insure best results for yourself and accurate data for the experimenters, please DO NOT COMMUNICATE or interact with other people on other media at any point during the experiment. If you have any questions, or need assistance of any kind, please call +1-647-XXX-ZZZZ or use Skype (j.hoelzemann@utoronto.ca) anytime from 8am to 8pm Toronto time (EST) and one of the experimenters will help you privately. We expect the experiment to take up to 90 minutes to complete, but you can take as much time as you want to finish it (until this experiment terminates at 8pm EST).

This experiment has two parts. In each part you will face four decision-making problems. During the experiment, and in order to determine your payment, you will be randomly matched with **another** participant (see below for details), who already made her/his choices in a previous session.

The other participants (Players Z and Y)

The other participant (called "Player Z") with whom you will be matched with is either an undergraduate student from any year or discipline at The University of Toronto or an Economics PhD student who took several advanced courses that are highly relevant for this experiment. You will not learn whether the other participant is an undergraduate student from any year or discipline or an Economics PhD student until the experiment concludes. Therefore, you will always be asked to make two choices: one if Player Z is an undergraduate student from any year or discipline and another if (s)he is an Economics PhD student.

Player Z participated in a previous experimental session in which (s)he was matched with another participant ("Player Y") who participated in the same session and played your role. When Player Z was an undergraduate student from any year or discipline, so was Player Y; and when Player Z was an Economics PhD student, so was Player Y.

The choices Player Z made are used to determine your earnings in the current session, but you will not be told which choices Player Z made when you make your choices. You can, however, attempt to reason about the choices Player Z made.

PART 1

The Basic Idea

This part has four different problems. In each round, you will face a different decision problem similar to the one below.

Your Earnings

Your action	Player Z's action: A	B	C	D
a	7	12	8	4
b	7	1	9	10
c	13	2	10	6
d	3	10	11	6

Player Y had the same actions and earnings as you.

Player Z's Earnings

Player Z's action	Player Y's action: a	b	c	d
A	13	8	3	18
B	16	4	13	30
C	10	21	16	12
D	19	5	9	21

In order to assist you to choose an action, when you move your mouse over a row in the `Your Earning' table on the left, the action will be highlighted in yellow in both tables: a row on the left table, and a column on the right table. By left clicking your mouse over a row it will remain highlighted, and you can unhighlight it by clicking your mouse again or clicking another row.

Similarly, when you move your mouse over a row that corresponds to an action of Player Z in the 'Player Z's Earnings' on the right, the row will be highlighted in green on the right table and the corresponding column will be highlighted in green on the left table. Clicking your mouse over the row will keep it highlighted, and clicking it again (or clicking another action) will unhighlight it.

Please try to highlight actions for you and Player Z in the earnings tables above.

Your earnings in each problem depend on your choice of action (between: a, b, c, d) and Player Z's choice of action (between A, B, C, D). Your earnings possibilities are presented in tables like the ones above. In each problem, your earnings are given by the blue numbers in the left table. Your choice of action determines the row in the `Your Earnings' table and Player Z's choice of action determines the column in the same table. The blue number in the cell corresponding to any combination of actions (yours and Player Z's) represents your earnings.

Player Z's earnings are given in the right table. This table is important because it may help you figure out which action Player Z chose when s/he faced this decision problem. Player Z's choice of action determines the row in Player Z's earnings table, while Player Y's choice of action determines the column in this table. The number in the cell corresponding to any combination of actions (Player Z's and Player Y's) represents Player Z's earnings.

Finally, Player Y had an identical earnings table to yours (the one on the left side of the screen), and her/his earnings depended on Player Y's choice of action as well as on Player Z's (just like yours). You can therefore consult your earnings table in order to try and figure out what was Player Y's choice of action, and so forth.

In summary, your choice of action and Player Z's choice of action affect your earnings, while Players Z and Y earnings depend on both of their chosen actions. Just like you know Player Z's earnings table, Player Y knew Player Z's earnings table and Player Z knew Player Y's earnings table.

For example, if you choose action "b" and Player Z chose action "B" then your earnings would be $1. If Player Y chose action "b" too then Player Z's earnings were $4. If, however, Player Y chose action "d" then Player Z's earnings were $30. If you choose action "c" and Player Z chose action "A", your earnings would be $13. If Player Y chose action "c" too then Player Z's earnings were $3. If, however, Player Y chose action "d" player Z's earnings were $18. Numbers in the example are just an example and do not intend to suggest how anyone should make their choices.

Problem structure

The problems that you will face will take one of two forms. One problem will have four possible actions for both you (e.g. a, b, c or d) and Player Z (e.g. A, B, C or D) as in Example Problem 1. The other three problems will have three possible choices for both you (e.g. a, b, or c) and Player Z (e.g. A, B, or C) as in Example Problem 2. In these three problems your earnings table is always the same, while the earnings table for Player Z changes in each problem (remember that Player Y's earnings and potential actions are always identical to yours).

Example Problem 1

Your Earnings

		Player Z's action			
		A	B	C	D
Your action	a	7	12	8	4
	b	7	1	9	10
	c	13	2	10	16
	d	3	10	11	6

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action			
		a	b	c	d
Player Z's action	A	13	8	3	18
	B	16	4	13	30
	C	10	21	16	12
	D	19	5	9	21

Example Problem 2

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Notice that your earnings generally depend on Player Z's chosen action. When considering which action to choose you may consider how likely it is that Player Z chose each action. This, in turn, may depend on which action Player Z believed that Player Y (who had the same actions and earning as you) will choose. As Player Y's earnings depended on Player Z's choice too (just like yours), Player Y's chosen action may have depended how likely (s)he believed that Player Z will choose each action.

Finally, to choose an action you must click on the rectangular button around the action's name (the lowercase letter next to the row, on the margin of the left table), after it has been activated (turned blue).

The four decision problems

There will be four problems: you will face different decision problems with different earnings tables and possible actions. You will need to choose two actions in each problem: one if Player Z is an undergraduate student from any year or discipline and a second action if Player Z is an Economics PhD student (the actions could be the same or different, it is totally up to you). After you chose the two actions, you will advance to the next screen and play a new decision problem. In one of these problems each player has four possible actions and in the other three problems each player has three possible actions. In the problems with three possible actions your (and Player Y's) earnings table is always the same, while Player Z's earnings table changes in each decision problem. (Remember that Player Y's earnings and potential actions are always identical to yours.)

Note that the earnings tables in each problem are different, so you should look carefully at them before making your choice. You will be required to spend some time on each problem, after which the rectangular buttons that allow you to choose an action will be activated. You can continue and deliberate your choices after the buttons have been activated.

Once you have completed the four problems, you will have another opportunity to revisit your choices and confirm them. You will then advance to a second part of the experiment.

Payment

You will earn a participation payment of $5.00 for participating in this experiment.

Before the actual experiment starts, you will be asked to answer several (9 in Part 1 and additional 5 in Part 2) questions. You will earn 25 cents for answering each question correctly on your first trial. If you make a mistake, you will not receive a payment for that question, but you must answer it correctly in order to move to the next question.

In addition to the participation payment and the payment for answering the quiz correctly, one decision problem that counts will be randomly selected for payment at the end of the experiment. You will be paid your earnings in that decision problem as described above or a monetary amount (that is independent of yours or Player Z's chosen actions). Any of the four problems could be the one selected, so you should treat each problem as if it will be the one determining your payment.

You will be informed of your payment, the decision problem chosen for payment, and the choices of you and Player Z only at the end of the experiment. You will not learn any other information about the choices of other participants during the experiment. The identity of Player Z will never be revealed.

Finally, after completing the experiment you will be paid electronically via interac e-transfer with the e-mail address you entered on the previous page.

Frequently Asked Questions

Q1. Is this some kind of psychology experiment with an agenda you haven't told us?
No. It is an economics experiment. If we do anything deceptive or don't pay you cash as described, then you can complain to the University of Toronto Research Ethics Board and we will be in serious trouble. These instructions are meant to clarify how you earn money, and our interest is in seeing how people make decisions.

Q2. Is there a "correct" choice of action? Is this kind of a test?
No. Your optimal action depends on your belief which action did Player Z choose. Different people may hold different beliefs.

This button will be activated after 10 minutes. Please take your time to read through the instructions.

Next

Quiz

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Player Y had the same actions and earnings as you.

player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Use the above earnings table to answer the following questions:

1. If you choose action 'a' and Player Z chose action 'C' what would your earnings be?

A $15

B $13

C $1

D $6

Quiz

	Your Earnings			
		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Player Y had the same actions and earnings as you.

	Player Z's Earnings			
		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Use the above earnings table to answer the following questions:

2. If Player Z chose action ‘C’ and Player Y chose action ‘a’, what were Player Z’s earnings?

A $13

B $10

C $1

D $8

Quiz

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Use the above earnings table to answer the following questions:

3. If Player Z chose action 'A', which action would give you the highest earnings?

A a

B b

C c

Quiz

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Use the above earnings table to answer the following questions:

4. If Player Y chose action 'a', which action would give Player Z the highest earnings?

A A

B B

C C

Quiz

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Use the above earnings table to answer the following questions:

5. If Player Z chose action 'B', which action would give you the highest earnings?

A a

B b

C c

Quiz

Your Earnings

		Player Z's action			
		A	B	C	D
Your action	a	7	12	8	4
	b	7	1	9	10
	c	13	2	10	16
	d	3	10	11	6

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action			
		a	b	c	d
Player Z's action	A	13	8	3	18
	B	16	4	13	30
	C	10	21	16	12
	D	19	5	9	21

Use the above earnings table to answer the following questions:

6. If you choose action 'c' and the Player Z chose action 'A' what would be your earnings?

A $8

B $13

C $3

D $10

Quiz

Your Earnings					
		Player Z's action			
		A	B	C	D
Your action	a	7	12	8	4
	b	7	1	9	10
	c	13	2	10	16
	d	3	10	11	6

Player Y had the same actions and earnings as you.

Player Z's Earnings					
		Player Y's action			
		a	b	c	d
Player Z's action	A	13	8	3	18
	B	16	4	13	30
	C	10	21	16	12
	D	19	5	9	21

Use the above earnings table to answer the following questions:

7. If Player Z chose action 'B' and Player Y chose action 'd', what were Player Z's earnings?

A $10

B $5

C $30

D $4

Quiz

Your Earnings

		Player Z's choice			
		A	B	C	D
Your action	a	7	12	8	4
	b	7	1	9	10
	c	13	2	10	16
	d	3	10	11	6

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action			
		a	b	c	d
Player Z's action	A	13	8	3	18
	B	16	4	13	30
	C	10	21	16	12
	D	19	5	9	21

Use the above earnings table to answer the following questions:

8. If Player Z chose action 'D', which action would give you the highest earnings?

A a

B b

C c

D d

Quiz

Your Earnings

		Player Z's choice			
		A	B	C	D
Your action	a	7	12	8	4
	b	7	1	9	10
	c	13	2	10	16
	d	3	10	11	6

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action			
		a	b	c	d
Player Z's action	A	13	8	3	18
	B	16	4	13	30
	C	10	21	16	12
	D	19	5	9	21

Use the above earnings table to answer the following questions:

9. If Player Y chose action 'a', which action would give Player Z the highest earnings?

A A

B B

C C

D D

You have successfully finished the quiz. The experiment follows.

You will face four problems: In each problem you will choose one action if Player Z is an undergraduate student from any year or discipline (red earnings table)

and a second action if Player Z is a PhD student in Economics (blue earnings table).

In one of these problems each player has four possible actions and in the other three problems each player has three possible actions.

In the problems with three possible actions your (and Player Y's) earnings table is always the same, while Player Z's earnings table changes in each decision problem.

You are encouraged to make use of "Your Notes" (including editing them) which is a box located below the decision problem. This text will be displayed later and will help you during the second part of the experiment. You can use it in any way you wish but it will be most beneficial for you if you record your reasoning that led you to choose your action.

When you are ready please click "next" to start the experiment.

Next

Problem 1
- Z = Undergraduate ←
- Z = PhD

Problem 2
- Z = Undergraduate
- Z = PhD

Problem 3
- Z = Undergraduate
- Z = PhD

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 1 - Player Z is an undergraduate student from any year or discipline

Please choose an action by clicking one of the buttons that is at the margin of "Your Earnings" table. Each button will be automatically activated after 3 minutes.

Player Z is an undergraduate student from any year or discipline.

Instructions

Your Earnings

Your action	Player Z's action: A	B	C
a	0	12	11
b	5	13	0
c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

Player Z's action	Player Y's action: a	b	c
A	6	15	10
B	3	8	9
C	4	13	9

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

column A of player Z has highest possible outcome regardless of which letter I choose. I'm assuming they'll choose column A and for this reason i chose column c.

Problem 1
- Z = Undergraduate ✓
- Z = PhD

Problem 2
- Z = Undergraduate
- Z = PhD

Problem 3
- Z = Undergraduate
- Z = PhD

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 1 - Player Z is a PhD student in Economics

Please choose an action by clicking one of the buttons that is at the margin of "Your Earnings" table. Each button will be automatically activated after 3 minutes.

Player Z is a PhD student in Economics.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	6	15	10
	B	3	8	9
	C	4	13	9

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

Z will always choose A, so I choose C

Problem 1
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2
- Z = Undergraduate ⟵
- Z = PhD

Problem 3
- Z = Undergraduate
- Z = PhD

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 2 - Player Z is an undergraduate student from any year or discipline

Please choose an action by clicking one of the buttons that is at the margin of "Your Earnings" table. Each button will be automatically activated after 3 minutes.

Player Z is an undergraduate student from any year or discipline.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	6	16	9
	B	10	3	8
	C	8	10	10

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

I think Player Z would choose C because it has the most consistent earning. If Player Z chose C, I would only earn something if I chose A. I'm choosing A in hopes that Player Z will not also choose A

Problem 1
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2
- Z = Undergraduate ✓
- Z = PhD ←

Problem 3
- Z = Undergraduate
- Z = PhD

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 2 - Player Z is a PhD student in Economics

Please choose an action by clicking one of the buttons that is at the margin of "Your Earnings" table. Each button will be automatically activated after 3 minutes.

Player Z is a PhD student in Economics.

Instructions

Your Earnings

Your action \ Player Z's action	A	B	C
a	0	12	11
b	5	13	0
c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

Player Z's action \ Player Y's action	a	b	c
A	6	16	9
B	10	3	8
C	8	10	10

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

I think a PhD student would know the optimal earning for both assuming that both parties are cooperative. I think they would assume I go with A, for them, the best return would be B. So I'm sticking with A.

Problem 1
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 3
- Z = Undergraduate ←
- Z = PhD

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 3 - Player Z is an undergraduate student from any year or discipline

Please choose an action by clicking one of the buttons that is at the margin of "Your Earnings" table. Each button will be automatically activated after 3 minutes.

Player Z is an undergraduate student from any year or discipline.

Instructions

Your Earnings

		Player Z's action			
		A	B	C	D
Your action	a	0	12	13	11
	b	4	14	0	6
	c	10	0	11	12
	d	13	8	6	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action			
		a	b	c	d
Player Z's action	A	12	0	16	7
	B	14	0	5	11
	C	12	16	0	10
	D	8	4	0	12

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

oh four! Okay so new 0s. Lets start with what I've been doing... For Z: A: max=16, min=0, range=16 (DAMN, high risk) B: max=14, min HWM, all have 0s, so all have high risk. Same with Y's. So looks like range isn't the best measure here. *remember! This is an undergrad. Let's go with the strategy of maximizing for both. (maybe PhDs would try to maximize both too. That distinction might be a red herring. Why would they not? That's how contracts are signed anyway) (would

Problem 1
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 3
- Z = Undergraduate ✓
- Z = PhD ←

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 3 - Player Z is a PhD student in Economics

Please choose an action by clicking one of the buttons that is at the margin of "Your Earnings" table. Each button will be automatically activated after 3 minutes.

Player Z is a PhD student in Economics.

Instructions

Your Earnings

		Player Z's action			
		A	B	C	D
Your action	a	0	12	13	11
	b	4	14	0	6
	c	10	0	11	12
	d	13	8	6	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action			
		a	b	c	d
Player Z's action	A	12	0	16	7
	B	14	0	5	11
	C	12	16	0	10
	D	8	4	0	12

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

yeah I really think they'd do the same thing, make it good for everyone. Maybe this is testing how people think about phd students in economics hahaha. No but really, the avgs of C and a are the best for the respective peoples. So on that alone, this should be good.

Problem 4 - Player Z is an undergraduate student from any year or discipline

Please choose an action by clicking one of the buttons that is at the margin of "Your Earnings" table. Each button will be automatically activated after 3 minutes.

Player Z is an undergraduate student from any year or discipline.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	10
	B	14	3	9
	C	6	16	9

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

As this is an undergrad student, i assume they will straight away go to their highest earning column (c w/ 16) but as they can see if i chose to get the best outcome for them i would end up getting zero, so then i went to the second best option (b w/14) however the biggest earning for me was in row b but for them it was just 3, so I chose option a so they can get their highest reward but also decided to go with option a as each of the rows have a chance of getting zero but this row has the

Problem 1
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 3
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 4
- Z = Undergraduate ✓
- Z = PhD ←

Problem 4 - Player Z is a PhD student in Economics

Please choose an action by clicking one of the buttons that is at the margin of "Your Earnings" table. Each button will be automatically activated after 3 minutes.

Player Z is a PhD student in Economics.

Instructions

Your Earnings

	Player Z's action		
Your action	A	B	C
a	0	12	11
b	5	13	0
c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

	Player Y's action		
Player Z's action	a	b	c
A	13	5	10
B	14	3	9
C	6	16	9

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

I have a better chance of earning more with the #12 and $11 in option a, so if player Z chooses option A in predicting I will choose A so they will get $13, I chose C so I will get $12

Problem 1

- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2

- Z = Undergraduate ✓
- Z = PhD ✓

Problem 3

- Z = Undergraduate ✓
- Z = PhD ✓

Problem 4

- Z = Undergraduate ✓
- Z = PhD ✓

You have completed the four problems. Now you have the opportunity to revisit your choices.

You have completed the four problems: In each problem you chose one action if Player Z is an undergraduate student from any year or discipline (red earnings table)

and a second action if Player Z is an Economics PhD student (blue earnings table).

In one of these problems each player had four possible actions and in the other three problems each player had three possible actions.

In the problems with three possible actions your (and Player Y's) earnings table was always the same, while Player Z's earnings table changed in each decision problem.

You will have the opportunity to revisit your choices and confirm them. You are encouraged to make use of "Your Notes" (including editing them) which is a box located below the decision problem. This text will be displayed later and will help you during the second part of the experiment. You can use it in any way you wish but it will be most beneficial for you if you record your reasoning that led you to choose your action.

When you are ready please click "next" to revisit your choices and confirm them.

Next

Problem 1
- Z = Undergraduate ←
- Z = PhD

Problem 2
- Z = Undergraduate
- Z = PhD

Problem 3
- Z = Undergraduate
- Z = PhD

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 1 - Player Z is an undergraduate student from any year or discipline:

Please confirm your choice of action

You chose action **c**.

You have a final opportunity to confirm or revise your choice of action in the decision problem below. In order to proceed to the next screen please click on your final choice of action in the table below.

Player Z is an undergraduate student from any year or discipline.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	6	15	10
	B	3	8	9
	C	4	13	9

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

column A of player Z has highest possible outcome regardless of which letter I choose. I'm assuming they'll choose column A and for this reason i chose column c.

Problem 1
- Z = Undergraduate ✓
- Z = PhD ←

Problem 2
- Z = Undergraduate
- Z = PhD

Problem 3
- Z = Undergraduate
- Z = PhD

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 1 - Player Z is a PhD student in Economics:

Please confirm your choice of action

You chose action **c**.

You have a final opportunity to confirm or revise your choice of action in the decision problem below. In order to proceed to the next screen please click on your final choice of action in the table below.

Player Z is a PhD student in Economics.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	6	15	10
	B	3	8	9
	C	4	13	9

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

Z will always choose A, so I choose C

Problem 1
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2
- Z = Undergraduate ←
- Z = PhD

Problem 3
- Z = Undergraduate
- Z = PhD

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 2 - Player Z is an undergraduate student from any year or discipline:

Please confirm your choice of action

Player Z is an undergraduate student from any year or discipline.

You chose action **a**.

You have a final opportunity to confirm or revise your choice of action in the decision problem below. In order to proceed to the next screen please click on your final choice of action in the table below.

Instructions

Your Earnings

Your action	Player Z's action: A	B	C
a	0	12	11
b	5	13	0
c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

Player Z's action	Player Y's action: a	b	c
A	6	16	9
B	10	3	8
C	8	10	10

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

I think Player Z would choose C because it has the most consistent earning. If Player Z chose C, I would only earn something if I chose A. I'm choosing A in hopes that Player Z will not also choose A

Problem 1
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2
- Z = Undergraduate ✓
- Z = PhD ←

Problem 3
- Z = Undergraduate
- Z = PhD

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 2 - Player Z is a PhD student in Economics:

Please confirm your choice of action

Player Z is a PhD student in Economics.

You chose action **a**.

You have a final opportunity to confirm or revise your choice of action in the decision problem below. In order to proceed to the next screen please click on your final choice of action in the table below.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	6	16	9
	B	10	3	8
	C	8	10	10

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

I think a PhD student would know the optimal earning for both assuming that both parties are cooperative. I think they would assume I go with A, for them, the best return would be B. So I'm sticking with A.

Problem 1
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 3
- Z = Undergraduate ←
- Z = PhD

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 3 - Player Z is an undergraduate student from any year or discipline:

Please confirm your choice of action

Player Z is an undergraduate student from any year or discipline.

You chose action **a**.

You have a final opportunity to confirm or revise your choice of action in the decision problem below. In order to proceed to the next screen please click on your final choice of action in the table below.

Instructions

Your Earnings

		Player Z's action			
		A	B	C	D
Your action	a	0	12	13	11
	b	4	14	0	6
	c	10	0	11	12
	d	13	8	6	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action			
		a	b	c	d
Player Z's action	A	12	0	16	7
	B	14	0	5	11
	C	12	16	0	10
	D	8	4	0	12

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

oh four! Okay so new 0s. Lets start with what I've been doing... For Z: A: max=16, min=0, range=16 (DAMN, high risk) B: max=14, min HWM, all have 0s, so all have high risk. Same with Y's. So looks like range isn't the best measure here. *remember! This is an undergrad. Let's go with the strategy of maximizing for both. (maybe PhDs would try to maximize both too. That distinction might be a red herring. Why would they not? That's how contracts are signed anyway) (would

Problem 1
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 3
- Z = Undergraduate ✓
- Z = PhD ←

Problem 4
- Z = Undergraduate
- Z = PhD

Problem 3 - Player Z is a PhD student in Economics:

Please confirm your choice of action

Player Z is a PhD student in Economics.

You chose action **a**.

You have a final opportunity to confirm or revise your choice of action in the decision problem below. In order to proceed to the next screen please click on your final choice of action in the table below.

Instructions

Your Earnings

		Player Z's action			
		A	B	C	D
Your action	a	0	12	13	11
	b	4	14	0	6
	c	10	0	11	12
	d	13	8	6	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action			
		a	b	c	d
Player Z's action	A	12	0	16	7
	B	14	0	5	11
	C	12	16	0	10
	D	8	4	0	12

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

yeah I really think they'd do the same thing, make it good for everyone. Maybe this is testing how people think about phd students in economics hahaha. No but really, the avgs of C and a are the best for the respective peoples. So on that alone, this should be good.

Problem 1
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 3
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 4
- Z = Undergraduate ←
- Z = PhD

Problem 4 - Player Z is an undergraduate student from any year or discipline:

Please confirm your choice of action

Player Z is an undergraduate student from any year or discipline.

You chose action **a**.

You have a final opportunity to confirm or revise your choice of action in the decision problem below. In order to proceed to the next screen please click on your final choice of action in the table below.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	10
	B	14	3	9
	C	6	16	9

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

As this is an undergrad student, i assume they will straight away go to their highest earning column (c w/ 16) but as they can see if i chose to get the best outcome for them i would end up getting zero, so then i went to the second best option (b w/14) however the biggest earning for me was in row b but for them it was just 3, so I chose option a so they can get their highest reward but also decided to go with option a as each of the rows have a chance of getting zero but this row has the

Problem 1
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 2
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 3
- Z = Undergraduate ✓
- Z = PhD ✓

Problem 4
- Z = Undergraduate ✓
- Z = PhD ←

Problem 4 - Player Z is a PhD student in Economics:

Please confirm your choice of action

Player Z is a PhD student in Economics.

You chose action **c**.

You have a final opportunity to confirm or revise your choice of action in the decision problem below. In order to proceed to the next screen please click on your final choice of action in the table below.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	10
	B	14	3	9
	C	6	16	9

Your Notes:

In the space below you can write down the reasoning behind your choice of action. What you type will be displayed later on in the experiment and will help you when making choices in Part 2 of the experiment.

I have a better chance of earning more with the #12 and $11 in option a, so if player Z chooses option A in predicting I will choose A so they will get $13, I chose C so I will get $12

Instructions

PART 2

The Basic Idea

In this part of the experiment, you will be asked to make a sequence of choices between playing the four decision problems (against an undergraduate student from any year or discipline and against an Economics PhD student) in Part 1 and sure amounts. There are no correct choices. Your choices depend on your preferences and beliefs, so different participants will usually make different choices. You will be paid according to your choices, so read these instructions carefully and think before you decide.

Example of Choice Problems

In all the choice problems you will face in this part you will be asked to choose between payments from the decision problems you made in Part 1 and sure amounts. All choice problems will be organized in lists that share a simple structure, which is explained below. The following example illustrates, but is not directly related to the choice problems that determine your payment.

Suppose you have $5.50, and are asked to make a series of choices between keeping the $5.50 and receiving money amounts that vary from $0 to $10. As long as you like to have more money to less, this is how you would fill in this list of choices.

Choice Problem	A	B	Choose A or B
0	$5.50	$0	A
1	$5.50	$1	A
2	$5.50	$2	A
3	$5.50	$3	A
4	$5.50	$4	A
5	$5.50	$5	A
6	$5.50	$6	B
7	$5.50	$7	B
8	$5.50	$8	B
9	$5.50	$9	B
10	$5.50	$10	B

Notice the structure:

- Option A (in this case, keeping your $5.50) is the same on every line of the list, but option B improves as you go down the list

- There is a unique choice problem in which you switch from A to B. In the example above, it is choice problem 6.

Suppose now that Option A would be more valuable. For example, suppose it is $7.50 instead of $5.50. How would it affect your choices?

Instead of switching from A to B in choice problem 6, you would switch in choice problem 8. This has a general lesson:

- The more valuable Option A is, the later you would switch from A to B.

One can replace Option A with an amount that may depend on Player Z's action. For example, consider the following Option A: Suppose Player Z can choose between Left and Right.

	Player Z chose Left	**Player Z chose Right**
Option A	$5.50	$5.50

In this case your payment is independent of the action chosen by Player Z, as in either case you will earn $5.50. Therefore, this option is identical to the first Option A discussed above and you will switch from A to B in choice problem 6.

Consider, however, the following Option A:

	Player Z chose Left	**Player Z chose Right**
Option A	$8.50	$0

The value of this option depends on how likely you think Player Z chose Left.

If you are sure that (s)he chose Left, then the value is $8.50 and you will switch from A to B in choice problem 9 in the list.

If, however, you believe that Player Z may have chosen Right, then the value of Option A would fall, and you will switch to B in an earlier choice problem. Moreover, the more likely you believe (s)he chose Right -- the lower would be the value of Option A for you, and you would switch from A to B in an earlier choice problem.

The Protocol

The following choice problems are organized in 4 pairs (8 lists), where Option A changes across lists and represents your earnings from each of the 4 decision problems from Part 1 against the two potential Player Z (undergraduate students from any year or discipline and Economics PhD students).

For example, suppose that in Part 1 you faced the following decision problem and chose action 'c' when Player Z is an undergraduate student from any year or discipline:

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

In the choice problems you will be asked to choose between Option A (you choose 'c' and being paid from this Part 1 decision problem, when the payment depends on the action chosen by Player Z), and sure amounts, as above. In other words, you can think of Option A as:

	Player Z chose 'A'	Player Z chose 'B'	Player Z chose 'C'
Option A	$6	$9	$5

Obviously, when deciding how much you value this Option A, you need to consider how likely it is that Player Z will choose actions A, B or C. The more likely you think Player Z chose 'B' the closer would be the value to 9, and the more likely you think that Player Z chose 'C', the closer it would be to 5. In determining these likelihoods, you need to consult Player Z's earnings table, and possibly Player Y's earnings table (that is identical to yours) – as it may affect how likely Player Z believed Player Y chose each action and therefore Player Z's earnings.

If you want you can fill in the choice list by clicking the lowest line you wish to choose Option A, then automatically all the lines above the one you chose will be marked as Option A too. In addition, by clicking on the first line you wish to choose Option B, then all lower lines will automatically be marked as Option B. You can adjust your choices as many times as you wish. When you are ready to proceed, you can click on the "Next" button at the bottom of the page.

You will see each list exactly once and there will not be a screen asking you to confirm your choices as in Part 1 of the experiment.

Payment

One of the choice problems in one of the lists will be randomly selected by the computer, and your choice in that choice problem will determine your payment.

Your choice (A or B) in the randomly-selected choice problem will determine your payment in the whole experiment. If you chose B, you will get the payment specified in B on that choice problem. If you chose A, your payment will depend on the action you chose in the decision problem in Part 1, if your Player Z is an undergraduate student from any year or discipline or an Economics PhD student, and on the action chosen by Player Z.

So, in order to determine the value of each Option A (the choice problem in which you will switch from A to B in the list), you need to consider how likely it is that Player Z chose each action in the specific decision problem.

This protocol of determining payments suggests that you should choose in each choice problem as if it is the only problem that determines your payment.

This button will be activated after 10 minutes. Please take your time to read through the instructions.

Next

Quiz

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	**6**	**9**	**5**

Player Y had the same actions and earnings as you.

player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Suppose that in Part 1 you faced the above decision problem and chose action 'c' when Player Z is an undergraduate student from any year or discipline. (To highlight row 'c' please click on that row.) Refer to the list below to answer the following questions.

Choice Problem	A	B	Choose A or B
0	Earnings from the decision problem	$0	
1	Earnings from the decision problem	$2	
2	Earnings from the decision problem	$4	
3	Earnings from the decision problem	$5	
4	Earnings from the decision problem	$6	
5	Earnings from the decision problem	$7	
6	Earnings from the decision problem	$8	
7	Earnings from the decision problem	$9	

8	Earnings from the decision problem	$10	
9	Earnings from the decision problem	$10.50	
10	Earnings from the decision problem	$11	
11	Earnings from the decision problem	$11.50	
12	Earnings from the decision problem	$12	
13	Earnings from the decision problem	$12.50	
14	Earnings from the decision problem	$13	
15	Earnings from the decision problem	$14	
16	Earnings from the decision problem	$15	
17	Earnings from the decision problem	$16	
18	Earnings from the decision problem	$18	
19	Earnings from the decision problem	$20	
20	Earnings from the decision problem	$22	
21	Earnings from the decision problem	$24	

Use the above earnings tables to answer the following questions:

1. What is Option 'A'?

A $3 if Player Z chose 'A', $15 if Player Z chose 'B'; $1 if Player Z chose 'C'

B $8 if Player Z chose 'A', $0 if Player Z chose 'B'; $4 if Player Z chose 'C'

C $6 if Player Z chose 'A', $9 if Player Z chose 'B'; $5 if Player Z chose 'C'

Quiz

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	**6**	**9**	**5**

Player Y had the same actions and earnings as you.

player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Suppose that in Part 1 you faced the above decision problem and chose action 'c' when Player Z is an undergraduate student from any year or discipline. (To highlight row 'c' please click on that row.) Refer to the list below to answer the following questions.

Choice Problem	A	B	Choose A or B
0	Earnings from the decision problem	$0	
1	Earnings from the decision problem	$2	
2	Earnings from the decision problem	$4	
3	Earnings from the decision problem	$5	
4	Earnings from the decision problem	$6	
5	Earnings from the decision problem	$7	
6	Earnings from the decision problem	$8	
7	Earnings from the decision problem	$9	

A

8	Earnings from the decision problem	$10	
9	Earnings from the decision problem	$10.50	
10	Earnings from the decision problem	$11	
11	Earnings from the decision problem	$11.50	
12	Earnings from the decision problem	$12	
13	Earnings from the decision problem	$12.50	
14	Earnings from the decision problem	$13	
15	Earnings from the decision problem	$14	
16	Earnings from the decision problem	$15	
17	Earnings from the decision problem	$16	
18	Earnings from the decision problem	$18	
19	Earnings from the decision problem	$20	
20	Earnings from the decision problem	$22	
21	Earnings from the decision problem	$24	

Use the above earnings tables to answer the following questions:

2. What option gives you more money in Choice 2?

A A

B B

Quiz

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Player Y had the same actions and earnings as you.

player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Suppose that in Part 1 you faced the above decision problem and chose action 'c' when Player Z is an undergraduate student from any year or discipline. (To highlight row 'c' please click on that row.) Refer to the list below to answer the following questions.

Choice Problem	A	B	Choose A or B
0	Earnings from the decision problem	\$0	
1	Earnings from the decision problem	\$2	
2	Earnings from the decision problem	\$4	
3	Earnings from the decision problem	\$5	
4	Earnings from the decision problem	\$6	
5	Earnings from the decision problem	\$7	
6	Earnings from the decision problem	\$8	
7	Earnings from the decision problem	\$9	

8	Earnings from the decision problem	$10	
9	Earnings from the decision problem	$10.50	
10	Earnings from the decision problem	$11	
11	Earnings from the decision problem	$11.50	
12	Earnings from the decision problem	$12	
13	Earnings from the decision problem	$12.50	
14	Earnings from the decision problem	$13	
15	Earnings from the decision problem	$14	
16	Earnings from the decision problem	$15	
17	Earnings from the decision problem	$16	
18	Earnings from the decision problem	$18	
19	Earnings from the decision problem	$20	
20	Earnings from the decision problem	$22	
21	Earnings from the decision problem	$24	

Use the above earnings tables to answer the following questions:

3. What option gives you more money in Choice Problem 8?

A A

B B

Quiz

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Player Y had the same actions and earnings as you.

player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Suppose that in Part 1 you faced the above decision problem and chose action 'c' when Player Z is an Economics PhD student. (To highlight row 'c' please click on that row.) Refer to the list below to answer the following questions.

Choice Problem	A	B	Choose A or B
0	Earnings from the decision problem	$0	
1	Earnings from the decision problem	$2	
2	Earnings from the decision problem	$4	
3	Earnings from the decision problem	$5	
4	Earnings from the decision problem	$6	
5	Earnings from the decision problem	$7	
6	Earnings from the decision problem	$8	
7	Earnings from the decision problem	$9	

8	Earnings from the decision problem	$10	
9	Earnings from the decision problem	$10.50	
10	Earnings from the decision problem	$11	
11	Earnings from the decision problem	$11.50	
12	Earnings from the decision problem	$12	
13	Earnings from the decision problem	$12.50	
14	Earnings from the decision problem	$13	
15	Earnings from the decision problem	$14	
16	Earnings from the decision problem	$15	
17	Earnings from the decision problem	$16	
18	Earnings from the decision problem	$18	
19	Earnings from the decision problem	$20	
20	Earnings from the decision problem	$22	
21	Earnings from the decision problem	$24	

Use the above earnings tables to answer the following questions:

4. Suppose that you are sure that Player Z chose action 'C'. What option gives you more money in Choice Problems 2 and 4, respectively?

A A & A

B A & B

C B & A

D B & B

Quiz

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	**6**	**9**	**5**

Player Y had the same actions and earnings as you.

player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Suppose that in Part 1 you faced the above decision problem and chose action 'c' when Player Z is an Economics PhD student. (To highlight row 'c' please click on that row.) Refer to the list below to answer the following questions.

Choice Problem	A	B	Choose A or B
0	Earnings from the decision problem	$0	
1	Earnings from the decision problem	$2	
2	Earnings from the decision problem	$4	
3	Earnings from the decision problem	$5	
4	Earnings from the decision problem	$6	
5	Earnings from the decision problem	$7	
6	Earnings from the decision problem	$8	
7	Earnings from the decision problem	$9	

8	Earnings from the decision problem	$10	
9	Earnings from the decision problem	$10.50	
10	Earnings from the decision problem	$11	
11	Earnings from the decision problem	$11.50	
12	Earnings from the decision problem	$12	
13	Earnings from the decision problem	$12.50	
14	Earnings from the decision problem	$13	
15	Earnings from the decision problem	$14	
16	Earnings from the decision problem	$15	
17	Earnings from the decision problem	$16	
18	Earnings from the decision problem	$18	
19	Earnings from the decision problem	$20	
20	Earnings from the decision problem	$22	
21	Earnings from the decision problem	$24	

Use the above earnings tables to answer the following questions:

5. Suppose that you are sure that Player Z chose action 'C'. What option gives you more money in Choice Problem 5

A A

B B

You have finished the quiz. Part 2 of the experiment follows.

You will see each list exactly once and there will not be a screen asking you to confirm your choices as in Part 1 of the experiment.

You will be able to consult your notes from Part 1 of the experiment.

When you are ready please click "next" to start Part 2 of the experiment.

Next

List 1
- Z = PhD ⟵
- Z = Undergraduate

List 2
- Z = PhD
- Z = Undergraduate

List 3
- Z = PhD
- Z = Undergraduate

List 4
- Z = PhD
- Z = Undergraduate

List 1 - Player Z is a PhD student in Economics

In Part 1 you chose action **c**. Therefore, if you choose Option A below you will play action **c** and be paid **$12, $8, or $0** depending on the action chosen by Player Z who is a PhD student in Economics.

(Note that you can still use the highlighting tool like in Part 1 of the experiment, but you cannot change your action.)

Option A: the earnings from the game when Player Z is a PhD student in Economics.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	**12**	**8**	**0**

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	6	15	10
	B	3	8	9
	C	4	13	9

Your Notes:

Z will always choose A, so I choose C.

Your Decision:

Option A			Option B
Your earnings from the decision problem	○	○	$8.00
Your earnings from the decision problem	○	○	$8.25
Your earnings from the decision problem	○	○	⋮
Your earnings from the decision problem	○	○	$13.75
Your earnings from the decision problem	○	○	$14.00

Next

List 1
- Z = PhD ✓
- Z = Undergraduate ←

List 2
- Z = PhD
- Z = Undergraduate

List 3
- Z = PhD
- Z = Undergraduate

List 4
- Z = PhD
- Z = Undergraduate

List 1 - Player Z is an undergraduate student from any year or discipline

In Part 1 you chose action **c**. Therefore, if you choose Option A below you will play action **c** and be paid **$12, $8, or $0** depending on the action chosen by Player Z who is an undergraduate student from any year or discipline.

(Note that you can still use the highlighting tool like in Part 1 of the experiment, but you cannot change your action.)

Option A: the earnings from the game when Player Z is an undergraduate student from any year or discipline.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	**12**	**8**	**0**

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	6	15	10
	B	3	8	9
	C	4	13	9

Your Notes:

column A of player Z has highest possible outcome regardless of which letter I choose. I'm assuming they'll choose column A and for this reason i chose column c..

Your Decision:

Option A			Option B
Your earnings from the decision problem	○	○	$8.00
Your earnings from the decision problem	○	○	$8.25
Your earnings from the decision problem	○	○	⋮
Your earnings from the decision problem	○	○	$13.75
Your earnings from the decision problem	○	○	$14.00

Next

List 1
- Z = PhD ✓
- Z = Undergraduate ✓

List 2
- Z = PhD ⟵
- Z = Undergraduate

List 3
- Z = PhD
- Z = Undergraduate

List 4
- Z = PhD
- Z = Undergraduate

List 2 - Player Z is a PhD student in Economics

In Part 1 you chose action **a**. Therefore, if you choose Option A below you will play action **a** and be paid **$0, $12, or $11** depending on the action chosen by Player Z who is a PhD student in Economics.

(Note that you can still use the highlighting tool like in Part 1 of the experiment, but you cannot change your action.)

Option A: the earnings from the game when Player Z is a PhD student in Economics.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	**0**	**12**	**11**
	b	5	13	0
	c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	6	16	9
	B	10	3	8
	C	8	10	10

Your Notes:

I think a PhD student would know the optimal earning for both assuming that both parties are cooperative. I think they would assume I go with A, for them, the best return would be B. So I'm sticking with A..

Your Decision:

Option A			Option B
Your earnings from the decision problem	○	○	$8.00
Your earnings from the decision problem	○	○	$8.25
Your earnings from the decision problem	○	○	⋮
Your earnings from the decision problem	○	○	$13.75
Your earnings from the decision problem	○	○	$14.00

Next

List 1
- Z = PhD ✓
- Z = Undergraduate ✓

List 2
- Z = PhD ✓
- Z = Undergraduate ←

List 3
- Z = PhD
- Z = Undergraduate

List 4
- Z = PhD
- Z = Undergraduate

List 2 - Player Z is an undergraduate student from any year or discipline

In Part 1 you chose action **a**. Therefore, if you choose Option A below you will play action **a** and be paid **$0, $12, or $11** depending on the action chosen by Player Z who is an undergraduate student from any year or discipline.

(Note that you can still use the highlighting tool like in Part 1 of the experiment, but you cannot change your action.)

Option A: the earnings from the game when Player Z is an undergraduate student from any year or discipline.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	6	16	9
	B	10	3	8
	C	8	10	10

Your Notes:

I think Player Z would choose C because it has the most consistent earning. If Player Z chose C, I would only earn something if I chose A. I'm choosing A in hopes that Player Z will not also choose A.

Your Decision:

Option A			Option B
Your earnings from the decision problem	○	○	$8.00
Your earnings from the decision problem	○	○	$8.25
Your earnings from the decision problem	○	○	⋮
Your earnings from the decision problem	○	○	$13.75
Your earnings from the decision problem	○	○	$14.00

Next

List 1	List 2	List 3	List 4
• Z = PhD ✓ • Z = Undergraduate ✓	• Z = PhD ✓ • Z = Undergraduate ✓	• Z = PhD ⟵ • Z = Undergraduate	• Z = PhD • Z = Undergraduate

List 3 - Player Z is a PhD student in Economics

In Part 1 you chose action **a**. Therefore, if you choose Option A below you will play action **a** and be paid **$0, $12, $13, or $11** depending on the action chosen by Player Z who is a PhD student in Economics.

(Note that you can still use the highlighting tool like in Part 1 of the experiment, but you cannot change your action.)

Option A: the earnings from the game when Player Z is a PhD student in Economics.

Instructions

Your Earnings

		Player Z's action			
		A	B	C	D
Your action	a	**0**	**12**	**13**	**11**
	b	4	14	0	6
	c	10	0	11	12
	d	13	8	6	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action			
		a	b	c	d
Player Z's action	A	12	0	16	7
	B	14	0	5	11
	C	12	16	0	10
	D	8	4	0	12

Your Notes:

yeah I really think they'd do the same thing, make it good for everyone. Maybe this is testing how people think about phd students in economics hahaha. No but really, the avgs of C and a are the best for the respective peoples. So on that alone, this should be good..

Your Decision:

Option A			Option B
Your earnings from the decision problem	○	○	$8.00
Your earnings from the decision problem	○	○	$8.25
Your earnings from the decision problem	○	○	⋮
Your earnings from the decision problem	○	○	$13.75
Your earnings from the decision problem	○	○	$14.00

Next

- List 1
  - Z = PhD ✓
  - Z = Undergraduate ✓
- List 2
  - Z = PhD ✓
  - Z = Undergraduate ✓
- List 3
  - Z = PhD ✓
  - Z = Undergraduate ←
- List 4
  - Z = PhD
  - Z = Undergraduate

List 3 - Player Z is an undergraduate student from any year or discipline

In Part 1 you chose action **a**. Therefore, if you choose Option A below you will play action **a** and be paid **$0, $12, $13, or $11** depending on the action chosen by Player Z who is an undergraduate student from any year or discipline.

(Note that you can still use the highlighting tool like in Part 1 of the experiment, but you cannot change your action.)

Option A: the earnings from the game when Player Z is an undergraduate student from any year or discipline.

Instructions

Your Earnings

		Player Z's action			
		A	B	C	D
Your action	a	**0**	**12**	**13**	**11**
	b	4	14	0	6
	c	10	0	11	12
	d	13	8	6	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action			
		a	b	c	d
Player Z's action	A	12	0	16	7
	B	14	0	5	11
	C	12	16	0	10
	D	8	4	0	12

Your Notes:

oh four! Okay so new 0s. Lets start with what I've been doing... For Z: A: max=16, min=0, range=16 (DAMN, high risk) B: max=14, min HWM, all have 0s, so all have high risk. Same with Y's. So looks like range isn't the best measure here. *remember! This is an undergrad. Let's go with the strategy of maximizing for both. (maybe PhDs would try to maximize both too. That distinction might be a red herring. Why would they not? That's how contracts are signed anyway) (would Undergrad's? Why would they not, they'd be stupid to just choose the highest one for themselves without considering Z) A: avg=8.75 B: avg=7.5 C: 9.5 D: 6 ~~~~ aaah I see. Yeah see? The highest value for both are 0 for the respective player ou tricky stuff. Z has two max 16s. But C is the best in terms of avg. Lets look at Y now too a: 9 (dang that's good too!) b: 6 c: 8.23 d: 6.75 so a is best for Y. Yeah, I can see Ca being one. Ca: Z=12 Y=13 Cc: Z=16 Y=10 Ba: Z=14 Y=12 (not as good as Ca) Dangerous for Y, is there any chance Z would choose A? Well, avg of C is better, and both have the max 16, so probably not?.

Your Decision:

Option A			Option B
Your earnings from the decision problem	○	○	$8.00
Your earnings from the decision problem	○	○	$8.25
Your earnings from the decision problem	○	○	⋮
Your earnings from the decision problem	○	○	$13.75
Your earnings from the decision problem	○	○	$14.00

Next

List 1	List 2	List 3	List 4
• Z = PhD ✓ • Z = Undergraduate ✓	• Z = PhD ✓ • Z = Undergraduate ✓	• Z = PhD ✓ • Z = Undergraduate ✓	• Z = PhD ← • Z = Undergraduate

List 4 - Player Z is a PhD student in Economics

In Part 1 you chose action **c**. Therefore, if you choose Option A below you will play action **c** and be paid **$12, $8, or $0** depending on the action chosen by Player Z who is a PhD student in Economics.

(Note that you can still use the highlighting tool like in Part 1 of the experiment, but you cannot change your action.)

Option A: the earnings from the game when Player Z is a PhD student in Economics.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	**12**	**8**	**0**

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	10
	B	14	3	9
	C	6	16	9

Your Notes:

I have a better chance of earning more with the #12 and $11 in option a, so if player Z chooses option A in predicting I will choose A so they will get $13, I chose C so I will get $12.

Your Decision:

Option A			Option B
Your earnings from the decision problem	○	○	$8.00
Your earnings from the decision problem	○	○	$8.25
Your earnings from the decision problem	○	○	⋮
Your earnings from the decision problem	○	○	$13.75
Your earnings from the decision problem	○	○	$14.00

Next

List 1	List 2	List 3	List 4
• Z = PhD ✓ • Z = Undergraduate ✓	• Z = PhD ✓ • Z = Undergraduate ✓	• Z = PhD ✓ • Z = Undergraduate ✓	• Z = PhD ✓ • Z = Undergraduate ←

List 4 - Player Z is an undergraduate student from any year or discipline

In Part 1 you chose action **a**. Therefore, if you choose Option A below you will play action **a** and be paid **$0, $12, or $11** depending on the action chosen by Player Z who is an undergraduate student from any year or discipline.

(Note that you can still use the highlighting tool like in Part 1 of the experiment, but you cannot change your action.)

Option A: the earnings from the game when Player Z is an undergraduate student from any year or discipline.

Instructions

Your Earnings

		Player Z's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Player Y had the same actions and earnings as you.

Player Z's Earnings

		Player Y's action		
		a	b	c
Player Z's action	A	13	5	10
	B	14	3	9
	C	6	16	9

Your Notes:

As this is an undergrad student, i assume they will straight away go to their highest earning column (c w/ 16) but as they can see if i chose to get the best outcome for them i would end up getting zero, so then i went to the second best option (b w/14) however the biggest earning for me was in row b but for them it was just 3, so I chose option a so they can get their highest reward but also decided to go with option a as each of the rows have a chance of getting zero but this row has the highest other two earnings and i think it is unlikely for them to choose a in the end..

Your Decision:

Option A			Option B
Your earnings from the decision problem	○	○	$8.00
Your earnings from the decision problem	○	○	$8.25
Your earnings from the decision problem	○	○	⋮
Your earnings from the decision problem	○	○	$13.75
Your earnings from the decision problem	○	○	$14.00

Next

This is the end of the experiment.

Your payment is being calculated. Please click "Next" to go to next page to learn your payment for this experiment.

Next

Thank you for participating in this experiment!

Choice Problem **24** in **List 1 - Player Z is a PhD student in Economics** was randomly selected for payment.

You chose action **c** and your opponent chose action **A**.

		Other participant's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

In that choice problem you selected option **B**.

You earned **$3.50** from the quiz and **$13.75** from your choice.

In addition, you will receive a participation fee of **$5.00**.

As a result, your total earnings are **$22.25**.

You will receive your payment as an Interac e-transfer. If you encounter any problems, please contact Johannes Hoelzemann at j.hoelzemann@utoronto.ca or 647-YYY-ZZZZ.

Magic Mirror on the Wall, Who Is the Smartest One of All?

Online Appendix: Experimental Interface — Auxiliary Experiment —

Yoram Halevy   Johannes Hoelzemann   Terri Kneeland

December 9, 2021

Instructions

Welcome. This is an experiment in the economics of decision-making. If you pay close attention to these instructions, you can earn a significant amount of money that will be paid to you at the end of the experiment via interac e-transfer.

Your computer screen will display useful information. Remember that the information on your computer screen is PRIVATE. To insure best results for yourself and accurate data for the experimenters, please DO NOT COMMUNICATE or interact with other people on other media at any point during the experiment. If you have any questions, or need assistance of any kind, please call +1-647-XXX-ZZZZ or use Skype (j.hoelzemann@utoronto.ca) anytime from 8am to 8pm Toronto time and one of the experimenters will help you privately.

In this experiment, you will face four rounds of decision-making problems. During the experiment, and in order to determine your payment, you will be randomly matched with another participant in this session.

The Basic Idea

There will be four different rounds. In each round, you will be presented with an interactive decision problem similar to the one below.

Your Earnings

		Other participant's action			
		A	B	C	D
Your action	a	7	12	8	4
	b	7	1	9	10
	c	13	2	10	6
	d	3	10	11	6

Other Participant's Earnings

		Your action			
		a	b	c	d
Other's action	A	13	8	3	18
	B	16	4	13	30
	C	10	21	16	12
	D	19	5	9	21

Your earnings in each problem depend on your choice of action (between: a, b, c, d) and the other participant's choice of action (between A, B, C, D). Your earnings possibilities are presented in tables like the ones above. In each problem, your earnings are given by the blue numbers in the left table, labelled 'Your Earnings'. The other participant's earnings are given in the right table, labelled 'Other Participant's Earnings'. Your choice of action determines the row in the `Your Earnings' table and the other participant's choice of action determines the column in the same table. The blue number in the cell corresponding to any combination of actions (yours and the other participant's) represent your earnings. Similarly, the other participant's choice of action determines the row in the 'Other Participant's Earnings' table, while your choice of action determines the column in this table. The number in the cell corresponding to any combination of actions (yours and the other participant's) represents the other participant's earnings. In summary, your choice of action AND the other participant's choice of action affect both your earnings and the other participant's earnings.

For example, if you choose action "b" and the other participant chooses action "B" your earnings would be $1 and the other participant's earnings would be $4. If you choose action "c" and the other participant chooses action "A", your earnings would be $13 and the other participant's earnings would be $3. Numbers in the example are just an example and do not intend to suggest how anyone should make their choices.

Problems

The problems that you will face will take one of two forms. The problem will either have four possible actions for both you (e.g. a, b, c or d) and the other participant (e.g. A, B, C or D) as in Example Problem 1. Or, the problem will have three possible choices for both you (e.g. a, b, or c) and the other participant (e.g. A, B, or C) as in Example Problem 2.

Example Problem 1

Your Earnings

		Other participant's action			
		A	B	C	D
Your action	a	7	12	8	4
	b	7	1	9	10
	c	13	2	10	16
	d	3	10	11	6

Other Participant's Earnings

		Your action			
		a	b	c	d
Other's action	A	13	8	3	18
	B	16	4	13	30
	C	10	21	16	12
	D	19	5	9	21

Example Problem 2

Your Earnings

		Other Participant's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Other Participant's Earnings

		Your action		
		a	b	c
Other participant's action	A	13	5	8
	B	7	9	10
	C	10	6	12

In order to assist you to choose an action, when you move your mouse over a row in the `Your Earning' table on the left, the action will be highlighted in yellow in both tables: a row on the left table, and a column on the right table. By left clicking your mouse over a row it will remain highlighted, and you can unhighlight it by clicking your mouse again or clicking another row. Similarly, when you move your mouse over a row that corresponds to an action of the other participant in the `Other participant's Earnings' on the right, the row will be highlighted in green on the right table and the corresponding column will be highlighted in green on the left table. Clicking your mouse over the row will keep it highlighted, and clicking it again (or clicking another action) will unhighlight it.

Please try to highlight actions for you and the other participant in Problems 1 and 2 above.

Finally, to choose an action you must click on the radio button around the action name (the lowercase letter next to the row, on the margin of the left table), after it has been activated (turned blue).

The Rounds

There will be four rounds. You will need to choose an action in each round, as described above. After you have confirmed your choice of action you will advance to the next screen and play a new round.

The earnings tables in each round are different, so you should look carefully at them before making your choice. You will be required to spend at least 5 minutes on each round. You may spend more than 5 minutes on each round if you wish.

The Other Participants

At the beginning of the experiment, you will be randomly matched with another participant with whom you will be matched for all four rounds. Your match is participating in this session. You do not know which actions the other participant chooses when you make your choices of actions. You can, however, attempt to reason about the actions the other participant will choose.

Payment

You will earn a participation payment of $5.00 for participating in this experiment.

In addition to the participation payment, one round will be randomly selected for payment at the end of the experiment. You will be paid your earnings in that round as described above. Any of the four rounds could be the one selected. So you should treat each round like it will be the one determining your payment.

Before the actual experiment starts, you will be asked to answer 6 questions. You will earn 50 cents for answering each question correctly on your first trial. If you make a mistake, you will not receive a payment for that question, but you must answer it correctly in order to move to the next question.

You will be informed of your payment, the round chosen for payment, and the choices of you and of the other participant only at the end of the experiment. You will not learn any other information about the choices of other participants during the experiment. The identity of the other participants to which you will be matched will never be revealed.

Finally, after completing the experiment you will be paid electronically via interac e-transfer with the e-mail address you entered on the previous page.

Frequently Asked Questions

Q1. Is this some kind of psychology experiment with an agenda you haven't told us? Answer. No. It is an economics experiment. If we do anything deceptive or don't pay you cash as described, then you can complain to University of Toronto Research Ethics Board and we will be in serious trouble. These instructions are meant to clarify how you earn money, and our interest is in seeing how people make decisions.

Q2. Is there a "correct" choice of action? Is this kind of a test? No. Your optimal action depends on your belief which actions will other participants choose. Different people may hold different beliefs.

This button will be activated after 10 minutes. Please take your time to read through the instructions.

Next

Quiz

Your Earnings

		Other participant's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Other Participant's Earnings

		Your action		
		a	b	c
Other's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Use the above earnings table to answer the following questions:

1. If you choose action 'a' and the other participant chose action 'C' what would your earnings be?

A $15

B $13

C $1

D $6

Quiz

Your Earnings

		Other participant's action		
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Other Participant's Earnings

		Your action		
		a	b	c
Other's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Use the above earnings table to answer the following questions:

2. If you choose action 'a' and the other participant chose action 'C' what would the other participant's earnings be?

A $13

B $10

C $1

D $8

Quiz

Your Earnings

	Other participant's action			
		A	B	C
Your action	a	3	15	1
	b	8	0	4
	c	6	9	5

Other Participant's Earnings

	Your action			
		a	b	c
Other's action	A	13	5	8
	B	7	9	10
	C	10	6	12

Use the above earnings table to answer the following questions:

3. If the other participant chose action 'A', which action would give you the highest earnings?

A a

B b

C c

Quiz

Your Earnings

		Other participant's action			
		A	B	C	D
Your action	a	7	12	8	4
	b	7	1	9	10
	c	13	2	10	16
	d	3	10	11	6

Other Participant's Earnings

		Your action			
		a	b	c	d
Other's action	A	13	8	3	18
	B	16	4	13	30
	C	10	21	16	12
	D	19	5	9	21

Use the above earnings table to answer the following questions:

4. If you choose action 'c' and the other participant chose action 'A' what would be your earnings?

A $8

B $13

C $3

D $10

Quiz

Your Earnings

		Other participant's action			
		A	B	C	D
Your action	a	7	12	8	4
	b	7	1	9	10
	c	13	2	10	16
	d	3	10	11	6

Other Participant's Earnings

		Your action			
		a	b	c	d
Other's action	A	13	8	3	18
	B	16	4	13	30
	C	10	21	16	12
	D	19	5	9	21

Use the above earnings table to answer the following questions:

5. If you choose action 'd' and the other participant chose action 'B' what would be the other participant's earnings?

A $10

B $5

C $30

D $4

Quiz

Your Earnings

		Other participant's choice			
		A	B	C	D
Your action	a	7	12	8	4
	b	7	1	9	10
	c	13	2	10	16
	d	3	10	11	6

Other Participant's Earnings

		Your action			
		a	b	c	d
Other's action	A	13	8	3	18
	B	16	4	13	30
	C	10	21	16	12
	D	19	5	9	21

Use the above earnings table to answer the following questions:

6. If the other participant chose action 'D', which action would give you the highest earnings?

A a

B b

C c

D d

Round 1

Please choose one action from below. Each button will be automatically activated after 3 minutes.

Instructions

Your Earnings

		Other participant's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Other Participant's Earnings

		Your action		
		a	b	c
Other's action	A	13	5	10
	B	14	3	9
	C	6	16	9

Round 2

Please choose one action from below. Each button will be automatically activated after 3 minutes.

Instructions

Your Earnings

		Other's action			
		A	B	C	D
Your action	a	0	12	13	11
	b	4	14	0	6
	c	10	0	11	12
	d	13	8	6	0

Other Participant's Earnings

		Your action			
		a	b	c	d
Other's action	A	12	0	16	7
	B	14	0	5	11
	C	12	16	0	10
	D	8	4	0	12

Round 3

Please choose one action from below. Each button will be automatically activated after 3 minutes.

Instructions

Your Earnings

		Other participant's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Other Participant's Earnings

		Your action		
		a	b	c
Other's action	A	6	16	9
	B	10	3	8
	C	8	10	10

Round 4

Please choose one action from below. Each button will be automatically activated after 3 minutes.

Instructions

Your Earnings

		Other participant's action		
		A	B	C
Your action	a	0	12	11
	b	5	13	0
	c	12	8	0

Other Participant's Earnings

		Your action		
		a	b	c
Other's action	A	6	15	10
	B	3	8	9
	C	4	13	9