Rationally Inattentive and Strategically (Un)sophisticated: Theory and Experiment

Eric Spurlino*

New York University

Abstract

In games with costly information acquisition, the information acquired by one player directly affects her opponent's incentives of gathering information. Rational inattention theory posits that the opponent's information acquisition strategy is a direct function of these incentives. This paper argues that people are cognitively limited in predicting their opponent's level of information and hence lack the strategic sophistication that theory assumes. Using an experiment involving a real effort attention task and a simple two player trading game, I study the ability of subjects to (1) anticipate the information acquisition of opponents in this strategic game, and (2) best respond when acquiring their own costly information. The above is studied by exogenously manipulating the difficulty of the attention task for both the player and their opponent. Predictions of behavior are generated by a novel theoretical model in which Level-K agents can acquire information à la rational inattention. The findings are an outsized lack of strategic sophistication, driven largely by the cognitive difficulties of predicting opponent information. These results suggest a necessary integration of the theories of rational inattention and cognitive uncertainty in strategic settings.

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1 Introduction

A recurring thread in recent advances in behavioral economics is that cognition is difficult, and that this can lead to predictable divergences from classic economic behavior. Two areas that have found significant success in modeling such cognitive difficulties are that of rational inattention and strategic sophistication. Rational inattention proponents (beginning with Sims 2003) have shown successfully that in decision making settings, individuals acquire information in way that maximizes the utility of gaining that information less the mental costs of doing so. In strategic settings, the strategic sophistication literature (beginning with Nagel 1995) has shown that individuals are limited in their ability to reason contingently and anticipate the actions of others.

A key question that joins the two sub-fields above is how individuals behave in games with endogenous information. Recently, a number of papers have theoretically examined equilibria in such settings–how people acquire information optimally in games where one or multiple players can acquire costly information about payoff relevant parameters. This has been done in bargaining games (Ravid 2020), buyer-seller games (MatÄjka 2015, Martin 2017), global games (Yang 2015), and Bayesian persuasion games (Gentzkow and Kamenica 2014, Bloedel 2019). However, all of the papers above have looked at rational inattention in strategic settings without examining the ability of players to reason strategically as well. It is reasonable to presume that individuals who are limited cognitively in information acquisition may also be cognitively limited in strategic reasoning. An open line of research then is to what extent players are able to anticipate and best respond to the information acquisition of others.

In this paper, I examine exactly this question. The simplest possible strategic setting is chosen, modelled after the standard Market for Lemons game proposed by Akerlof 1970. Here, two individuals decide on a deal of unknown quality. Accepting the deal is good for one agent and bad for the other, but ex-ante beneficial to both. In such a case, the utility of making a "right" or "wrong" decision transparently hinges on the ability of the other agent to make a "right" or "wrong" decision. In such a game, each party must (1) predict how often (and of what type) the other party is making a mistake, and (2) optimally choose their own level of accuracy in light of the former. Given the cognitive difficulty of each step, it is of fundamental importance to test to what degree individuals are capable of such thinking, and in which ways they systematically deviate. Furthermore, by restricting the experiment to focus to the simplest of strategic situations, this test gives subjects the "best shot" of behaving in a strategically sophisticated manner.

Predictions are generated by combining the leading theory of information acquistion—rational inattention—with the leading theory of strategic sophistication—Level-K theory. These predictions are then tested with a laboratory experiment in which I carefully alter information acquistion costs of each player in a simple two player game. The findings are that individuals have extremely limited ability to conduct this type of contingent reasoning, above and beyond the difficulty typically found in other strategic settings. I argue that this is largely due to a third strand of the cognitive economics field–cognitive uncertainty. The cognitive uncertainty literature posits that when critical thinking about a situation is difficult (such as when one attempts to model the information acquisition of their opponent), one's beliefs about unknown variables (opponent behavior) drift towards a salient, possibly incorrect value. In this case, the salient value is to suppose the opponent is not rationally inattentive at all, with agents treating strategic settings much like they would a decision problem. A follow-up treatment tests this mechanism specifically. In this treatment, subjects play a computer which exactly mimics the mean behavior of subjects in the main treatment. Subjects in this treatment do adjust their information strategies in response to different computer strategies. This finding supports the hypothesis that cognitive uncertainty plays a sizeable role in behavior in such games.

In studying the above, this paper naturally contributes to two strands of literature: rational inattention and strategic sophistication. Each can be said to belong to the overarching class of "cognitive economics", each delivering a structured and testable model of an individual's varying ability to understand and best respond to the world around them. The present paper shows how all the two can complement one another in order to provide a view of how individuals interact in strategic settings with information acquisition.

The rational inattention literature, beginning with Sims 2003 and expanded on by Matejka and McKay 2015 and Caplin, Dean, and Leahy 2019 has primarily focused on non-strategic decision-making. However, and emerging subfield has studied what happens when one or both agents in a game are rationally inattentive. Theoretically, papers studying games where one party is rationally inattentive include studies on strategic pricing (Martin 2015), bargaining (Ravid 2020), and persuasion (Gentzkow and Kamenica 2014, Bloedel and Segal 2018, Matyskova 2018). Other games with multiple inattentive agents have been focused on coordination games with symmetric attention costs (Yang 2015, Szkup and Trevino 2015). Most recently, Domotor 2021 has studied theoretically a market for lemons game with two-sided rational inattention. While similar in spirit to the game in this paper, Domotor's model has a more complex action and state space, and a sequential structure which does not lend itself as well to predictions of strategic sophistication in the lab. More loosely, the present paper's game structure closely resembles that of Carroll 2016, which is a study of robustness and allows for a continuum of differing information structures on the part of the buyer and seller. Only one previous paper experimentally tests the predictions of strategic rational inattention, Martin 2016. However, the game in this paper only features one rationally inattentive party, whereas the present paper examines a game with both parties being rationally inattentive. This paper's setting is more well-suited to study strategic sophistication in information acquisition games, which was not the focus of the previous paper.

This paper also uses ideas and tools developed by the sophistication literature. Specifically, I utilize the powerhouse Level-K model of Nagel 1995. This model, and its close relative the Cognitive Hierarchy model, have been used in a variety of different settings to explain non-equilibrium behavior in experimental games. Examples include the p-beauty contest (Nagel 1995), various matrix games (Costa-Gomes, Crawford and Broseta 2001), and the 11-20 game (Arad and Rubinstein 2012). To my knowledge, no paper has studied strategic sophistication in a game with costly information acquistion. The present paper is not, however, the first to integrate the two strands of literature. Aloui and Penta (2016) introduce a model of endogenous depth of reasoning, which posits that higher levels of strategic sophistication come at higher cognitive costs, much like how higher degrees of information acquistion come at higher costs in the rational inattention model. While there paper considers general economic games, and not games with information acquistion, their theory is strongly compatible with the one developed in the present paper. For the sake of exposition the present theoretical analysis will only consider exogenous depth of reasoning (i.e. level-K theory); however, I discuss possible integration with endogenous depth of reasoning in the paper's concluding section, and believe this is a natural future direction of the present work.

2 The Model

This section will first present the main game present in the experimental design. I will then analyze best responses of each player, conditional on their beliefs. A Nash equilibrium in which these beliefs are in fact correct is then discussed. Then, I will use Level-K theory to generate predictions on the data for various levels of strategic sophistication.

2.1 The Game

The game consists of two players, which I will call R and B (for Red and Blue). The two players must decide whether to accept or reject a deal. There are two possible states, $\theta \in \{\text{Blue}, \text{Red}\}$, which dictate the payoffs each player receives if a deal is accepted. A deal is only made if both players accept the deal. If either or both parties reject the deal, both players receive an identical outside option v_o. If both players accept the deal, their payoffs will be determined by the state of the deal. If the deal is Blue, player B gets v_H and player R gets v_L, while if the deal is Red, player B gets v_L and player R gets v_H, with $v_L < v_o < v_H$. For ease of explanation, a deal that matches the color of the player will sometimes be referred to as a *favorable deal*, whereas a deal of the opposing color will be referred to as an *unfavorable deal*.

Informationally, I assume that both players have an identical prior over the two states, with $\mu \in (0, 1)$ being the probability of a Red deal. For the remained of the paper, I will assume that each state is equally likely, $\mu = \frac{1}{2}$, as this will mirror the game present in the experimental design. An additional assumption I will make on the model parameters is that $\frac{1}{2}v_H + \frac{1}{2}v_L > v_o$, which means that trades are ex-ante optimal, but ex-post inefficient (as $v_L < v_o < v_H$).

Notice that if each player has full information, no trades will be made in any equilibrium. If both players have only the prior, an equilibrium will exist where all players always trade. If information is asymmetric and perfect (i.e. one player has full information and the other has none), trade can also not occur in any equilibrium, as in the classic Market for Lemons game.

What I add to this simple game structure is costly information acquisition, in the style of rational inattention (Sims 2003). Both players can simultaneously acquire information about the state of the deal. One formulation of this is a cost of information that is linear in the expected reduction in Shannon entropy from the prior. Shannon entropy defined over some set of beliefs $P[\theta]$ is simply $-\sum_\theta P[\theta] \log P[\theta]$, and can be thought of as how much uncertainty is present in one's beliefs. For example, if one knows the probability of one realization of θ is certain, there is 0 Shannon entropy in beliefs—the minimal possible value. If one has only a uniform prior, Shannon entropy is at it's maximal possible value, as there is complete uncertainty about the state. Thus reducing Shannon entropy is equivalent to reducing uncertainty in beliefs, or increasing the informativeness of ones beliefs. As demonstrated in Caplin and Dean 2015, an equivalent formulation is expressed in terms of State Dependent Stochastic Choice (henceforth *SDSC*), which are the probabilities of choosing each action in each state. In the present game, because there are only two possible actions—accept or reject—SDSC is fully characterized by $P[a|\theta]$ for $\theta \in \{R, B\}$. The probability of rejecting in a given state is simply $P[r|\theta] = 1 - P[a|\theta]$. Note that it is always at least weakly optimal for a Red player to accept a Red deal and reject a Blue deal, while the reverse is true for a Blue player. So a mistake can either be accepting an unfavorable deal, or rejecting a favorable one. Rational inattention theory then says that reducing these mistakes is costly, and the cost of reducing them is convex. Formally, if

$P^i[a|\theta]$ is the SDSC of a player, their cost of information is:

$$\lambda^i(\sum_{\theta \in \{R,B\}} \frac{1}{2}(\sum_{c \in \{a,r\}} P^i[\text{c}|\theta] \ln P^i[c|\theta]) - \sum_{c \in \{a,r\}} P^i[c] \ln P^i[c]]$$

where $\lambda^i > 0$ parameterizes an individuals difficulty of acquiring information, with a higher value corresponding to higher costs of information. One interpretation of this is that it is more costly to have larger cross-state differences in action probabilities, because in order to do so one needs to be quite good at distinguishing states from one another.

2.2 Solving the Player's Problem

The optimal solution to the player's problem is the SDSC that maximizes their expected utility, less the costs of information as described above. Specifically, the expected utility of a given SDSC is given by

$$EU^i[P^i] = \sum_{\theta \in \{R,B\}} \mu(\theta) \sum_{c \in \{a,r\}} P^i[c|\theta] * v^i(c|\theta)$$

What adds an extra level of difficulty in strategic settings is that one's $v^i(c|\theta)$ are themselves an expected utility, being a function of the SDSC of their opponent. Due to symmetry, I will limit discussion to that of the Red player. The Blue player's best response will be identical to that of the Red player's, simply with the labels for each state switched in their SDSC. For now, assume that the Red player has some belief about what the other player is doing. Specifically, suppose they think that the Blue player has SDSC $P^B[a|B]$ and $P^B[a|R]$, i.e. the Red player believes the Blue player will accept a Blue deal with probability $P^B[a|B]$ and a Red deal with probability $P^B[a|R]$. Note that if the Red player chooses to reject, their payoff will be v_o regardless of the state of the deal. If the red player chooses accept, however, their payoff depends both on the state of the deal, and the likelihood of the other player choosing accept in that state. Specifically,

$$v^R(a|R) = P^B[a|R] * v_H + (1 - P^B[a|R]) * v_o$$

$$v^R(a|B) = P^B[a|B] * v_L + (1 - P^B[a|B]) * v_o$$

where $P^B[a|R]$ is the probability that the Blue player accepts an unfavorable deal, and $P^B[a|B]$ is the probability that the Blue player accepts a favorable deal. I can then write:

$$v^R(a|R) = v_o + P^B[a|R](v_H - v_o)$$

$$v^R(a|B) = v_L - P^B[a|B](v_o - v_L)$$

As already established, the state-dependent utilities of rejecting are constant, $v^R(r|R) = v^R(r|B) = v_o$. With these state-dependent action utilities and the cost parameter λ^R, I can fully solve the Red player's optimization problem, conditional on their beliefs about the Blue player's error rates.

To solve for the optimal strategy, I take the approach designed by Caplin, Dean, and Leahy 2019 (henceforth *CDL*) using optimal consideration sets. An action (accept or reject) is said to be in the player's consideration set if there is a strictly positive probability of that action being chosen. Thus there are then three cases to consider: the player indiscriminately accepts, indiscriminately rejects, and when they mix between the two. Naturally, the last case also involves determining with what probabilities each action is chosen in each state.

From CDL, an SDSC is optimal if and only if for all $c \in \{a, r\}$

$$\sum_{\theta \in \{R,B\}} \frac{e^{v(c|\theta)/\lambda^R} \mu(\theta)}{\sum_{b \in \{a,r\}} P(b) e^{v(b|\theta)/\lambda^R}} \leq 1$$

with equality of c is chosen with positive probability. I can then use this to develop expressions for when a player best responds by acquiring no information and either indiscriminately accepting or indiscriminately rejecting the deal.

The player will best respond by unconditionally accepting the deal (i.e. $P^R[a] = 1$) when

$$\frac{1}{2} e^{\frac{(v_o - v_L)(P^B[a|B])}{\lambda^R}} + \frac{1}{2} e^{\frac{-(v_H - v_o) P^B[a|R]}{\lambda^R}} < 1$$

Note that a player is more likely to play this strategy if they believe their opponent to be making a sufficiently high number of mistakes.

The player will best respond by always rejecting the deal (i.e. $P^R[a] = 0$) when

$$\frac{1}{2}e^{\frac{-(v_o - v_L)(P^B[a|B])}{\lambda^R}} + \frac{1}{2}e^{\frac{(v_H - v_o)P^B[a|R]}{\lambda^R}} < 1$$

which occurs when the other player is making fewer errors (i.e. accepting more favorable deals and rejecting more unfavorable deals).

Finally, I consider the intermediate case in which the player accepts and rejects with positive probability in each state. Because the two previous conditions are disjoint, it directly follows that if neither of them is satisfied, the player will have both actions in their consideration set. What remains to be shown is what SDSC a player will optimally best respond with specifically. To find this, I first solve for the unconditional accept probability using the first expression. This yields

$$P^R[A] = \frac{e^{v_o/\lambda^R} - \mu e^{v^R(a|R)/\lambda^R} - (1-\mu)e^{v^R(a|B)/\lambda^R}}{e^{-v_o/\lambda^R}\left(e^{v^R(a|R)/\lambda^R} - e^{v_o/\lambda^R}\right)\left(e^{v^R(a|B)/\lambda^R} - e^{v_o/\lambda^R}\right)}$$

The conditions on SDSC then are direct functions of the above description, utilizing the conditions found in Matejka Mckay (2015):

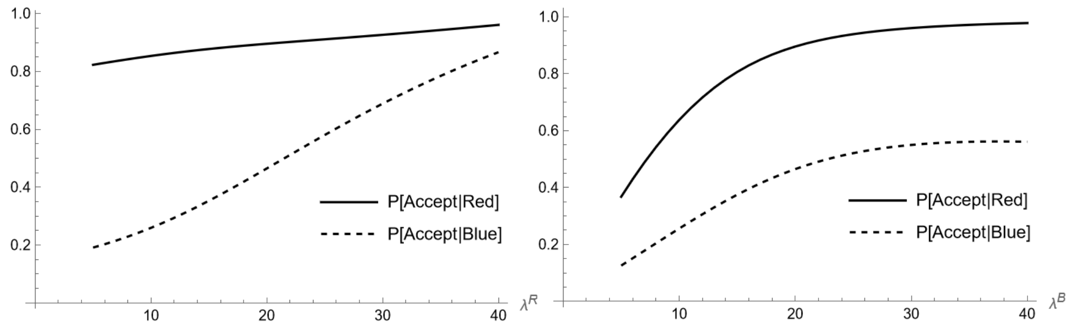
$$P^R[A|R] = \frac{P^R[a]e^{v^R[a|R]/\lambda^R}}{P^R[A]e^{v^R[a|R]/\lambda^R} + (1 - P^R[a])e^{v_o/\lambda^R}}$$

$$P^R[a|B] = \frac{P^R[a]e^{v^R[a|B]/\lambda^R}}{P^R[A]e^{v^R[a|B]/\lambda^R} + (1 - P^R[a])e^{v_o/\lambda^R}}$$

2.3 Nash Predictions

The preceding section have shown that given an opponent's SDSC, you can generate optimal SDSC as a best response. A Nash equilibrium in this setting is then simply a pair of SDSC $(P^i[a|R], P^i[a|B])$ for each $i \in \{R, B\}$ such that each SDSC is a best response to the other.

Trivially, there is always an equilibrium in which both players never accept any trade.



(a) Changing Own Cost (b) Changing Opponent Cost

Figure 1: Nash Predictions

This is because if one player is always rejecting, the other player will always get v_o, regardless of the state or their action. Then, *any* inattentive SDSC (i.e. no information acquired) is a best response, including the one which indiscriminately rejects deals.

Naturally the more interesting case is non-trivial Nash equilbria. It can be shown numerically that there exists a unique non-trivial Nash equilibria for a wide range of parametric assumptions, so long as no player has too low of information costs. The problem is fairly simple to solve numerically, but does not have a closed form solution. Thus one must take known parameters (λ^i, v_o, v_H, and v_L) and solve for the non-trivial equilibrium. Figure 1 illustrates an example of such an equilibrium[1].

In a non-trivial equilibrium, numerical solutions demonstrate that as attention costs increase, for either an individual or their opponent, the probability of accepting a deal of either state increases. When costs become sufficiently high, both individuals indiscriminately accept. The intuition of these equilibria is that higher attention costs act as a sort of commitment device, allowing a player to tie their hands and not discriminate much between the two states. As long as the other player does not have such low costs that they can then take advantage of this player, the players are able to engage in a higher amount of deal acceptance than when costs are low.

[1]Parameterization for this equilibrium is $v_H = 90$, $v_L = 10$, $v_o = 30$, and the "fixed" attention cost in either graph is set to $\lambda = 20$.

2.4 Best Response Dynamics: Level-K Predictions

In addition to examining Nash behavior, Level-K theory will generate non-equilibrium predictions for different levels of strategic sophistication. As is standard in Level-K theory, I will assume that a Level-K player plays as if their opponent is of type Level-(K-1). It is also worth noting that the following predictions are simply a reasonable way to structure what I mean by strategic sophistication in such a setting. The experiment will be designed to test predictions on behavior given any beliefs, and not just the beliefs as determined in this theory. Discussions are limited to the first 3 levels, Level-0 through Level-2, as predictions for behavior beyond these levels have diminishing intuitive explanations, and because the levels provided are sufficient in explaining any behavior present in the experiment.

2.4.1 Level-0

As with any Level-K analysis, one must make some assumptions as far as how a "level 0" player will play. The standard assumption is to assume the Level-0 player plays all actions with equal probability. In this setting, this translates to the player choosing $P[a|\theta] = \frac{1}{2}$ for all θ. However, the only critical assumption is that a level-0 player has $P[a|B] = P[a|R]$, i.e. they do not acquire any information. In other words, a level-0 player in this game is not rationally attentive—they simply indiscriminately acceptor reject a deal with some probability.

2.4.2 Level-1

A Level-1 player then best responds to a Level-0 player. The essential result is that a Level-1 player is *rationally attentive* but does not realize that their opponent is also rationally inattentive. For the following specific predictions, the Level-0 player is assumed to follow the specific $P[a|\theta] = \frac{1}{2}$ strategy, however as noted this is just for clarity of presentation, and any $P[a|\theta] = p$ constant for each θ will suffice. Again, analysis is presented for the Red player, noting that the Blue player will have the same predictions, with the "good" and

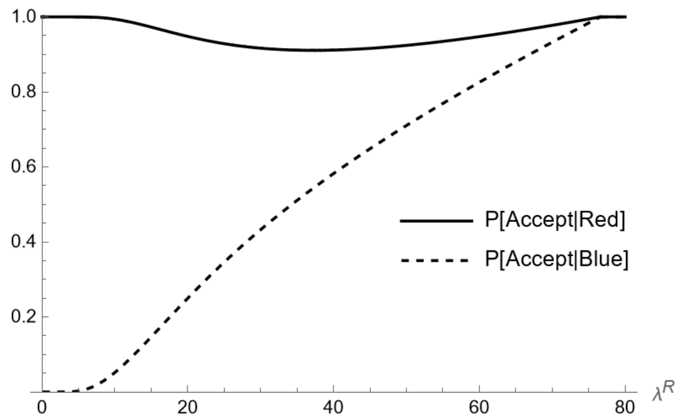


Figure 2: Probability of accepting each color deal as a function of own attentional cost for a Level-1 player

"bad" states reversed. A Level-1 player then has

$$v^R(a|R) = v_o + \frac{v_H - v_o}{2} = \frac{v_H + v_o}{2}$$

$$v^R(a|B) = v_L + \frac{v_o - v_L}{2} = \frac{v_o + v_L}{2}$$

Using the result from the preceding section, one can then directly map out SDSC of a Level-1 agent as a function of v_o, v_L, v_H, and λ^i. Crucially, since a Level-1 player assumes they are playing against a Level-0 player, who is not rationally attentive, the SDSC of the Level-1 player does not depend on the attention cost parameter of the other agent, λ^{-i}.

Figure 1 illustrates the optimal SDSC as a function of the player's own attention cost parameter. Notice that the probability of accidentally accepting an unfavorable deal is strictly increasing in attention costs, while the probability of accepting a favorable deal is non-monotonic. As attention costs go to 0, a player will perfectly distinguish the two states and only accept in the good state. As attention costs get sufficiently large, a player will indiscriminately accept, because of the assumption that there are ex-ante gains for trade ($\frac{v_L+v_H}{2} > v_o$).

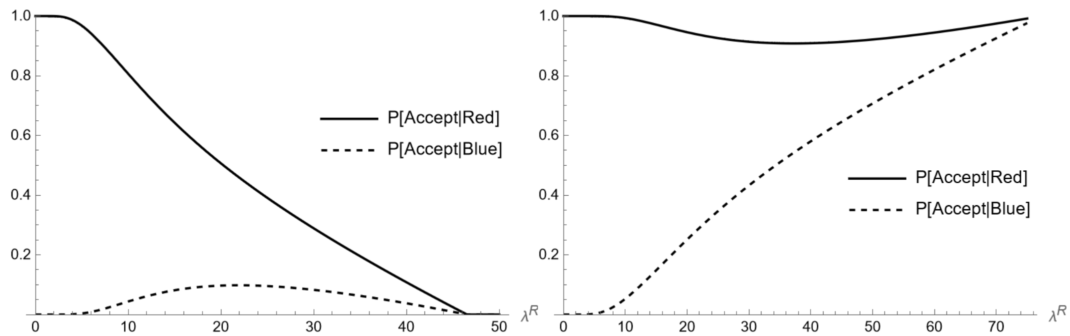
2.4.3 Level-2

A Level-2 player best responds to the behavior a Level-1 player. From the previous section, one can derive the SDSC of a Level-1 player as a function of their attention cost parameter. The main takeaway for a Level-2 player is that their SDSC will be a function of not only their own attention cost parameter, but also the attention cost parameter of their opponent. That is, a Level-2 player is rationally inattentive, and realizes their opponent is *also* rationally inattentive.

Figure 2 illustrate the optimal error rates as a function of one's own attention cost parameter, holding the other fixed. One finding of interest as that dynamics with respect to one's own costs depend crucially on the cost of one's opponent. Figure 2(a) shows a case in which the opponent has low costs of attention, while Figure 2(b) shows one in which they have high costs of attention.

If the opponent has low enough costs (underneath some threshold), then as own costs increase, the probability of accepting favorable deals decreases. If the opponent has higher costs, however, then the probability of accepting unfavorable deals increases. The intuition is that a high cost Level-1 opponent tends to accept most deals, making the ex-ante benefit of accepting high. A low cost Level-0 opponent, however, tends to only accept their own favorable deals, making the ex-ante benefit of accepting low. Thus as own costs become sufficiently large, one who faces a low cost opponent rejects all deals, while one who faces a high cost opponent accepts all deals.

Figure 3 holds fixed one's own attention cost parameter, and varies that of the opponent. If an opponent has sufficiently low attention costs, a Level-2 player assumes they will do a very good job as discerning the state of the deal, and thus the benefits of paying costly attention are very low. Because of this, with low opponent costs, a Level-2 player will always reject. As opponent costs increase, the Level-2 player assumes their opponent will make more mistakes, making it more beneficial to accept, causing the SDSC of accepting to increase in each state. This will continue until the opponent has some sufficiently high costs. After these costs, the Level-2 player assumes their opponent will accept all deals, resulting in a constant SDSC at these opponent cost values.



(a) λ^B Low (b) λ^B High

Figure 3: Probability of accepting each color deal as a function of own attentional cost for a Level-1 player, holding the attention cost of opponent constant at either a high or low level

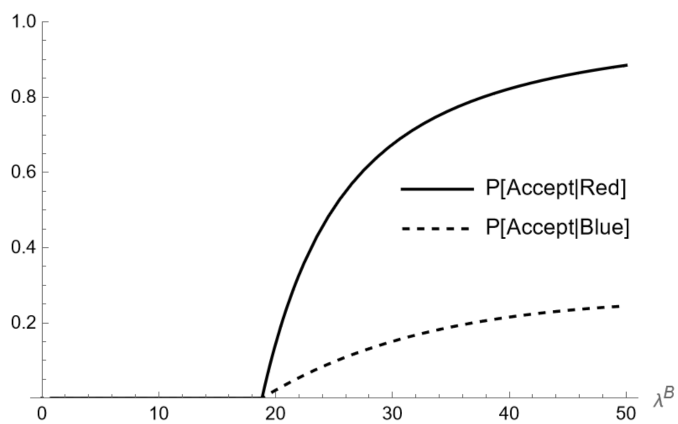


Figure 4: Probability of accepting each color deal as a function of opponent attentional cost for a Level-2 player, holding fixed own attentional cost

3 Experimental Design: Main Treatment

The experiment is designed to test the ability of subjects to both anticipate and best-respond to the information acquisition of opponents in the game examined theoretically. Doing so will test to what degree subjects are rationally inattentive and strategically sophisticated in a game with costly information acquisition. In anticipation of heterogeneity in subject behavior, I utilize a within subject treatment that determines to what extent individuals are able to best respond to the attention costs of themselves and their opponents. The main experiment consists of 4 parts–including 3 incentivized parts and 1 non-incentivized survey.

As the predictions in the theory section above rely on expected utility theory, and assume I am able to observe the utilities of certain rewards, I use probability points as my incentivization scheme. That is, the earnings for an individual subject are points, valued from 0 to 100, which indicate their probability of winning a $10 bonus payment, in addition to the $10 completion payment. In my analysis, I can then normalize the utility of the $10 bonus payment to be 100, and the points will then directly correspond to their value in utility. In order to prevent hedging (especially with regards to incentivized belief elicitation), I choose only one randomly selected question from the incentivized portion of the experiment for payment.

The experiment itself took place online via Prolific and using oTree software. I will save discussion on the decision to implement this as an online experiment versus an in-person experiment for after a description of the overall design.

3.1 Part One: Decision Making Task

The first part of the experiment served two purposes: (1) introduce a real-effort attention task to the subjects, which will be used later in the strategic portion of the experiment, and (2) gauge individual level ability in this attention task. The attention task used in this experiment was the "dot task", which has been established as reliable task which rewards attentional effort with better outcomes. The task consists of a square grid of red and blue

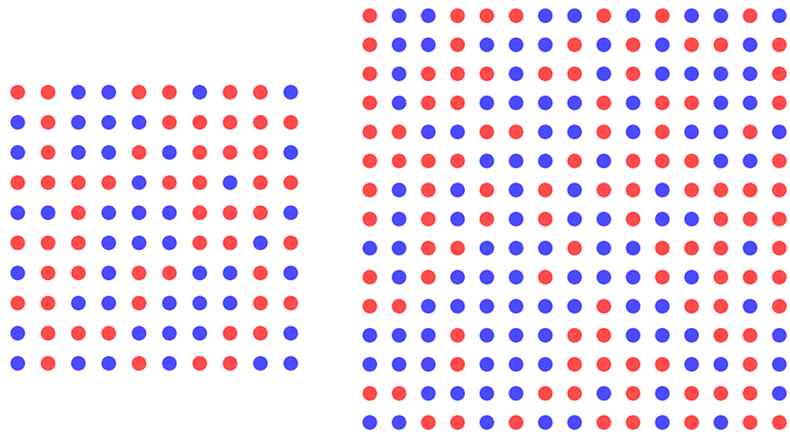


Figure 5: 100-Dot Grid (Left), 225-Dot Grid (Right)

dots. With 50% probability, there are more red dots than blue dots (a “red grid"), and with 50% probability there are more blue dots than red dots (a “blue grid"). The task is then to determine whether the grid is red or blue. Subjects were given a maximum of 30 seconds to determine whether they think the grid is red or blue. A correct classification is rewarded with 75 points, while an incorrect classification is awarded with 25 points.

Because the strategic portion of the experiment will manipulate the difficulty of the above task for both the subject and their opponent, subjects are introduced to two difficulty levels in this part of the experiment. These difficulty levels are labeled “100-Dot” and “225-Dot”. As the names suggest, a 100-Dot grid is a 10 by 10 grid featuring 100 dots, and a 225-Dot grid is a 15 by 15 grid featuring 225 dots. Another difference between the two grid types is the difference in number of dots between the “majority” and “minority” colors. On the 225-Dot grid, there are either 5 more blue dots (on a blue grid) or 5 more red dots (on a red grid). On the 100-Dot grid, there are 8 more blue dots or 8 more red dots. Piloting designed to elicit the difficulty of various dot tasks (only in decision making settings) has determined that these two tasks are perceived to be of consistently different difficulty levels, with the 100-Dot task being much easier than the 225-Dot task. Figure 5 illustrates and example of these two grid types.

In order to elicit individual SDSC for each task, I utilize repetition. The two classification tasks are repeated 15 times each, for a total of 30 rounds. Because I am eliciting probabilities on the individual level, I did not want subjects to react to feedback, or demonstrate learning over time. Thus, no feedback about whether a subject was right or wrong on any particular round is provided until after the conclusion of the experiment. For ease of instruction, and in order to familiarize subjects to the structure of the strategic portion of the experiment, these 30 rounds are divided into 6 blocks of 5 rounds each. Within each block, the type of grid (100-Dot or 225-Dot) remains constant. Subjects are reminded of the upcoming grid type and the rules of the decision before each round.

3.2 Part Two: Strategic Game

Part two is the central part of the experiment. It consists of exactly the game described in Section 3. The values for v_o, v_H, and v_L were set at 30 points, 90 points, and 10 points respectively. These values were chosen the data the "best chance" at observing differences in subject errors with respect to opponent task difficulty. First, note that the ex-ante optimality of accepting a deal is very salient. If both agents acquire no information at all and indiscriminately accept the deal, the expected payout is 50 points, versus 30 points for rejecting the deal. According to the theory, this will also lead to larger differences in the probability of erroneously accepting unfavorable deals in response to opponent difficulty. A v_o value more central to v_L and v_H, the low gains from trade would lead to less stark—and thus more difficult to observer empirically—effects of opponent difficulty on SDSC.

At the start of this part of the experiment, subjects were assigned to one of two roles: Red player and Blue player. To avoid confusion, subjects were assigned to the same role throughout the experiment. Players were then told they would be randomly re-matched with a player of the other role type over 120 rounds. In each round, subjects played the game described in Section 3. Both players knew that a "Red Deal" and a "Blue Deal" were each equally likely. Their choice each round was to accept or reject the deal. A deal was "made" if both players accepted the deal. This would give 90 points to the player who's role color matched that of the deal and 10 points to the other player. If either or both players rejected the deal, they would each receive 30 points.

As in Part One of the experiment, subjects were again shown either 100-Dot or 225-Dot grids. The additional manipulation in this part of the experiment was to vary (1) the subject's grid type and (2) their opponent's grid type each round. Like in Part One, this was divided into 8 blocks of 15 questions each. Within each block, the grid type for the subject and their opponent remained constant. Crucially, subjects were made aware of their grid type and their opponents grid type. Thus for each subject, I will be able to elicit their SDSC in all four possible attentional setups. Again in order to avoid feedback and learning effects in repeated game environment, no feedback was provided to subjects during this stage of the experiment.

Each subject had a random order of the four task difficulty combinations, and they went through this order twice sequentially to make up the 8 blocks. This structure allows me to elicit beliefs about opponent behavior after only the blocks in the second half of the experiment (in order to make sure eliciting such beliefs did not change subsequent behavior). Belief elicitation occurred at the end of blocks 5 through 8. At the beginning of Part 2, subjects were told there would be two additional questions at the end of these blocks, but were not told they would be belief elicitation questions specifically. The goal of these questions is to elicit the subject's beliefs of their opponents SDSC. In order to do so in a clear and understandable manner, subjects were asked to estimate the probabilities (in percent) of red deals, and of blue deals that their opponents in the last block accepted. Payment would then be made via a quadratic scoring rule[2], where their payment would be the maximum of $100 - \frac{\text{Error}^2}{25}$ and 0 points, where the Error is the difference in percentage points between their belief and the actual probability of red or blue deals their opponent accepted in the previous block.

[2]Quadratic scoring rule should be incentive compatible for all agents given prizes are in probability points. Subjects were told that it is in their best interest to report true beliefs, as is advised in the literature. Exact payment structure was available via a graph and the actual equation on a separate page that subjects could get to if desired

3.3 Part Three: Other Measurements

After the above rounds, a few potential co-variates are elicited. First, subjects play a variation of the 11-20 game proposed by Arad and Rubinstein (2011). Subjects are randomly assigned into pairs and are each told to request a number of points between 51 and 60. Subjects receive the number of points they request, plus an additional 20 points if they request exactly one less point than their opponent. Arad and Rubinstein show that this is an easy to explain game that elicits the level of strategic sophistication of an individual.

Next, subjects are asked the three question Cognitive Reflection Test (CRT) (Frederick 2005) as another measurement of cognitive ability. Previous literature has shown correlation between this measurement and strategic sophistication, as well as performance in other economic games. This quiz was not incentivized, which I found to be the standard approach in previous economic experiments involving the CRT.

Finally, subjects filled out a brief survey. Aside from basic demographics (gender and education level), subjects were also asked to explain their strategy in part two of the experiment. This is done through a series of questions. First, subjects were asked to what extent they attempted to actually count the dots in each attentional setup of the game. They were then asked how their strategy depended on the task of their opponent for each of their own tasks, and for a free form description of their overall strategy.

3.4 Decision to Conduct Experiment Online

The experiment was run online via Prolific, and I will argue that rational inattention experiments (in general), and more importantly *strategic* rational inattention experiment necessitate such an environment. Firstly, an online environment allows subjects to go through the experiment at their own pace. In the above experiment, subjects could choose, for example, to inattentively click through each round of decision making, and finish the experiment extremely early. Likewise, subjects could spend up to 30 seconds on each task, which could end up taking well over an hour. Allowing for both of these, and the spectrum in between, allows subjects to acquire information in a truly flexible and endogenous way–more in line with the theoretical concept of rational inattention. An online environment allows for this kind of flexibility, whereas a traditional classroom lab experiment typically has a structure such that participants could not leave the room until all subject have completed the experiment. This can create unwanted social pressure effects which are difficult to control for and can contaminate any treatment effects the researcher may be interested in.

The above underscores why this is an especially important problem for *strategic* information acquisition experiments. In most classroom labs, it becomes very obvious the average response time of decisions of the other subjects in the lab (via sounds of clicking mouses and keyboards, seeing subjects sitting idly). This has the potential to create large session-level effects, and introduces a noisy signal of opponent strategy that is difficult to model or control for.

In the online setup, subjects can play the game at their own pace. Subjects proceed through all stages without waiting for any opponent actions. Because no feedback is provided, this is feasible in the design outlined above. Subjects are told that payments will be calculated once all subjects in the session have completed the experiment, no later than 7 days after that subject has finished. At this time, subjects are given a Qualtrics survey link where they log-in with their Prolific credentials and are shown their award in points. These points then translate to their probability in percent of winning a $10 bonus payment. I utilize the lottery mechanism designed by Caplin et al 2020 to credibly award the bonus with the correct probability. Subjects are shown a timer synced to their computer system clock in milliseconds. They can stop this clock once and only once, and the milliseconds in one's and ten's constitutes a random number, where a number less than their point value results in the bonus payment. Subjects have access to a practice version of this task before taking part in the experiment, to credibly justify the randomness of the device.

4 Results

Sessions for the experiment took place in July and August of 2022. In total 100 subjects completed the experiment online via Prolific, and the median duration of the experiment

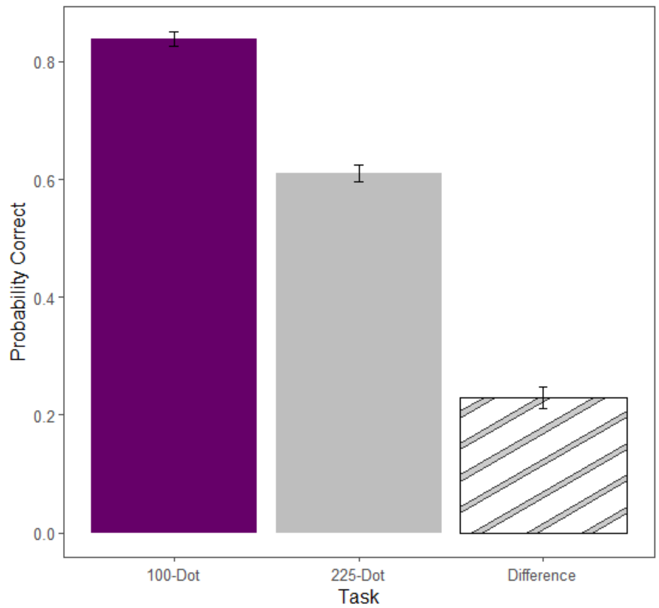


Figure 6: Average Accuracy by Task (Standard errors clustered by subject) and Average Difference

was 40 minutes. Demographically, all subjects were residents of the United States, had at least a high school education, were fluent in English, and were between the ages of 18 and 30. Subjects were also restricted from taking the experiment multiple times, and the subject pool was balanced across sex[3].

4.1 Decision Task: Difficulty Validation

Of first priority is to verify that the two tasks were of consistently different difficulty levels. To do this, I will examine the accuracy rate of classification during the decision making rounds. Recall that each participant played 15 rounds of each task type. Figure 6 shows the average accuracy across the two tasks, the average difference between the two, with error bars to indicate one standard error. In the 225-Dot task 61% of grids were correctly classified, while in the 100-Dot task this proportion was 84%.

Table A.1 in Appendix A presents results from a logistic regression and a linear proba-

[3]This was done due to Prolific's recent over-representation of female participants, see https://www.prolific.co/blog/we-recently-went-viral-on-tiktok-heres-what-we-learned

bility model of correctness on round, true color, and task difficulty, with errors are clustered at the individual level. Regression analysis confirms that the 225-Dot task is significantly more difficult than the 100-Dot task. In addition, there is no aggregate round effects, nor any systematic differences in discerning red or blue images.

It is also of interest to examine any heterogeneity in ability across the two tasks. There is indeed substantial heterogeneity in ability[4]. Figure 6 plots probability correct in the 100-Dot task on the vertical axis and probability correct in the 225-Dot task on the horizontal axis, along with the 45-degree line.

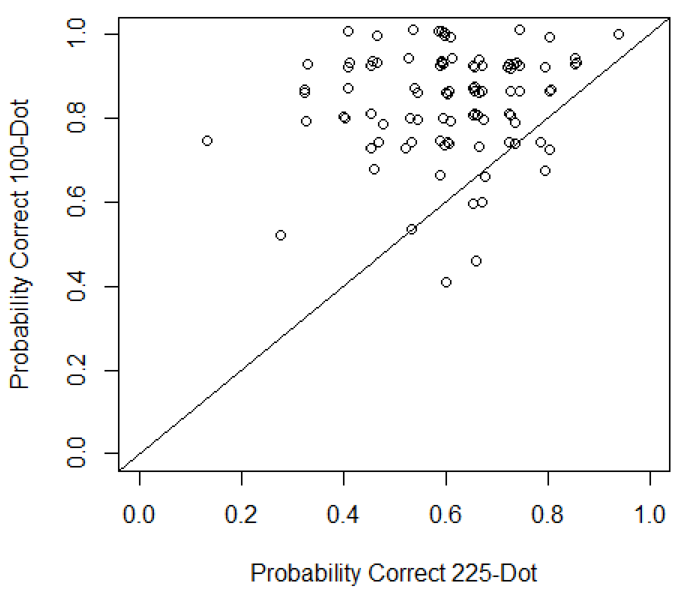


Figure 7: Individual Heterogeneity in Decision Task Accuracy

While there is substantial heterogeneity in accuracy across individuals, almost all subjects are more accurate in the 100-Dot task than the 225-Dot task, observable in most of the points in Figure 6 lying above the 45-degree line. Just 12 of the 100 subjects did not have higher accuracy in the 100-Dot case (including 4 subjects who had the exact same

[4]I use ability and effort interchangeably to mean "accuracy in classification".

accuracy in the two tasks). These findings as indicative that the tasks developed are almost universally ordered in terms of difficulty.

In addition, the probability of correct classification in the two tasks is ideal for this setting. The 225-Dot task is very difficult; however, the average accuracy is 61% which is above what one could get by randomly guessing (i.e. the task is *difficult* but not *impossibly* so). The 100-Dot task, on the other hand, has a significantly higher accuracy rate of 84%, which is significantly smaller than perfect accuracy (i.e. the task is *easy* but not *trivially* so).

4.2 Strategic Behavior

Having validated the manipulation in task difficulty, I now turn to subjects' behavior in Part 2 of the experiment. For all results, a state will be referred to as "favorable" if the color of the deal matches the color of the role, with a state being "unfavorable" otherwise.

The first degree of importance is to check for bare-minimum characteristics of rational inattention. Namely, I check for No Improving Action Switches, a key axiom in characterizing rational inattention, as introduced by Caplin and Dean (2015). In this setting, the condition is equivalent to requiring subjects to accept with weakly higher probability in favorable states. Note that this is true regardless of what strategy the opponent holds[5]. Thus a basic test of rational inattention is to verify that $P[a|\text{Favorable}] \geq P[a|\text{Unfavorable}]$. Table 1, Column 2 shows the mean difference in acceptance probability between favorable and unfavorable deals for that attentional setup. Column 3 reports p-values from a two-tailed, paired t-test between the probability of accepting a favorable and unfavorable deal for each setup. Column 4 reports the percentage of subjects who accept weakly more favorable deals than unfavorable deals for each setup, while Column 5 reports the percentage of subjects who accept strictly more favorable deals than unfavorable deals.

One can immediately verify that NIAS is strongly satisfied by the data. Average differences are highly significant, and weak NIAS is satisfied for a large majority of the subjects. Note that NIAS is not satisfied by 20% of subjects in the 225/225 setup, which is largely

[5]A trivial proof is presented in the Appendix

Setup (Own Task / Opponent Task)	Difference	p-value	Weak %	Strict %
100 / 100	0.500	<0.001	92%	82%
100 / 225	0.495	<0.001	93%	83%
225 / 100	0.168	<0.001	86%	69%
225 / 225	0.137	<0.001	80%	64%

Table 1: NIAS checks for strategic rounds, columns 4 and 5 report proportion of subjects satisfying NIAS, an axiom necessary for subjects to be considered "rationally inattentive"

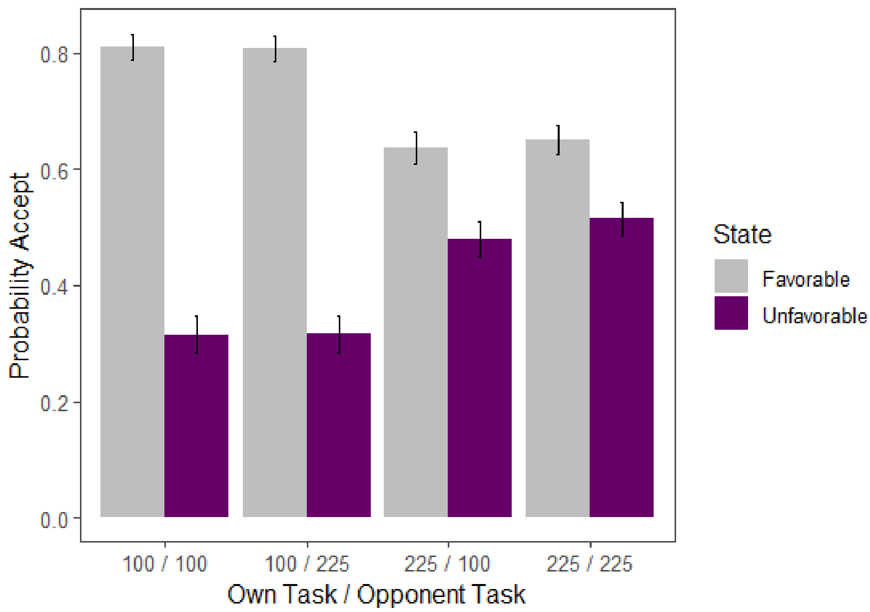


Figure 8: Probability of Accepting Favorable and Unfavorable Deals by Setup

an artifact of a higher proportion of subjects inattentively guessing in the difficult settings. Nevertheless, 80% compliance in the worst case scenario is more than sufficient in such an experiment.

I will next examine the SDSC of subjects across attentional setups. Figure 8 visualizes the average data of all 100 subjects, with standard errors clustered at the level of subject and own difficulty[6]. There is a significant large significant effect of own-task difficulty on accepting both favorable and unfavorable deals. Table 2 shows the difference in acceptance

[6]Clustering in the strategic setting will be at the subject and own difficulty level because standard errors of residuals are likely to be different for the two tasks.

probability, holding fixed the opponent difficulty and favorability of the deal. Column 2 shows the difference of $P[a|\text{Own 225-Dot}] - P[a|\text{Own 100-Dot}]$, Column 3 shows the p-value of the corresponding paired t-test, and Column 4 shows the percentage of subjects whose individual effect is in the same direction as the group effect. The findings demonstrate

Setup (Opponent Task / Favorability)	Difference	p-value	Proportion
100 / Favorable	0.172	$<$0.001	83%
225 / Favorable	0.159	$<$0.001	80%
100 / Unfavorable	-0.160	$<$0.001	85%
225 / Unfavorable	-0.200	$<$0.001	89%

Table 2: Differences in probability of accepting a deal when given a 225-Dot task and a 100-Dot task, holding favorability of deal and opponent task fixed, with column 4 indicating the proportion of subjects with the same sign as the aggregate

that, almost universally, subjects who face the more difficult task accept far fewer favorable deals, and far more unfavorable deals. The average difference of accepting favorable deals and accepting unfavorable deals is roughly 15.2% for those with 225-Dot tasks, while this figure is 49.8% for those with 100-Dot tasks.

Despite the above facts, Figure 8 also shows that there is *no* aggregate effect of opponent difficulty on subject SDSC. There is no significant treatment effect of opponent task difficulty on probability of accepting in either favorable or unfavorable state. Mirroring Table 2, Table 3 shows the difference in acceptance probability, holding fixed own difficulty and deal favorability. Column 3 shows the p-value of the corresponding paired t-test, while Columns 4-6 show the percentage of subjects where the difference (225-Dot opponent minus 100-Dot opponent) is positive, equal, and negative, respectively. These findings again suggest that there is no aggregate effect of opponent task on SDSC. Individual behavior appears to be approximately symmetric around this mean 0 difference, suggestive that deviations from this aggregate value are more likely to be noise than systematic heterogeneity.

Setup (Own Task / Favorability)	Difference	p-value	% Pos	% Equal	% Neg
100 / Favorable	0.004	0.77	40%	21%	39%
225 / Favorable	-0.009	0.67	39%	19%	42%
100 / Unfavorable	-0.001	0.92	41%	18%	41%
225 / Unfavorable	-0.040	0.06	46%	17%	37%

Table 3: Differences in probability of accepting a deal when facing 225-Dot opponent and 100-Dot opponent, holding favorability of deal and own task fixed, with columns 4-6 indicating the proportion of subjects with a difference of each sign

To confirm this more rigorously, I run both logistic[7] and linear regressions of:

$$y_{it} = \beta_0 + \beta_1 \text{Own100}_{it} + \beta_2 \text{Opponent100}_{it} + \beta_3 \text{Own100}_{it} * \text{Opponent100}_{it} + \beta_4 t + \epsilon_{it}$$

where y_{it} is an indicator for when subject i accepts a deal in round t. The regression is run once for when the deal is favorable, and once for when it is unfavorable, because the coefficients on the independent variable are likely to be different in each case. "Own10" is an indicator for when a subject faces a 100-Dot task in a given round and "Opponent100" is an indicator for when a subject's opponent faces a 100-Dot task in a given round. In addition, errors are clustered on pairs of subject and own task difficulty. The results for these regressions are presented in Table A.2 in Appendix A.

First, note that own task difficulty is highly significant for either acceptance probability. The effect of Own100 is large and positive for the favorable case (i.e. people correctly accept more favorable deals), and large and negative for the unfavorable case (i.e. people correctly reject more unfavorable deals). Opponent task is only significant ($p < 0.10$) in the unfavorable case, suggesting subjects make slightly less (roughly 3%) mistakes in accepting unfavorable deals when their opponent has an easy task. However, opponent task is not at all significant for the favorable case, and the interaction terms are not significant in either case. Finally, another worry with any experimental study involving many repeated tasks is that performance will change over time due to fatigue or learning. This is especially crucial to check in this setting, as my analysis implicitly assumes that behavior in each

[7]The response variable for the logistic equation is $\log y_{it}$.

game is independent of the other games (this assumption allows one to treat individual's probabilities of accepting in various states as true SDSC in the rational inattention sense). The coefficients on Round support this assumption, which is also supported by previous experimental tests of rational inattention (Dean and Neligh 2017).

4.2.1 Assessing Possible Heterogeneity

While Table 3 provides suggestive evidence that the aggregate results from the logistic regression are unlikely masking meaningful individual level heterogeneity, I now provide more exhaustive support of this claim.

To do this, for each subject i I run the linear probability model of

$$y_{it} = \beta_0^i + \beta_1^i \text{Own100}_{it} + \beta_2^i \text{Opponent100}_{it} + \beta_3^i \text{Own100}_{it} * \text{Opponent100}_{it} + \epsilon_{it}$$

for favorable states and for unfavorable states, where once again y_{it} is a dummy indicated accepting the deal. Note that by excluding the round variable, the above linear probability regression gives the true marginal probabilities of each of the independent variable dummies. Give the lack of a time trend in the aggregate data, this this choice is without much loss.

This result in a collection of β^i coefficient estimates for each individual. Because this is a linear probability model and not a logistic model, these coefficients are directly comparable across individuals. Primary interest lies in the heterogeneity of coefficients on opponent task, and the interaction between opponent and own task. Thus I create a new set of four coefficient estimates for each individual (opponent and interaction coefficients for favorable and unfavorable regressions).

On this new data-set of coefficients I run the mixture models cluster analysis used by Brocas et al (2014) via the `mclust` package in R (Fraley and Raftery 2007). This analysis assesses any possible heterogeneity by calculating possible clusters of up to 9 groups using 14 possible models, and then choosing the combination with the highest Bayes Information Criterion (BIC). The benefit of this approach is that it assesses *any* possible heterogeneity without assuming the exact nature of this heterogeneity, or the number of possible clusters.

	Cluster 1	Cluster 2
Size	95	5
β_2^F	0.0108	-0.3760
β_3^F	-0.0065	0.3791
β_2^U	-0.0209	-0.3926
β_3^U	0.0135	0.5007

Table 4: Mean Parameter Values for Optimal Clusters

The results of this clustering analysis support the hypothesis that there is very little meaningful heterogeneity in the subjects' sensitivity to opponent task. Figure A.1 in Appendix A shows the BIC value for each model and for each number of clusters (up to 9). The winning model is that with ellipsoidal, equal volume and orientation (EVE) and 2 clusters. These two clusters consist of 95 subjects and 5 subjects. Table 4 reports the average coefficient values for each cluster.

Figure A.2 in Appendix A shows the scatter-plots associated with this classification. The classification again confirms that by and large that the aggregate effects are not hiding meaningful heterogeneity. 95% of subjects fall into a cluster in which the average percentage effect of the opponent having an easy task is between 0% and 2%. 5 subjects can be categorized into a cluster where these differences are much larger, indicating an average percentage effect of up to 39%. This suggests that while some subjects appear to have higher levels of strategic sophistication, the vast majority of participants behave extremely similar to Level-1 types–with behavior invariant to the attention ability of their opponents. This proportion of Level-1 types is far greater than commonly found in other economic games (an exhaustive study by Georganas et al 2015 finds between 28% and 71% proportion of Level-1 players, depending on the game).

4.3 Beliefs

The preceding section showed that there is a strong effect of own task on behavior, and essentially no effect of opponent task on behavior. While this offers strong evidence of an

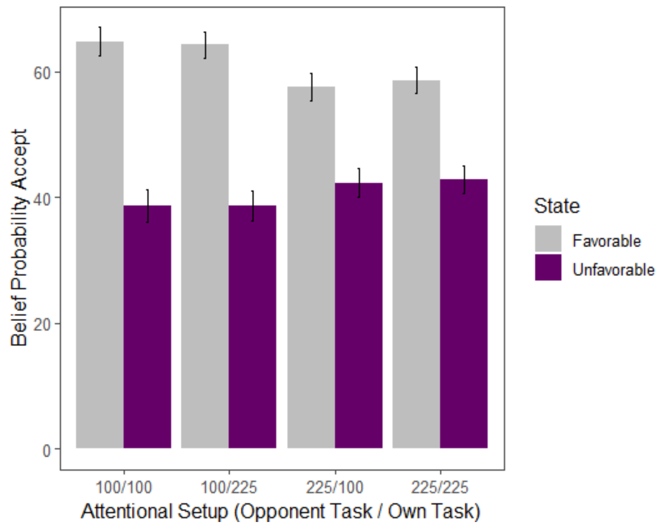


Figure 9: Beliefs of Opponent Behavior by Setup

out-sized lack of strategic sophistication, it is yet unclear what the *mechanism* behind this is. There are two clear possibilities: subjects have difficulties in anticipating opponent behavior (i.e. their beliefs are incorrect), or the subjects' information acquisition are not sensitive to incentives (i.e. the subjects are not *rationally inattentive*. The following two sections, alongside a follow up experiment described thereafter, seek to provide support for the first of these two hypotheses. The current section shows that beliefs are largely incorrect and noisy. The following section shows that people largely seem to acquire attention as a best response to these beliefs.

As a reminder, all subjects are asked to report their beliefs about how frequently their opponents accepted deals of either color in the preceding block (i.e. under the preceding block's attentional setup). That is, I elicit, in an incentive compatible manner, their beliefs about the SDSC of their opponents. Figure 9 shows the analogous plot of Figure 8, however this time showing subjects' mean beliefs of their opponent accepting in the various attentional setups. Note that the figure take the opponent's perspective in labelling a state as "favorable" or "unfavorable" (so that the figure is exactly comparable to that of Figure 8).

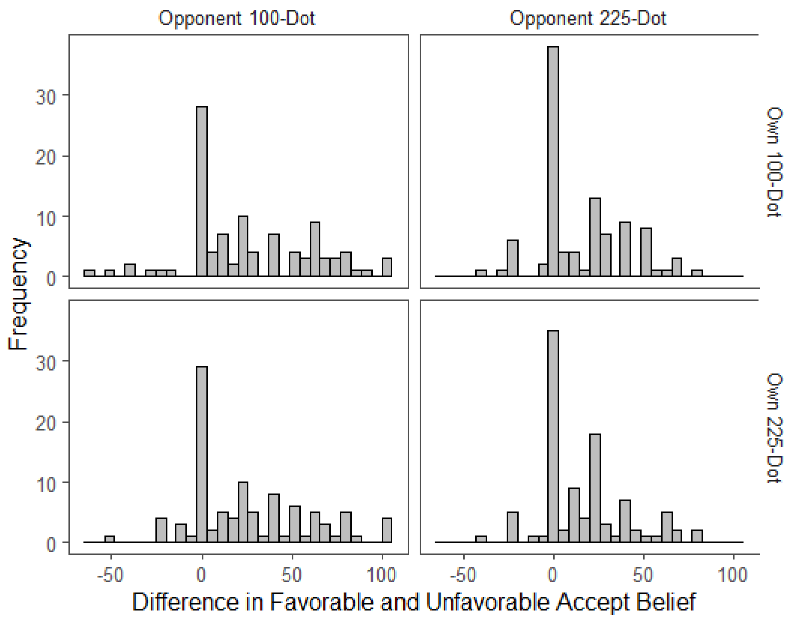
One minimal check to insure people understood the strategic setup of the game is to see whether they expected their opponent's to accept more often in their opponent's favored state. The findings confirm this on the aggregate. Paired t-tests show that subjects believe opponents have a 15.8 and 15.3 percentage point higher accept rate in favorable deals over unfavorable deals when the opponents has a 225-Dot task and the subject has a 225-Dot and 100-Dot task, respectively ($p < 0.001$ for both tests). When the opponent has a 100-Dot task, these numbers are 25.6% and 26.2% (again with $p < 0.001$ for each test).

Comparing the above numbers to the actual SDSC of the subjects, however, reveals that subjects far underestimate the information acquisition of subjects in the 100-Dot task. Note that Table XX shows that the average Favorable/Unfavorable difference in SDSC is nearly 50% for subjects, while the analogous difference in beliefs is only 25%. Combined with a slight over-estimation of information acquisition ability in the 225-Dot task, the difference in these differences across tasks goes from 35 percentage points in SDSC to only 10 percentage points in beliefs.

Similarly to how I assessed heterogeneity in behavior, I can now examine heterogeneity in beliefs. Figure 10 shows histograms for the differences in Favorable/Unfavorable acceptance beliefs under each attentional setup. This is indicative of a large number of subjects with what are essentially Level-1 beliefs–i.e. they roughly believe $P[a|R] = P[a|B]$. Reaffirming the previous figure, very few subjects report an incorrect sign (negative) for this number, suggesting a broad understanding of the strategic incentives of the game. However, the main takeaway of the figure is the sharp concentration of subjects with reported beliefs of opponent favorable and unfavorable acceptance probabilities which are extremely close.

The above could represent two possible mechanisms. Either subjects truly believe their opponents are acquiring very little information, or they have a large degree of cognitive uncertainty about their opponent's information acquistion, and so for all intents and purposes they behave *as if* their opponent is acquiring very little information. While the present experiment lacks the ability to distinguish these two specific mechanisms, the second is more plausible, and will be discussed further in the paper's conclusion.

Figure 10: Difference in Favorable and Unfavorable Accept Belief, by Attentional Setup



4.4 Beliefs as the Mechanism for Strategic Unsophistication

Whatever the mechanism behind subjects' largely incorrect beliefs about opponent SDSC, it is clear that even under incentivization they are largely unable to correctly anticipate opponent behavior. The next step is to see whether the subjects themselves acquired information as if their opponents were playing according to these incorrect beliefs.

In order to do this, I run the same linear regression as presented in Table A.2 but instead substitute two belief variables—"BA" and "BD"—along with their interaction terms with the dummy indicating a 100-Dot task for the subject, in lieu of dummies for opponent task. Here, "BA" refers to the unconditional belief that their opponent chose to accept, calculated by taking the average of the two belief elicitations for that round's attentional setup. "BD" refers to the difference in beliefs of the opponent accepting in their favorable state and their unfavorable state for the relevant attentional setup, i.e. the values illustrated in Figure 10. These two transformations of the subjects' elicited beliefs were chosen instead of the raw values because of the high correlation between a high value in the favorable belief with that of the unfavorable belief. Thus coefficients on either of these values alone are difficult to interpret independent of the other coefficient. The interpretation of the coefficient on "BA" then is how sensitive a subject's behavior is to the unconditional likelihood of their opponent accepting, while the coefficient of "BD" is the causal impact of one's beliefs about the extent of their opponent's information acquistion on their behavior. The dummy for opponent task was excluded from these regressions as it is highly correlated with beliefs, leading to multicollinearity concerns. Once again, I run this regression twice, for favorable and unfavorable deals, and errors are clustered on the combination of own task difficulty and subject. The coefficients on the relevant interaction terms then indicate how these effects change when the subject is shown a 100-Dot task. In Appendix A, Table A.3 runs the same specification as a logistic regression rather than a linear probability model.

Table 5 presents the results of this regression, while table A.3 in Appendix A shows the analogous logistic regression. Columns (1) and (3) regress on the entire sample, while Columns (2) and (4) regress on only the subset with non-negative values for all four "BD" measurements (76 out of 100 subjects). Reassuringly, there are still strongly significant coefficients for own task difficulty of the expected sign.

There are strongly positive effects on the unconditional belief that opponents will accept a deal, in both favorable and unfavorable cases. There are two possibilities to describe this effect. First, it could be that subjects who accept more often simply expect that their opponents will accept more often as well. Second, the more often an opponent *unconditionally* accepts deals, the ex-ante benefit of accepting a deal increases (because there are ex ante gains from trade). Since the ex-ante benefit of accepting a deal increases, rational inattention theory predicts the probabilities of accepting a deal should increase in both favorable and unfavorable conditions (accepting is becoming more attractive relative to rejecting).

In the 225-Dot case, where attention is especially costly, there are negative coefficients for "BD" in all four regressions, significant in all but the restricted sample favorable case[8]. Again, this is consistent with predictions of rational inattention theory. As one's opponent becomes more informed, and is accepting more favorable deals and rejecting more unfavorable deals, the benefits of accepting one's own favorable deal are decreasing while the costs

[8]These results are more strongly significant in the logistic regression, presented in Table A.3 in Appendix A.

	Dependent variable:			
	Accept (Favorable)		Accept (Unfavorable)	
	(1)	(2)	(3)	(4)
Constant	0.267***	0.235***	0.026	−0.010
	(0.066)	(0.077)	(0.059)	(0.062)
Own100	0.323***	0.300**	−0.195**	−0.230***
	(0.099)	(0.119)	(0.080)	(0.089)
BD	−0.001*	−0.001	−0.002***	−0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
BA	0.008***	0.008***	0.010***	0.010***
	(0.001)	(0.001)	(0.001)	(0.001)
Own100*BD	0.002***	0.003***	−0.001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Own100*BA	−0.004***	−0.003**	0.001	0.001
	(0.002)	(0.002)	(0.001)	(0.001)
Round	−0.00004	−0.0001	0.0001	0.00004
	(0.0002)	(0.0003)	(0.0002)	(0.0002)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 5: Linear Probability Regression of Accept, by Favorability

of accepting one's own unfavorable deal are increasing. Thus the ex-ante value of accepting is decreasing relative to the value of rejecting. However, in the 100-Dot case this trend is reversed for favorable deals–the more subjects believed their opponent was separating their SDSC, the more the accepted favorable deals. It is unclear exactly why this would be the case, and may relate to some degree of overconfidence in one's own ability. Discovering the mechanism behind this discrepancy is an interesting avenue of future research.

4.5 Response Times as Attentional Input in Games

The previous literature has shown that response times are an important input in the information acquistion process, and that there exists correlations with both mental effort and choice accuracy within a given task (Caplin et al 2020). Thus, an additional avenue of analysis is to analyze these response times in the two parts of the experiment and under different attentional setups. While the previous literature has shown that these comparisons may not be entirely useful between own tasks, they can demonstrate whether people are paying more or less attention within a task, for example in response to incentives. One reason they are not especially useful across tasks is the "production function" of attention may look very different in different tasks. In the present experiment, for example, counting a large proportion of dots is a viable strategy in the 100-Dot case, whereas it is not in the 225-Dot task[9]. Observing reaction times within opponent tasks then shows whether subjects altered this critical attentional input as a response, even if their ultimate behavior showed little if any response.

Table A.4 in Appendix A shows linear regression under each task, with columns (2) and (4) also including belief data as independent variables. There is a slightly significant negative effect of the opponent having a 100-Dot task on response time under the specification including beliefs where the subject faces 225-Dot tasks, but the response time analysis is largely reflective of the behavioral analysis. There is also a strong significant positive effect of the level of attentiveness one believes their opponent has, "BD", on response times–indicating

[9]This observation was present in many open ended survey responses asking about player strategy, as well as questions about how often they counted dots across tasks.

that subjects spend more time examining a 225-Dot grid when they believe their opponent to be separating their stochastic choice more effectively. One interpretation of this could be that subjects spend more time when motivated to avoid "being taken advantage of" and accepting unfavorable deals. In Appendix C, Tables C.8 - C.11, I run equivalent regressions as those shown in Table A.2 and Table 5, except the samples are restricted to those who spent an average length of time on each decision task above various thresholds. As the this threshold is increased, the effect of opponent task on accept becomes more significantly negative in the unfavorable case. This suggests that those who are already spending a larger amount of time on the task do indeed slightly adjust their rate of "mistaken accept" to the task of their opponent. Regressions on beliefs report the same effects as those found in Table 5.

4.6 Survey Data and Correlates with Other Measurements

4.6.1 Survey Explanations of Strategy

In addition to looking strictly at behavior of subjects to see how behavior responds to opponent incentives, one can also look at subject's direct verbal explanations of their strategy in the experiment. At the end of the experiment, subjects are asked to explain, via text box, three questions to this extent. These questions ask: (1) the subjects general strategy in the strategic rounds of the experiment, (2) how their strategy depended on the task of the other player when the subject had a 100-Dot task, and (3) how their strategy depended on the other's task when the subject had a 225-Dot task[10].

In these open-ended responses, the overwhelming number of subjects admitted that their strategy did not depend on the task of their opponent. Out of 100 subjects, only 30 referred to other opponent task affecting their strategy in response to any of the three questions above. This is despite subjects being fully aware of the game's strategic setup (subjects were forced to answer all comprehension questions successfully, also viewable in the Appendix). This supports the conclusions made by the behavioral data and elicited belief data—subjects simply did not behave as if their opponents were rationally inattentive.

[10] Exact wording available in Appendix C

4.6.2 11-20 Game and Cognitive Reflection Test

While the above shows that subjects had a large lack of strategic sophistication in this setting, it is still necessary to show that this lack of strategic sophistication is *out-size*, in that it is larger than is typically found in experimental settings. When compared to other studies, this is obviously the case. There are almost no subjects exhibiting a level of sophistication past “Level-1", whereas typically Level-2’s are quite common in the data. To insure the large proportion of lower levels is not simply due a lower level of sophistication present in online subjects from Prolific, one can examine the behavior in the 11-20 game which was given to subjects at the end of the experiment, before the survey and payment screens.

As a reminder, in this game subjects were matched into pairs and asked to request a number of points from 51 to 60. They received that amount they requested, but would receive a 20 point bonus if they requested exactly 1 less point than their opponent. Note that this is the same game as in Arad and Rubinstein (2011), but with a flat rate of 50 points added to all payments. Arad and Rubinstein argue that there exists a mapping from requests to levels of strategic sophistication. A request of 60 would represent the request of a “Level-0” player, making 59 the request of a “Level-1” player, and so on.

Figure A.3 in Appendix A shows a histogram of requests by all 100 subjects in the experiment. The most frequent request by far is 58 points, which corresponds to Level-2 behavior. Only 11 subjects request amounts consistent with Level-0 or Level-1 behavior. Overall, the distribution is not significantly different from that found in Arad and Rubinstein, and if anything shows a higher degree of sophistication than in their experiments.

Likewise, examining scores on the Cognitive Reflection Test shows an average score of 1.86 out of 3, which is comparable to that found in many university subject pools (Frederick 2005). So, the lack of strategic sophistication found in the main experiment is not a product of simply a lower sophistication subject pool.

The above CRT and 11-20 game measurements can also be used as a way to restrict the sample and see if those who score as “more sophisticated” in these measurements behave on average in a more sophisticated way in the experimental game. Table 6 shows results from the linear[11] regression of accepting a (favorable or unfavorable) deal on own difficult, opponent difficult, their cross-product, and the round, with errors again clustered on an individual and difficulty level pair. Columns (1) and (4) report results for the sub-sample the requested less than 59 in the 11-20 game. Columns (2) and (5) use the sub-sample that received a score higher than 1 on the CRT, while (3) and (6) restrict the sample to those who scored a perfect score on the CRT.

	Dependent variable:					
	Accept (Favorable)			Accept (Unfavorable)		
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.643***	0.675***	0.662***	0.488***	0.501***	0.488***
	(0.017)	(0.020)	(0.025)	(0.018)	(0.021)	(0.026)
Own100	0.148***	0.187***	0.222***	−0.185***	−0.205***	−0.223***
	(0.017)	(0.019)	(0.024)	(0.019)	(0.022)	(0.027)
Opp100	−0.008	−0.041*	−0.081***	−0.018	−0.037*	−0.063**
	(0.019)	(0.022)	(0.028)	(0.019)	(0.022)	(0.028)
Own100*Opp100	0.017	0.017	0.071**	0.010	0.027	0.049
	(0.024)	(0.027)	(0.035)	(0.026)	(0.030)	(0.037)
Round	0.00002	−0.0002	−0.001**	0.0002	−0.00001	−0.0003
	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0002)	(0.0003)
Note:				*p<0.1; **p<0.05; ***p<0.01		

Table 6: Linear regression of Accept, Columns (1) and (4) restricted on sample that requested less than 59 in the 11-20 game, Columns (2) and (5) restricted on sample that received a score higher than 1 on the CRT, Columns (3) and (6) restricted on sample that received a score higher than 2 on the CRT.

While there is no opponent effects when restricting the sample to those who behaved in a sophisticated manner in the 11-20 game, there is an increasingly significant effect when the

[11]Logistic regression equivalent can be found in Table A.5 in Appendix A

sample is restricted to those who score highly on the cognitive reflection test. Furthermore, the effect has the negative sign predicted by the theory when opponent cost of attention decreases. As the opponent has easier access to information, these subjects show a slight adjustment towards reducing the error of accepting bad deals in favor of reducing the error of rejecting good deals. This further supports the theory that some level of difficult cognition with respect to anticipating opponent information acquisition plays a sizeable role in subject behavior.

5 Discussion of Experiment One Results

There are two major conclusions from the results of the preceding experiment. First, there is an out-sized lack of strategic sophistication in this extremely simple economic game environment. Second, the mechanism behind this behavior seems to be inaccurate and perhaps uncertain beliefs. In each of the four attentional setups, the plurality of subjects report beliefs that the probabilities an opponent accepts a favorable and an unfavorable deal are essentially the same. These correspond to the beliefs held by "Level-1" agents in the theoretical framework. Whether through simply incorrect beliefs or through cognitive difficulty in anticipating opponent behavior, these mistaken beliefs seem to drive the "Level-1" behavior of agents.

One natural question is to what extent did these mistakes in strategic reasoning affect outcomes, in terms of payoffs? While psychological costs of attention are only recovered and not measured directly, one approach is to look at how much subjects gained following their strategy, as opposed to how much they would have gained either indiscriminately accepting or indiscriminately rejecting deals. This is a high threshold for discussing possible welfare problems precisely because it does not account for the costs of acquiring information, which are at minimum bounded away from those of indiscriminate action.

I find that 29 out of 100 subjects would receive strictly higher expected payment by simply indiscriminately accepting all deals. Looking at those who did indeed receive higher expected payment under their strategy, indiscriminately accepting would only lead to an average loss of 2 points (i.e. an expected 2 percentage point decrease in gaining the $10 bonus payment). This suggests that this lack of strategic reasoning indeed decreased welfare for the subjects, especially when one considers the mental effort costs subjects paid in their strategies.

6 Experiment Two Design

In order to further test whether the mechanism behind the results of the previous experiment was indeed cognitive limitations of strategic modelling, I conducted a follow-up experiment. This follow-up experiment followed the exact design of Experiment 1, however instead of playing other subjects, subjects played against computer players who followed a pre-specified strategy.

Specifically, instead of being matched with either "225-Dot" or "100-Dot" subjects, subjects are now matched with either "30:80 Computer" or "50:65 Computer". A 30:80 Computer accepts a deal of the subject's color 30% of the time, and a deal of the opposing color 80% of the time, with the 50:65 Computer being analogous. These numbers were specifically chosen to mirror the average behavior seen by participants in Experiment 1. Just as in Experiment 1, subjects played 120 rounds of these games, spread across 8 equally sized blocks. There were 2 blocks for each combination of own-grid task and opponent Computer type. Crucially, this is all entirely identical to Experiment 1, with the only difference being the removal of all cognitive uncertainty about opponent strategy.

7 Experiment Two Results

The experiment took place again virtually via Prolific, with subjects filtered to be American residents between the ages of 18 and 30 with at least a high school education. Importantly, any subjects who may have taken part in Experiment 1 were excluded. Experiment Two was conducted on 40 subjects in September 2022.

First, I recreate Figure 8, Table 2, and Table 3 with the new treatment. However, instead of referring to opponent tasks, I instead refer to computer player. Recall playing

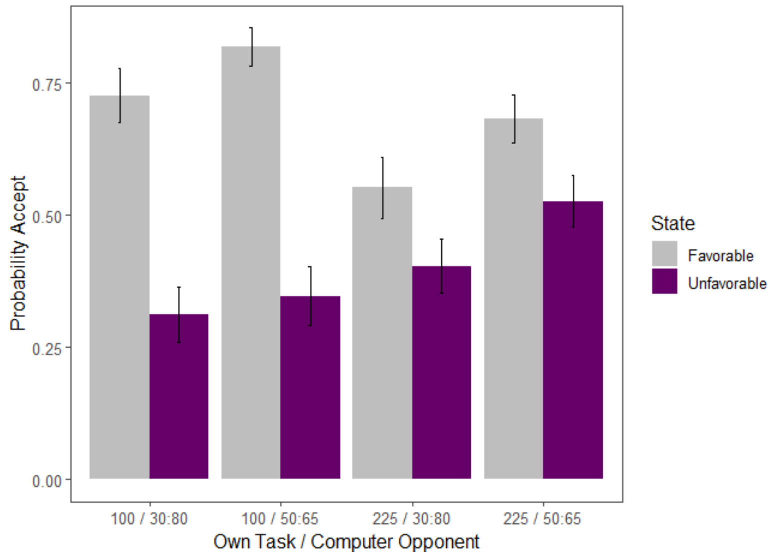


Figure 11: Probability of Accepting Favorable and Unfavorable Deal by Setup, computer Treatment

a "30:80" computer is equivalent to playing a 100-Dot opponent, while a "50:65" computer is equivalent to playing a 225-Dot opponent. Figure 11 shows probability of accepting a deal in favorable and unfavorable states, for each attentional setup. Contrary to the main experiment, there is a strong significant effect of computer opponent on subjects' SDSC. When subjects face a 30:80 computer (the payoff equivalent of facing a 100-Dot opponent in the main experiment), they rationally shade their SDSC towards rejection–favoring the reduction of accepting unfavorable deals over the reduction of rejecting favorable deals. When subjects face a 50:65 opponent, they prioritize reducing errors in rejecting favorable deals over reducing errors in accepting unfavorable deals.

Table 7 shows the average differences in accept probability when own task is 100-Dot vs 225-Dot, holding computer opponent and favorability of the deal fixed. Note that Column 2 shows the average difference, Column 3 shows the p-value from the associated paired t-test, and Column 4 shows the percentage of subjects who's data has the same sign as the average. Once again the vast majority of subjects make less errors when given a 100-Dot task.

Table 8, however, shows the average differences in accept probability when the computer is 50:65 vs 30:80, holding own task difficulty and favorability fixed. Note that Column 2

Setup (Computer Opponent / Favorability)	Difference	p-value	Proportion
30:80 / Favorable	0.196	$<$0.001	80%
50:65 / Favorable	0.133	0.001	83%
30:80 / Unfavorable	-0.099	0.213	75%
50:65 / Unfavorable	-0.176	$<$0.002	80%

Table 7: Differences in probability of accepting a deal when given a 225-Dot task and a 100-Dot task, holding favorability of deal and computer opponent fixed, with column 4 indicating the proportion of subjects with the same sign as the aggregate

shows the average difference, Column 3 shows the associate p-value, and Columns 4-6 show the percentage of subjects whose difference is positive, equal, and negative.

Setup (Own Task / Favorability)	Difference	p-value	% Pos	% Equal	% Neg
100 / Favorable	0.081	0.048	62.5%	15%	22.5%
225 / Favorable	0.144	0.002	70%	5%	25%
100 / Unfavorable	0.030	0.224	47.5%	17.5%	35%
225 / Unfavorable	0.114	0.007	57.5%	7.5%	35%

Table 8: Differences in probability of accepting a deal when facing 50:65 computer and 30:80 computer, holding favorability of deal and own task fixed, with columns 4-6 indicating the proportion of subjects with a difference of each sign

In sharp contrast to the analogous Table 3, there is a strong positive effect of a 50:65 computer on probability of accepting for all cases except for when subjects have a 100-Dot task and face an unfavorable deal (although this experiment has lower power than the main experiment). While in Table 4 showed roughly equal amounts of subjects had a positive and negative sign for this difference, now in all four cases significantly more subjects had a positive sign than a negative sign. This again supports the argument that subjects were largely sensitive to computer opponent accuracy in a way that they were not towards human opponent accuracy.

Finally, regression analysis can verify the above results, and findings are reported in Table A.6 in Appendix A. Unlike in the main experiment where there little if any effect of opponent task on accept probability, there is a strong negative effect of a 30:80 computer on accept probability in either favorability condition. Again this supports the story of subject's favoring the reduction of erroneously accepting unfavorable deals when facing a more accurate computer opponent.

Following the analysis of response times which showed no aggregate response towards opponent task, I run analogous regressions on this treatment. Results of this regression appear in Table A.7 of Appendix A. Unlike the regression in the main treatment, the effect of having an 100-Dot task opponent equivalent has a strong effect on response times, and the direction is negative. When the computer is separating very well, subjects on average spend less time gathering information, and simply reject more often. Also of note, the average response times are significantly longer in this treatment than in the main treatment. One explanation is that the reduced uncertainty about opponent behavior translated to more explicit incentives for information acquisition and thus more mental effort devoted to doing so.

8 Discussion and Future Directions

In the simplest possible strategic setting where multiple agents face costs of learning, I have found that subjects play in a strategically unsophisticated manner. They acquire information about the state of the world, but they do not acquire this information strategically. Through careful analysis of subjects' elicited beliefs, I find that the mechanism through which this behavior occurs is beliefs—subjects simply do not anticipate the information acquistion of their opponents. In the follow-up experiment, I show that by eliminating this part of the equation for subjects by having them play against automated computers with a known strategy, they are able to adjust their information acquisition strategies in a best-response manner.

One explanation for why strategic sophistication may be even lower in games with information acquisition than in standard settings may be "cognitive uncertainty". The cognitive uncertainty literature, beginning with Enke and Graeber (2019) suggests that when people are cognitively uncertain, their "decisions are severely attenuated functions of objective problem parameters". In the present setting, this could mean that the cognitively complex task of anticipating opponent information acquisition causes people to systematically act as if playing a "Level-0" opponent (one with no information acquistion at all). The high degree of "Level-1" beliefs and the general high variation in reported beliefs is suggestive of this explanation.

Yet another explanation lies within the work on costly depth of reasoning by Aloui and Penta (2016). Again coinciding with the above phenomenon, anticipating opponent information–and thus behavior–may be prohibitively costly given the incentives for doing so. Thus while information acquisition responds sharply to own task (in experiment 1 and 2), and to incentives (experiment 2), it does not respond to opponent task. Attention is costly in this setting, but not prohibitively so. This simply may not be the case with the costs inherent in strategic reasoning.

A future avenue of work then is to develop a model that integrates the above ideas, and see when–if ever–subjects may respond to strategic incentives. Yielding testable predictions is a central feature of the emerging field of cognitive economics, and by synthesizing existing models much in the ways suggested by the endogenous depth of reasoning literature, the cognitive uncertainty literature, and the noisy encoding literature steps can be made towards a more unified theory. The present paper demonstrates how using the various cognitive frictions the literature has developed in a vacuum can come at a large cost in predictability.

While the current paper shows how strategic unsophistication can be "fixed" by having subjects play perfectly predictable machines, another future step is to see how more realistic nudges could help alter behavior. For example, how subjects behave in response to feedback or information about past performance could bridge the gap between the main treatment and the computer treatment.

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A Additional Tables

	Dependent variable:	
	Correct (Logit)	Correct (LPM)
	(1)	(2)
Constant	0.478***	0.616***
	(0.110)	(0.022)
100-Dot	1.200***	0.228***
	(0.105)	(0.018)
Round	0.003	0.001
	(0.005)	(0.001)
Blue-Majority	−0.155	−0.029
	(0.099)	(0.018)
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table A.1: Regression of Correctness in Decision Making Rounds

	Dependent variable:			
	Accept (Favorable)		Accept (Unfavorable)	
	Logit	LPM	Logit	LPM
	(1)	(2)	(3)	(4)
Constant	0.638***	0.654***	0.015	0.505***
	(0.130)	(0.028)	(0.129)	(0.032)
Own100	0.822***	0.158***	−0.833***	−0.199***
	(0.183)	(0.034)	(0.192)	(0.044)
Opp100	−0.061	−0.014	−0.144*	−0.036*
	(0.089)	(0.020)	(0.083)	(0.021)
Own100*Opp100	0.075	0.016	0.142	0.036
	(0.129)	(0.025)	(0.114)	(0.027)
Round	−0.0003	−0.00005	0.001	0.0002
	(0.001)	(0.0002)	(0.001)	(0.0002)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table A.2: Regression of Accept in Strategic Rounds

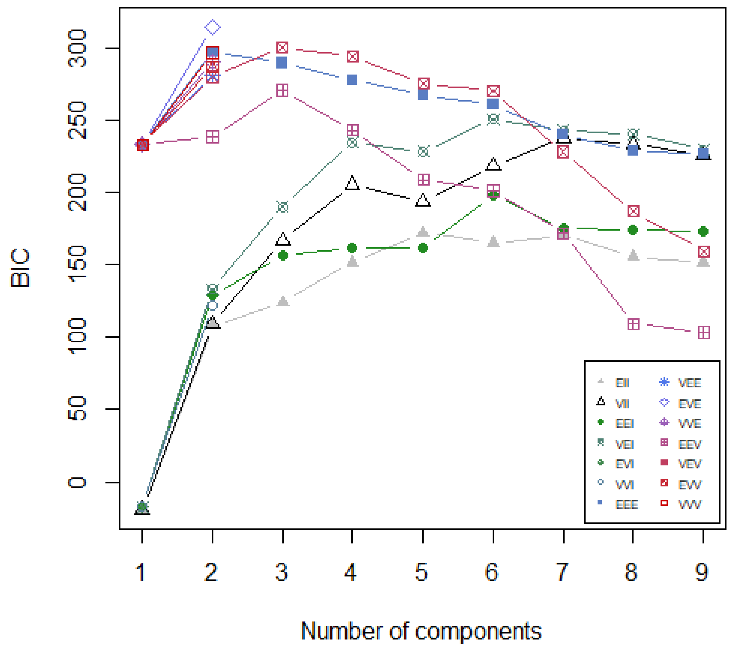


Figure A.1: BIC of Possible Cluster Classifications

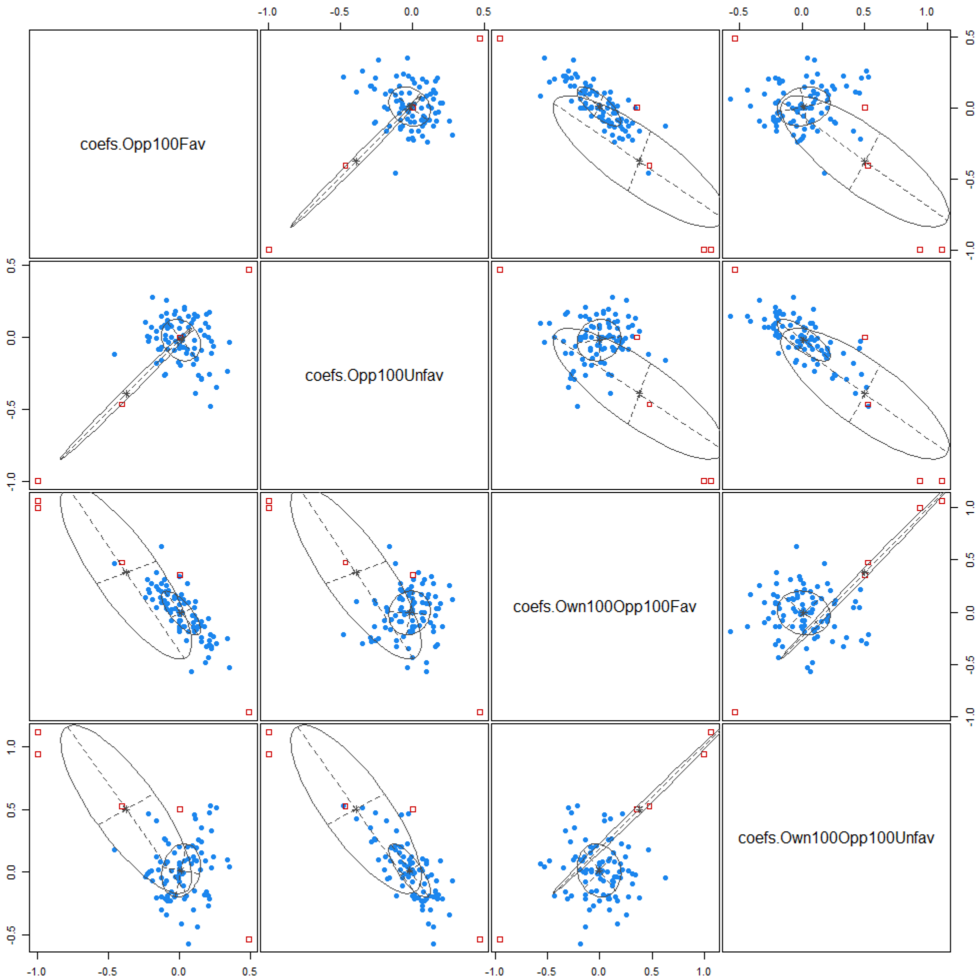


Figure A.2: Classification of Optimal Cluster

	Dependent variable:			
	Accept (Favorable)		Accept (Unfavorable)	
	(1)	(2)	(3)	(4)
Constant	-1.529^{***}	-1.772^{***}	-2.779^{***}	-3.164^{***}
	(0.459)	(0.531)	(0.533)	(0.592)
Own100	1.550^{**}	1.243	-1.174^{*}	-1.709^{**}
	(0.635)	(0.760)	(0.710)	(0.803)
BD	-0.006^{**}	-0.007^{**}	-0.010^{***}	-0.010^{***}
	(0.003)	(0.004)	(0.003)	(0.003)
BA	0.046^{***}	0.052^{***}	0.058^{***}	0.065^{***}
	(0.008)	(0.009)	(0.010)	(0.011)
Own100*BD	0.013^{***}	0.017^{***}	-0.008^{*}	-0.006
	(0.005)	(0.006)	(0.004)	(0.005)
Own100*BA	-0.019	-0.012	0.008	0.016
	(0.012)	(0.014)	(0.013)	(0.014)
Round	-0.0003	-0.001	0.001	0.0002
	(0.001)	(0.002)	(0.001)	(0.001)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table A.3: Logistic Regression of Accept, by Favorability

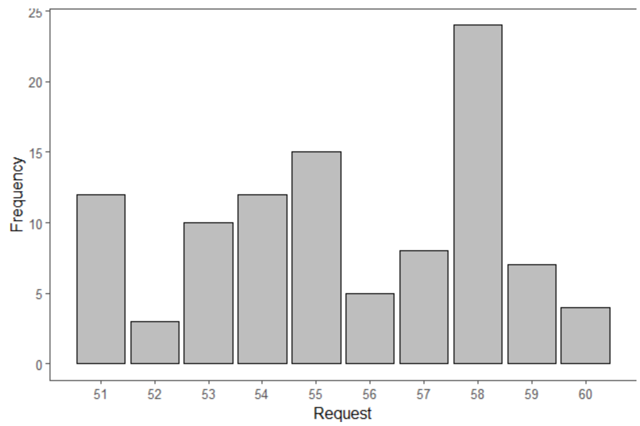


Figure A.3: Requests in the 11-20 Game

	Dependent variable:			
	Own 100-Dot		Own 225-Dot	
	(1)	(2)	(3)	(4)
Opp100	0.121	−0.019	0.017	−0.478*
	(0.154)	(0.224)	(0.159)	(0.290)
Round	−0.025***	−0.025***	−0.014**	−0.015**
	(0.005)	(0.005)	(0.006)	(0.006)
BD		0.014		0.047***
		(0.013)		(0.014)
BA		−0.003		−0.011
		(0.017)		(0.019)
Constant	6.049***	5.932***	6.329***	6.208***
	(0.590)	(0.982)	(0.545)	(1.186)

Note: *p<0.1; **p<0.05; ***p<0.01

Table A.4: Linear Probability Regression of Response Time, by Own Task

	Dependent variable:					
	Accept (Favorable)			Accept (Unfavorable)		
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.586***	0.744***	0.708***	−0.053	0.006	−0.034
	(0.080)	(0.097)	(0.120)	(0.075)	(0.088)	(0.113)
Own100	0.742***	1.055***	1.214***	−0.777***	−0.869***	−0.996***
	(0.088)	(0.111)	(0.141)	(0.080)	(0.094)	(0.124)
Opp100	−0.035	−0.179*	−0.340***	−0.072	−0.149*	−0.257**
	(0.081)	(0.094)	(0.117)	(0.077)	(0.090)	(0.115)
Own100*Opp100	0.088	0.004	0.267	0.034	0.101	0.179
	(0.125)	(0.154)	(0.196)	(0.114)	(0.134)	(0.177)
Round	0.0001	−0.001	−0.003**	0.001	−0.0001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Note:						*p<0.1; **p<0.05; ***p<0.01

Table A.5: Logistic regression of Accept, Columns (1) and (4) restricted on sample that requested less than 59 in the 11-20 game, Columns (2) and (5) restricted on sample that received a score higher than 1 on the CRT, Columns (3) and (6) restricted on sample that received a score higher than 2 on the CRT

	Dependent variable:			
	Accept (Favorable)		Accept (Unfavorable)	
	Logit	LPM	Logit	LPM
	(1)	(2)	(3)	(4)
Constant	0.572***	0.641***	0.107	0.527***
	(0.161)	(0.036)	(0.155)	(0.038)
Own100	0.762***	0.147***	−0.749***	−0.182***
	(0.263)	(0.048)	(0.250)	(0.058)
Opp100	−0.553***	−0.133***	−0.502***	−0.124***
	(0.187)	(0.045)	(0.164)	(0.040)
Own100*Opp100	0.010	0.033	0.343	0.089*
	(0.284)	(0.060)	(0.224)	(0.052)
Round	0.001	0.0003	−0.0001	−0.00002
	(0.002)	(0.0003)	(0.001)	(0.0003)

Note: *p<0.1; **p<0.05; ***p<0.01

Table A.6: Regression of Accept in Strategic Rounds (Computer Experiment)

	Dependent variable:	
	Own 225-Dot	Own 100-Dot
	(1)	(2)
30:80	-1.017^{***}	-0.519^{*}
	(0.266)	(0.279)
Round	-0.018^{***}	-0.028^{***}
	(0.004)	(0.004)
Constant	7.070^{***}	8.360^{***}
	(0.324)	(0.341)
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table A.7: Linear Probability Regression of Response Time, by Own Task (Computer Treatment)

B Proofs of Hypotheses

C Robustness Checks

	Dependent variable:			
	Min of 5s Avg On Decision Rounds		Min of 10s Avg On Decision Rounds	
	Accept (Favorable)	Accept (Unfavorable)	Accept (Favorable)	Accept (Unfavorable)
	(1)	(2)	(3)	(4)
Constant	0.666***	0.487***	0.705***	0.497***
	(0.035)	(0.039)	(0.039)	(0.055)
Own100	0.185***	−0.222***	0.192***	−0.196**
	(0.039)	(0.054)	(0.050)	(0.085)
Opp100	−0.034	−0.057*	−0.052	−0.075**
	(0.029)	(0.030)	(0.045)	(0.038)
Own100*Opp100	0.038	0.046	0.063	0.053
	(0.033)	(0.034)	(0.048)	(0.043)
Round	−0.0002	0.00001	−0.0003	0.0003
	(0.0003)	(0.0003)	(0.0003)	(0.0004)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table C.8: Linear regression of Accept on opponent task, by favorability, on sub-samples restricted by average time spent on Part 1 decision making tasks

	Dependent variable:			
	Min of 5s Avg On Decision Rounds		Min of 10s Avg On Decision Rounds	
	Accept (Favorable)	Accept (Unfavorable)	Accept (Favorable)	Accept (Unfavorable)
	(1)	(2)	(3)	(4)
Constant	0.704***	−0.051	0.899***	−0.017
	(0.165)	(0.159)	(0.194)	(0.222)
Own100	1.022***	−0.969***	1.212***	−0.815**
	(0.229)	(0.250)	(0.334)	(0.372)
Opp100	−0.148	−0.230*	−0.236	−0.300**
	(0.125)	(0.122)	(0.203)	(0.153)
Own100*Opp100	0.180	0.171	0.344	0.198
	(0.177)	(0.149)	(0.264)	(0.179)
Round	−0.001	0.00003	−0.002	0.001
	(0.001)	(0.001)	(0.002)	(0.002)

Note: *p<0.1; **p<0.05; ***p<0.01

Table C.9: Logistic regression of Accept on opponent task, by favorability, on sub-samples restricted by average time spent on Part 1 decision making tasks

	Dependent variable:							
	Minimum of 5 Second Avg On Decision Rounds				Minimum of 10 Second Avg On Decision Rounds			
	Accept (Favorable)		Accept (Unfavorable)		Accept (Favorable)		Accept (Unfavorable)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	-1.861^{***}	-1.988^{***}	-3.727^{***}	-3.727^{***}	-1.812^{***}	-1.890^{***}	-4.065^{***}	-4.065^{***}
	(0.083)	(0.098)	(0.065)	(0.065)	(0.082)	(0.098)	(0.084)	(0.084)
Own100	1.714^{***}	1.451^{***}	-0.891^{***}	-0.891^{***}	2.349^{***}	2.974^{***}	-1.004^{***}	-1.004^{***}
	(0.114)	(0.146)	(0.099)	(0.099)	(0.113)	(0.123)	(0.132)	(0.132)
BD	-0.006^{***}	-0.007^{***}	-0.008^{***}	-0.008^{***}	-0.011^{***}	-0.010^{***}	-0.012^{***}	-0.012^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
BA	0.053^{***}	0.056^{***}	0.074^{***}	0.074^{***}	0.057^{***}	0.057^{***}	0.079^{***}	0.079^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Own100*BD	0.010^{***}	0.015^{***}	-0.008^{***}	-0.008^{***}	0.024^{***}	0.019^{***}	-0.013^{***}	-0.013^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Own100*BA	-0.017^{***}	-0.012^{***}	0.0002	0.0002	-0.032^{***}	-0.037^{***}	0.007^{***}	0.007^{***}
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Round	-0.001^{***}	-0.002^{***}	0.0002	0.0002	-0.002^{***}	-0.002^{***}	0.002^{***}	0.002^{***}
	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0004)	(0.0004)

Note: *p<0.1; **p<0.05; ***p<0.01

Table C.10: Linear regression of Accept on beliefs, by favorability, on sub-samples restricted by average time spent on Part 1 decision making tasks, even numbered columns further restricted on sub-sample with non-negative differences in belief opponent accepted favorable and unfavorable deals

	Dependent variable:							
	Minimum of 5 Second Avg On Decision Rounds				Minimum of 10 Second Avg On Decision Rounds			
	Accept (Favorable)		Accept (Unfavorable)		Accept (Favorable)		Accept (Unfavorable)	
Constant	−1.861***	−1.988***	−3.727***	−3.727***	−1.812**	−1.890**	−4.065***	−4.065***
	(0.601)	(0.644)	(0.610)	(0.610)	(0.744)	(0.822)	(0.802)	(0.802)
Own100	1.714**	1.451	−0.891	−0.891	2.349**	2.974***	−1.004	−1.004
	(0.840)	(1.024)	(0.938)	(0.938)	(0.984)	(1.091)	(1.136)	(1.136)
BD	−0.006*	−0.007	−0.008***	−0.008***	−0.011**	−0.010*	−0.012***	−0.012***
	(0.003)	(0.004)	(0.003)	(0.003)	(0.005)	(0.005)	(0.004)	(0.004)
BA	0.053***	0.056***	0.074***	0.074***	0.057***	0.057***	0.079***	0.079***
	(0.011)	(0.010)	(0.011)	(0.011)	(0.013)	(0.013)	(0.015)	(0.015)
Own100*BD	0.010**	0.015**	−0.008	−0.008	0.024***	0.019***	−0.013	−0.013
	(0.005)	(0.007)	(0.005)	(0.005)	(0.007)	(0.007)	(0.008)	(0.008)
Own100*BA	−0.017	−0.012	0.0002	0.0002	−0.032*	−0.037**	0.007	0.007
	(0.016)	(0.019)	(0.018)	(0.018)	(0.018)	(0.018)	(0.021)	(0.021)
Round	−0.001	−0.002	0.0002	0.0002	−0.002	−0.002	0.002	0.002
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)	(0.002)
Note:								*p<0.1; **p<0.05; ***p<0.01

Table C.11: Logistic regression of Accept on beliefs, by favorability, on sub-samples restricted by average time spent on Part 1 decision making tasks, even numbered columns further restricted on sub-sample with non-negative differences in belief opponent accepted favorable and unfavorable deals

D Instructions (Experiment 1)

Part 1 Instructions

Experiment Structure

There will be 4 parts of the experiment. Parts 1 through 3 involve making incentivized economic decisions, either with another random subject, or individually. Part 4 is a short non-incentivized survey.

Bonus Payment

In total, there are 159 incentivized questions in Parts 1-3. At the end of the experiment, one of these 159 questions will be selected at random for payment.

In this question, you will earn some amount of points between 0 and 100. These points will be your percent probability of winning a $10 bonus payment (in addition to your $10 completion payment). For example, if you earn 50 points, you will have a 50% probability of winning a $10 bonus payment.

Because the number of points you earn may depend on decisions made by other subjects, you may not know how many points you have earned until after the experiment is completed by all subjects.

How You'll Receive Your Bonus Payment

You will receive a Prolific message no later than 7 days following your completion of this experiment with a link to a survey. On this survey, you will see your earnings in points.

Then, it will be determined whether you earn the $10 bonus payment. In order to ensure your probability of winning the bonus prize is equal to the number of points earned, we are utilizing a timer device. You will be shown a timer that uses your computer system clock, in milliseconds. You will get one chance to stop this timer. The number of milliseconds in one's and ten's will be a number between 0 and 99. If your earnings in points is strictly greater than this number, you will then earn $10.

Note that it is essentially impossible to stop a clock in milliseconds with any degree of accuracy, so the number generated by the timer game is random for all practical purposes.

To convince yourself of this game's randomness, you can try the timer game multiple times at the link below.

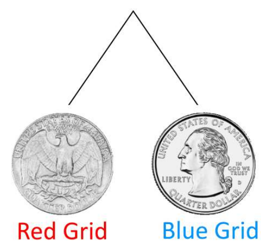
Click here for a demo of the randomized payment device (link opens in new tab)

Part 1 Instructions: Red and Blue Grids

For each of the 30 rounds in Part 1, you will be shown an image of red and blue dots.

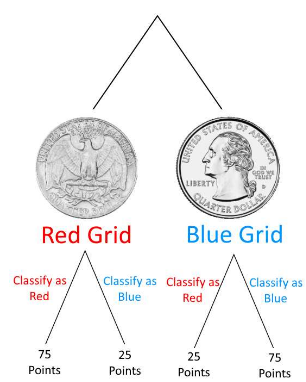
In each round, with 50% probability there will be more red dots than blue dots (call this a Red Grid), and with 50% probability there will be more blue dots than red dots (call this a Blue Grid).

Whether there is a Red Grid or a Blue Grid is determined independently each round. You can think of this as a coin flip that occurs each round, and on heads the grid is Blue and on tails the grid is Red. This means that a grid in one round being one color does not imply anything about future rounds being either Red or Blue.



Part 1 Instructions: Your Choice

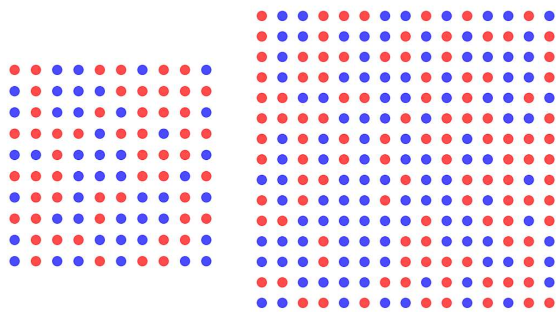
Your task will be to determine whether each grid is Red or Blue. You will have a maximum of thirty seconds to determine this. For each round, you will classify the grid as either "Red" or "Blue". If you are correct, you will earn 75 points, and if you are incorrect you will earn 25 points.



Part 1 Instructions: Types of Grids

You will always try to determine whether a grid is Red or Blue. However, there will be two different types of grids you will see in this part of the experiment, called "100-Dot" and "225-Dot". The 30 rounds in this part will be divided into 6 blocks of 5 rounds each. There will be 3 blocks of 100-Dot grids, and 3 blocks of 225-Dot grids.

- 100-Dot grids will have 100 dots in a 10 by 10 grid. There will be 8 more blue dots than red dots on Blue grids, and 8 more red dots than blue dots on Red grids
- 225-Dot grids will have 225 dots in a 15 by 15 grid. There will be 5 more blue dots than red dots on Blue grids, and 5 more red dots than blue dots on Red grids



100-Dot Grid Example (Left), 225-Dot Grid Example (Right)

Part 1 Instructions: Other Important Notes

After each round, you will not receive any feedback, nor learn whether the grid was truly Red or Blue. Once you have classified a grid as Red or Blue, you are free to proceed to the next question. Once you have proceeded to the next question, you cannot go back to previous questions.

Comprehension Questions

Below are three questions designed to test your comprehension of the instructions.

You must answer each question correctly in order to move on to the next page.

Once you have answer all questions correctly and click on the "Next" button, you will be shown a practice round of the types of questions in Part 1.

If you need to refer back to the instructions for this part of the experiment at any point, you can click on the following link: (Part One Instructions). This link will always be located on the bottom of your screen during Part 1 of the experiment.

If a 225 dot grid is Blue, how many more blue dots will there be than red dots?

If a 100 dot grid is Red, how many more red dots will there be than blue dots?

True or False: Any given grid is equally likely to be Blue or Red.

- True
- False

Next

Practice Question

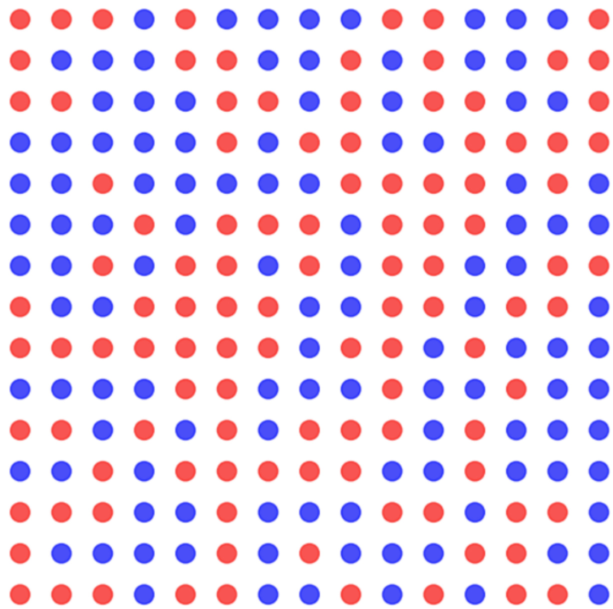
You will now have the chance to complete a practice question. The general format of this question is the same format as all other questions in Part 1 of the experiment, although as stated in the instructions the type of grid will vary from block to block. This Practice Question will not be included in those randomly selected for payment, it is just for practice.

Practice Question

This round, your grid is a **100-Dot** grid.

It is equally likely the grid is Red (8 more red dots than blue dots) or Blue (8 more blue dots than red dots)

The 30 second timer will show here



You will earn 75 points for a correct classification, and 25 points for an incorrect classification.

Your classification:

Red Blue

(Part One Instructions)

Begin Part 1

You will now proceed with Part 1 of the experiment. As a reminder, this part consists of 30 questions, broken into 6 blocks of 5 questions. At the start of each block you will be told the type of grids you will see in that block.

You have up to 30 seconds to make your decision once you have been shown the grid. You cannot go back once you submit your answer. You will not receive any feedback after each round.

Next

New Block: Block 1 of 6: Type 100-Dot Grid

For all five rounds in this block, you will be shown a **100-Dot** grid.

It is equally likely the grid is Red (8 more red dots than blue dots) or Blue (8 more blue dots than red dots)

As in all rounds of Part 1, you will earn 75 points for a correct classification and 25 points for an incorrect classification.

You may now start this block by clicking the "Next" button below.

Next

(Part One Instructions)

Loading Screen
Block 1 of 6: 100-Dot Grid
Question 1 of 5

Recall: Your grid is a **100-Dot** grid.

This means is equally likely the grid is Red (8 more red dots than blue dots) or Blue (8 more blue dots than red dots)

You will earn 75 points for a correct classification, and 25 points for an incorrect classification.

When you click the Next button below, you will be shown the above information, in addition to the dot grid. You will then have up to 30 seconds to make your decision.

Next

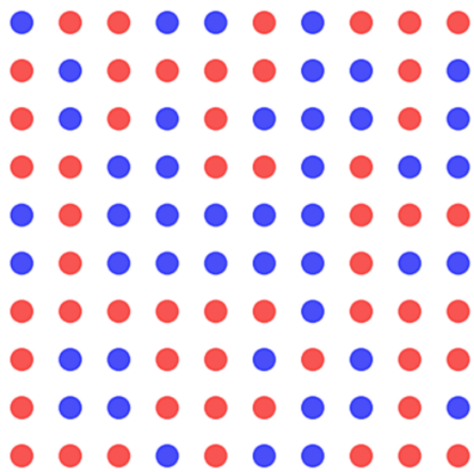
(Part One Instructions)

Block 1 of 6: 100-Dot Grid
Question 1 of 5

Recall: Your grid is a **100-Dot** grid.

This means is equally likely the grid is Red (8 more red dots than blue dots) or Blue (8 more blue dots than red dots)

Time Remaining: 29 seconds



You will earn 75 points for a correct classification, and 25 points for an incorrect classification.

Your classification:

Red

Blue

(Part One Instructions)

Part 2 Instructions

Part 2 Instructions

The next few screens will explain the instructions for Part 2 of this experiment.

Part 2 of the experiment will consist of 128 questions. These will be spread out in 8 blocks of 15 questions, with blocks 5-8 having two extra questions at the end of each block (to be explained when you reach those questions).

Part 2 Instructions: The Setup

At the start of Part 2, you will be assigned to one of two roles, called Red Player and Blue Player. Each round, you will be randomly matched with another Prolific user of the other role type. Recall that only Prolific users between the ages of 18-30, residing in the United States, and with at least a high school degree in education are eligible to participate in this experiment.

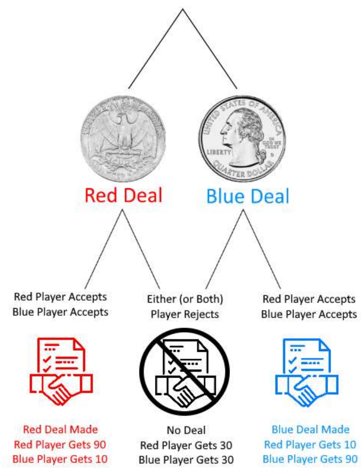
Each round (with the exclusion of the extra questions mentioned, to be described later), you and this other player will be deciding whether to Accept or Reject a deal.

Your payoffs resulting from a deal being made depend on the type of deal. There are two types of deals: Red Deals and Blue Deals, each equally likely (i.e. there is a 50% probability the deal is Red and a 50% probability the deal is Blue). Note that the deal in each round will be the same for each player. For example, if one player is shown a Red deal, the other play is also shown a Red deal. Again, whether the deal is Red or Blue is determined independently each round. You can think of this as a coin flip that occurs each round, and on heads the deal is Blue and on tails the deal is Red.

Part 2 Instructions: Your Actions and Payoffs

As mentioned, both you and the other player are going to decide to Accept or Reject a deal. A deal is only made if both players Accept the deal. If either or both players Reject a deal, it is not made, and both players will receive 30 points (regardless of the color of the deal). If a deal is made, however, the payoffs for each player will depend on the color of the deal:

- If both players Accept a Red Deal, the Red Player receives 90 points and the Blue Player receives 10 points
- If both players Accept a Blue Deal, the Blue Player receives 90 points and the Red Player receives 10 points

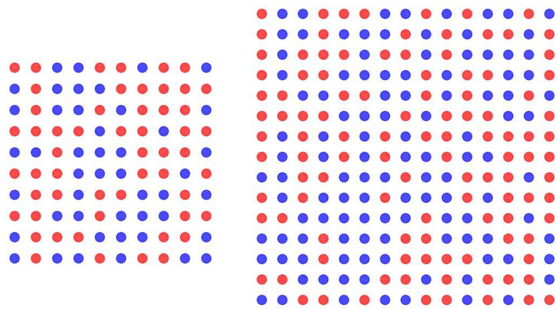


Part 2 Instructions: Determining the Type of Deal

While the above payment scheme is always true, you will have to determine whether you think the deal is Red or Blue by examining a grid of red and blue dots, as in the previous part of the experiment. A Red deal is represented by a Red grid, and a Blue deal is represented by a Blue grid. Recall a Red grid is one with more red dots than blue dots, and a Blue grid is one with more blue dots than red dots.

Like in Part 1, from block to block you will be shown different grid types, either 100-Dot grids or 225-Dot grids. However, in Part 2, the other player will also be shown different grid types from block to block, either 100-Dot grids or 225-Dot grids. At the start of each block, you'll be told the type of grids you will be shown, and the type of grid the other player will be shown. Recall:

- 100-Dot grids will have 100 dots in a 10 by 10 grid. There will be 8 more blue dots than red dots on Blue grids and 8 more red dots than blue dots on Red grids
- 225-Dot grids will have 225 dots in a 15 by 15 grid. There will be 5 more blue dots than red dots on Blue grids, and 5 more red dots than blue dots on Red grids



100-Dot Grid Example (Left), 225-Dot Grid Example (Right)

Part 2 Instructions: Blocks

There are 8 blocks of 15 questions each of the above type. There will be two blocks each of the following setups:

- Red Player and Blue Player both shown 100-Dot grids
- Red Player and Blue Player both shown 225-Dot grids
- Red Player is shown 100-Dot grid, while Blue Player is shown 225-Dot grid
- Red Player is shown 225-Dot grid, while Blue Player is shown 100-Dot grid

These 8 blocks will appear in random order. At the start of each block, you will be given a description of that block.

Part 2 Instructions: Time Limit and Reminders

Like in Part 1, once you are shown your grid you will have up to 30 seconds to decide whether to Accept or Reject the deal. Once you have made your decision, you can proceed to the next round. After proceeding, you cannot go back to previous rounds. You will also receive no feedback after each round.

As a reminder, one of the 159 rounds that make up Parts 1-3 will be randomly selected for payment at the end of the experiment. Should a round from this part be selected for payment, you will receive your payment in points according to the payoffs described above. Recall that these points then correspond to your probability of winning a $10 bonus payment (via the timer mechanism).

Role Assignment

For all Blocks in Part 2 of the experiment, you have been assigned the role of **Red Player**.

On the next screen, you will again be shown a brief comprehension quiz before starting Part 2 of the experiment. Please make sure you understand the instructions before moving on.

Next

Comprehension Quiz

Please answer the below questions to test your understanding of the instructions for Part 2. These questions are solely to check your understanding of the instructions, and have no influence on your payment.

You must answer all questions correctly before moving to the next screen. Once you have answered each question correctly, we will provide an explanation to the answers to each question on the next page.

If you need to refer back to the instructions for this part of the experiment at any point, you can click on the following link: (Part Two Instructions). This link will always be located on the bottom of your screen during Part 2 of the experiment.

For all 120 rounds of Part 2 of the experiment, you have been randomly assigned to the role of **Player Red**.

Please answer the below questions to test your understanding of the instructions for Part 2. These questions are solely to check your understanding of the instructions, and have no influence on your payment. If you have any questions, please raise your hand.

For questions 1-4, suppose you are a Red Player, and the grid on your screen is Red.

1. How many points will you receive if both you and the other player choose Accept?

2. How many points will the other player receive if you and the other player choose Accept?

3. How many points will you receive if you choose Reject?

4. How many points will you receive if the other player chooses Reject?

---

5. True or False: In any given round, you and the other player will have the same color grids

- True
- False

Next

Comprehension Quiz: Answers

For your reference, below are the correct answers for the comprehension quiz, and their explanation.

For questions 1-4, suppose you are a Red Player, and the grid on your screen is Red.

1. How many points will you receive if both you and the other player choose Accept?

    90 points. If both you and the other player Accept, then the deal is made. Since the deal is Red, you will earn 90 points.

2. How many points will the other player receive if you and the other player choose Accept?

    90 points. If both you and the other player Accept, then the deal is made. Since the deal is Red, the Blue Player will receive 10 points.

3. How many points will you receive if you choose Reject?

    30 points. If you choose to Reject the deal--regardless of what the other player chooses--you will receive 30 points. Note that in this case the color of the deal does not matter, a rejected deal will always pay both you and the other player 30 points.

4. How many points will you receive if the other player chooses Reject?

    30 points. If the other player chooses to Reject the deal--regardless of what you choose--the deal will not be made, and you will receive 30 points. Note that in this case the color of the deal does not matter, a rejected deal will always pay both you and the other player 30 points.

---

5. True or False: In any given round, you and the other player in your round always have the same color majority on your grids

    True. You and the other player will always have the same color majority in any specific round.

You can now proceed with the experiment. Recall that you have 30 seconds to complete each round.

Next

(Part Two Instructions)

Begin Part 2

You will now proceed with Part 2 of the experiment. Recall Part 2 consists of 8 blocks of 15 questions each, in addition to two extra questions at the ends of Blocks 5-8.

You have up to 30 seconds to make your decision (Accept or Reject) once you have been shown the grid. Once you have submitted your answer for a particular question, you cannot go back. You will not receive any feedback after each round.

Next

(Part Two Instructions)

New Block: Block 1 of 8

You are now beginning a new block, consisting of 15 questions.

In all 15 questions, you will be presented with a **225-Dot grid** and the other player will be presented with a **225-Dot grid**.

As a reminder:

- A 225-Dot grid consists of 225 dots, with 5 more red dots if the deal is "Red" and 5 more blue dots if the deal is "Blue".

It is equally likely that the deal is Red or Blue. You and the other player will both be seeing the same color deal.

- If either or both party rejects a deal of any color, you will both receive 30 points.
- If you both accept a Red deal, you will get 90 points and the other player will get 10 points.
- If you both accept a Blue deal, you will get 10 points and the other player will get 90 points.

You may now start this block by clicking the "Next" button below.

Next

(Part Two Instructions)

Loading Screen
Block 1 of 8
Question 1 of 15

Your Grid: 225-Dot Grid | Blue Player's Grid: 225-Dot Grid

Reminder: In all rounds of this block:

Your (Player Red's) Image:	225-Dot Grid
Blue Player's Image:	225-Dot Grid

As a reminder:

- A225-Dot grid consists of 225 dots, with 5 more red dots if the deal is "Red" and 5 more blue dots if the deal is "Blue".

Reminder: In all rounds of Part 2:

It is equally likely that the deal is Red or Blue. You and the other player will both be seeing the same color deal.

- If either or both party rejects a deal of any color, you will both receive 30 points.
- If you both accept a Red deal, you will get 90 points and the other player will get 10 points.
- If you both accept a Blue deal, you will get 10 points and the other player will get 90 points.

When you click the Next button below, you will be shown the above information, in addition to the dot grid. You will then have up to 30 seconds to make your decision.

Next

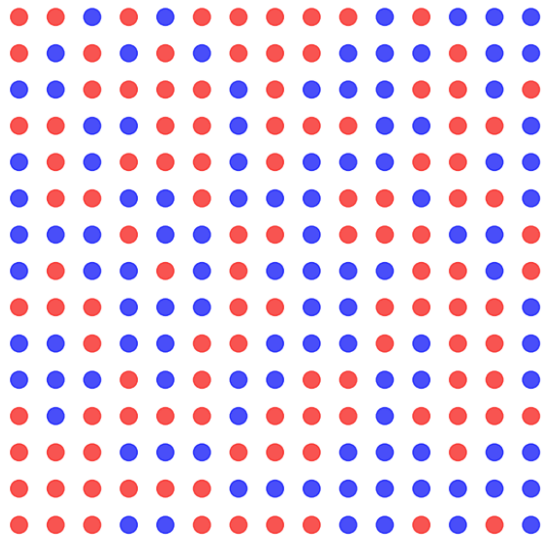
(Part Two Instructions)

Block 1 of 8

Question 1 of 15

Your Grid: 225-Dot Grid | Blue Player's Grid: 225-Dot Grid

Time Remaining: 21 seconds



Accept Reject

Reminder: In all rounds of this block:

Your (Player Red's) Image:	225-Dot Grid
Blue Player's Image:	225-Dot Grid

As a reminder:

- A225-Dot grid consists of 225 dots, with 5 more red dots if the deal is "Red" and 5 more blue dots if the deal is "Blue".

Reminder: In all rounds of Part 2:

It is equally likely that the deal is Red or Blue. You and the other player will both be seeing the same color deal.

- If either or both party rejects a deal of any color, you will both receive 30 points.
- If you both accept a Red deal, you will get 90 points and the other player will get 10 points.
- If you both accept a Blue deal, you will get 10 points and the other player will get 90 points.

(Part Two Instructions)

End of Block 8: Beliefs

Before moving onto the next block, we'd like to ask for your beliefs about how often the other player chose to Accept in the previous block.

Specifically, we're interested in what percent of Red deals and Blue deals you think the other player accepted in the last block.

If either of these questions is selected at random for payment, you will earn more points if the error in your belief (the distance between your reported belief and the actual percentage) is small. If you wish, you can view the specific relationship between your error and your points is demonstrated on a graph by clicking .

this link.

If you are roughly correct, you will earn close to 100 points. As your error becomes larger and larger, your payment will become lower and lower. If your error is more than 50 percentage points, you will receive 0 points.

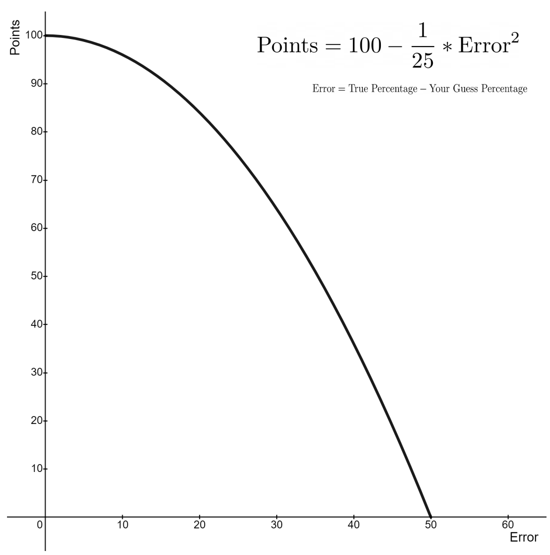
This payment mechanism was designed so that it is financially in your best interest to report your true beliefs. So, **the best thing you can do to maximize your expected earnings is to simply state your true beliefs about what you think the other player will do. Any other guess will decrease the amount you can expect to earn.**

Recall that in the previous block, you had a 225-Dot grid and the other player had a 100-Dot image.

What percent (out of 100) of Red deals do you think the other player accepted in this last block?

What percent (out of 100) of Blue deals do you think the other player accepted in this last block?

Next



Part Three Instructions

Part 3 of the experiment consists of one round. In this round, you will be matched with another Prolific participant. As a reminder, all participants of this experiment are Prolific users between the ages of 18 and 30, located in the United States, with at least a high school education.

You and this other player will play a game in which each player requests an amount of points. This amount must be a whole number between 51 and 60 points. Each player will receive the amount they request. A player will receive an additional amount of 20 points if they ask for exactly one point less than the other player.

As a reminder, one of the 159 questions that make up Parts 1-3 will be randomly selected for payment at the end of the experiment. Should the question from this part be selected for payment, you will receive your payment in points according to the payoffs described above. Recall that these points then correspond to your probability of winning a $10 bonus payment.

Next

Your Request

You and another player are playing a game in which each player requests an amount of points. The amount must be a whole number between 51 and 60 points. Each player will receive the amount they request. A player will receive an additional amount of 20 points if they ask for exactly one point less than the other player.

What amount of ECUs do you request?

Next

Survey Page 1 of 3

A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much in dollars does the ball cost?

If it takes 5 machines 5 minutes to make 5 widgets, how long in minutes would it take 100 machines to make 100 widgets?

In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long in days would it take for the patch to cover half the lake?

Next

Survey Page 2 of 3

Before calculating your earnings for this experiment, please fill out the following survey. These questions do not have any effect on your payment, but we ask you please complete them to the best of your ability.

Which best describes the highest level of education you have attained?

With which gender do you identify?

Next

Survey Page 3 of 3

For questions 1-6 below, we describe a type of round you faced in Part Two. Select the option that best describes your typical strategy for that type of question. If you need help recalling the instructions for this part of the experiment, you can click on the following link: (Part Two Instructions)

1. You had a 100 Dot grid and the other player had a 100 Dot grid

----

I did not count any dots on the image
I counted some of the dots on the image
I counted all of the dots on the image

ad a 100 Dot grid

3. You had a 100 Dot grid and the other player had a 225 Dot grid

----

4. You had a 225 Dot grid and the other player had a 225 Dot grid

----

5. When you had the 100 Dot task, how did your strategy depend on the task of the other player?

6. When you had the 225 Dot task, how did your strategy depend on the task of the other player?

7. Please explain as clearly as possible what your strategy was in general in the games in Part Two of this experiment. When did you try harder to avoid making mistakes? What type of mistakes did you try to avoid making (accepting the wrong deals, or rejecting the right deals)?

8. What do you think this experiment was trying to study?

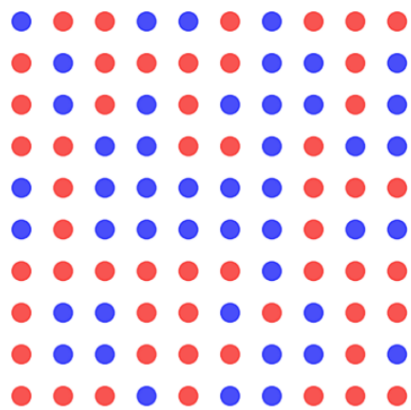
Next

Results

You have reached the end of the experiment. Thank you for your participation.

Out of the 159 questions that make up Parts 1-3 of the experiment, Question 1 of Block 1 of Part 1 was randomly selected for payment.

As a reminder, in this part of the experiment you were playing the single player game. In this specific round, you were shown a 100-Dot grid. Specifically, you were shown the grid below:



You were told you would earn 75 points for correctly guessing whether the grid was Blue or Red, and 25 points for guessing this incorrectly.

The grid in this question, displayed above, was Red. You classified it as Red.

Thus, your payment from this randomly selected question is 75 points.

As described at the beginning of the experiment, you will receive a Prolific message no later than 7 days from now with a Qualtrics link. You will log-in to this Qualtrics survey with your Prolific ID, and there you will see a summary of the above and the points you ended up receiving (if they depend on the choices of other subjects). You will then draw from a random lottery that gives a X percent probability of winning a $10 bonus payment, where X is the number of points you earned. Please be on the lookout for this Prolific message!

Thank you for your participation in this experiment. Please click the completion link below to make sure you get your completion payment.

You may wish to print this screen, or save an image of it for your records.

Click Here To Print Screen!

Important: Click here to complete the study (you must click this in order for Prolific to register you as completed)

E Instructions (Experiment 2)

Note: Part 1 of Experiment 2 is entirely identical to that of Experiment, and are thus excluded below.

Part 2 Instructions

Part 2 of the experiment will consist of 128 questions. These will be spread out in 8 blocks of 15 questions, with blocks 5-8 having two extra questions at the end of each block (to be explained when you reach those questions).

Part 2 Instructions: The Setup

At the start of Part 2, you will be assigned to one of two roles, called Red Player and Blue Player. Each round, you will play a game with a pre-programmed Computer player of the other role type. This Computer player has been programmed to play in a specific way, to be fully detailed later. Importantly, the Computer player's behavior is completely independent of your choices--the Computer player follows a pre-determined strategy that does not depend on your choices.

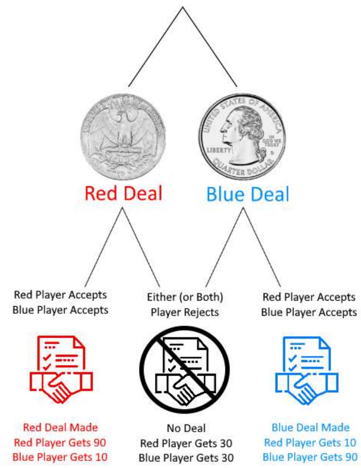
Each round (with the exclusion of the extra questions mentioned, to be described later), you and the Computer will be deciding whether to Accept or Reject a deal.

Your payoffs resulting from a deal being made depend on the type of deal. There are two types of deals: Red Deals and Blue Deals, each equally likely (i.e. there is a 50% probability the deal is Red and a 50% probability the deal is Blue). Note that the deal in each round will be the same for you and the Computer. For example, if the deal is Red for you, the deal is also Red for the Computer. Again, whether the deal is Red or Blue is determined independently each round. You can think of this as a coin flip that occurs each round, and on heads the deal is Blue and on tails the deal is Red.

Part 2 Instructions: Your Actions and Payoffs

As mentioned, both you and the Computer are going to decide to Accept or Reject a deal. A deal is only made if both you and the Computer accept the deal. If either or both you and the Computer reject a deal, it is not made, and you will receive 30 points (regardless of the color of the deal). If a deal is made, however, your payoffs will depend on the color of the deal:

- If both you and the Computer accept a Red Deal, a Red Player would receive 90 points, and a Blue Player would receive 10 points
- If both you and the Computer accept a Blue Deal, a Blue Player would receive 90 points and the Red Player would receive 10 points

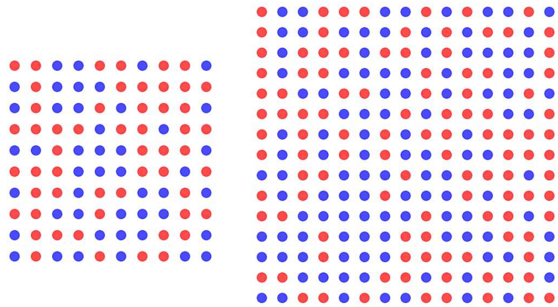


Part 2 Instructions: Determining the Type of Deal

While the above payment scheme is always true, you will have to determine whether you think the deal is Red or Blue by examining a grid of red and blue dots, as in the previous part of the experiment. A Red deal is represented by a Red grid, and a Blue deal is represented by a Blue grid. Recall a Red grid is one with more red dots than blue dots, and a Blue grid is one with more blue dots than red dots.

Like in Part 1, from block to block you will be shown different grid types, either 100-Dot grids or 225-Dot grids. At the start of each block, you'll be told the type of grids you will be shown. Recall:

- 100-Dot grids will have 100 dots in a 10 by 10 grid. There will be 8 more blue dots than red dots on Blue grids and 8 more red dots than blue dots on Red grids
- 225-Dot grids will have 225 dots in a 15 by 15 grid. There will be 5 more blue dots than red dots on Blue grids, and 5 more red dots than blue dots on Red grids



100-Dot Grid Example (Left), 225-Dot Grid Example (Right)

Part 2 Instructions: The Computer Players

We will now describe how Computer players will behave in this experiment. There will be two different types of Computer, we will call them **30:80** and **50:65**. Each type of Computer can be of either role type (if you are a Red player the Computer will always be Blue, and if you are a Blue player the Computer will always be Red).

The computers differ by how often they choose to Accept a deal of their role color, and a deal of your role color.

Computer 30:80 will:

- Accept a deal of *your* role color **30%** of the time
- Accept a deal of *their* role color **80%** of the time

Computer 50:65 will:

- Accept a deal of *your* role color **50%** of the time
- Accept a deal of *their* role color **65%** of the time

To help you remember this, we will color the Computer names appropriately. For example, if you are a Blue Player, the 50:65 Computer will be written as "50:65", as it accepts 50% of Blue deals and 65% of Red deals. If you are a Red Player, the 50:65 computer will instead be written as "50:65", as it accepts 50% of Red Deals and 65% of Blue Deals.

Note that the Computer's strategy is completely independent of the choices you make, in that round or in previous rounds.

Whether you play a Computer 30:80 or Computer 50:65 player will differ from block to block, and you will be told this beforehand.

Part 2 Instructions: Blocks

There are 8 blocks of 15 questions each of the above type. There will be two blocks each of the following setups:

- You have 100-Dot grids, the Computer Player is 30:80
- You have 100-Dot grids, the Computer Player is 50:65
- You have 225-Dot grids, the Computer Player is 30:80
- You have 225-Dot grids, the Computer Player is 50:65

These 8 blocks will appear in random order. At the start of each block, you will be given a description of that block.

Part 2 Instructions: Time Limit and Reminders

Like in Part 1, once you are shown your grid you will have up to 30 seconds to decide whether to Accept or Reject the deal. Once you have made your decision, you can proceed to the next round. After proceeding, you cannot go back to previous rounds. You will also receive no feedback after each round.

As a reminder, one of the 159 rounds that make up Parts 1-3 will be randomly selected for payment at the end of the experiment. Should a round from this part be selected for payment, you will receive your payment in points according to the payoffs described above. Recall that these points then correspond to your probability of winning a $10 bonus payment (via the timer mechanism).

On the next screen you will be shown your random role assignment (Red Player or Blue Player), which will remain the same throughout all blocks of Part 2. After that, you will be asked to complete a brief comprehension quiz.

Role Assignment

For all Blocks in Part 2 of the experiment, you have been assigned the role of **Red Player**.

On the next screen, you will again be shown a brief comprehension quiz before starting Part 2 of the experiment. Please make sure you understand the instructions before moving on.

Next

Comprehension Quiz

Please answer the below questions to test your understanding of the instructions for Part 2. These questions are solely to check your understanding of the instructions, and have no influence on your payment.

You must answer all questions correctly before moving to the next screen. Once you have answered each question correctly, we will provide an explanation to the answers to each question on the next page.

If you need to refer back to the instructions for this part of the experiment at any point, you can click on the following link: (Part Two Instructions). This link will always be located on the bottom of your screen during Part 2 of the experiment.

For all 120 rounds of Part 2 of the experiment, you have been randomly assigned to the role of **Player Red**.

Please answer the below questions to test your understanding of the instructions for Part 2. These questions are solely to check your understanding of the instructions, and have no influence on your payment. If you have any questions, please raise your hand.

For all of the following questions, suppose you are a Red Player.

For Questions 1-3, suppose the grid on your screen is Red.

1. How many points will you receive if both you and the Computer choose Accept?
2. How many points will you receive if you choose Reject?
3. How many points will you receive if the Computer chooses Reject?

---

4. Suppose you are playing a Computer 30:80. What percent of Red deals will the Computer Accept?
5. Suppose you are playing a Computer 30:80. What percent of Blue deals will the Computer Accept?
6. Suppose you are playing a Computer 50:65. What percent of Red deals will the Computer Accept?
7. Suppose you are playing a Computer 50:65. What percent of Blue deals will the Computer Accept?

Next

Comprehension Quiz: Answers

For your reference, below are the correct answers for the comprehension quiz, and their explanation.

For all of the following questions, suppose you are a Red Player.

For Questions 1-3, suppose the grid on your screen is Red.

1. How many points will you receive if both you and the Computer choose Accept?

> **90 points**. If both you and the Computer Accept, then the deal is made. Since the deal is Red, you will earn 90 points.

2. How many points will you receive if you choose Reject?

> **30 points**. If you choose to Reject the deal--regardless of what the Computer chooses--you will receive 30 points. Note that in this case the color of the deal does not matter, a rejected deal will always pay you 30 points.

3. How many points will you receive if the Computer chooses Reject?

> **30 points**. If the Computer chooses to Reject the deal--regardless of what you choose--the deal will not be made, and you will receive 30 points. Note that in this case the color of the deal does not matter, a rejected deal will always pay you 30 points.

---

4. Suppose you are playing a Computer 30:80. What percent of Red deals will the Computer Accept?

> **30 percent**. Since you are a Red Player, the Computer is a Blue Player. This means it will accept a Red deal (which is not its role color) 30% of the time.

5. Suppose you are playing a Computer 30:80. What percent of Blue deals will the Computer Accept?

> **80 percent**. Since you are a Red Player, the Computer is a Blue Player. This means it will accept a Blue deal (which is its role color) 80% of the time.

6. Suppose you are playing a Computer 50:65. What percent of Red deals will the Computer Accept?

> **50 percent**. Since you are a Red Player, the Computer is a Blue Player. This means it will accept a Red deal (which is not its role color) 50% of the time.

7. Suppose you are playing a Computer 50:65. What percent of Blue deals will the Computer Accept?

> **65 percent**. Since you are a Red Player, the Computer is a Blue Player. This means it will accept a Red deal (which is its role color) 65% of the time.

Next

(Part Two Instructions)

Begin Part 2

You will now proceed with Part 2 of the experiment. Recall Part 2 consists of 8 blocks of 15 questions each, in addition to two extra questions at the ends of Blocks 5-8.

You have up to 30 seconds to make your decision (Accept or Reject) once you have been shown the grid. Once you have submitted your answer for a particular question, you cannot go back. You will not receive any feedback after each round.

Next

(Part Two Instructions)

New Block: Block 1 of 8

You are now beginning a new block, consisting of 15 questions.

In all 15 questions, you will be presented with a **100-Dot grid** and you will play **Computer 50:65**.

As a reminder:

- Computer 50:65 will accept **50%** of Red deals
- Computer 50:65 will accept **65%** of Blue deals
- A 100-Dot grid consists of 100 dots, with 8 more red dots if the deal is "Red" and 8 more blue dots if the deal is "Blue".

It is equally likely that the deal is Red or Blue.

- If either (or both) you or the Computer Player rejects a deal of any color, you will receive 30 points.
- If both you and the Computer Player accept a Red deal, you will get 90 points.
- If both you and the Computer Player accept a Blue deal, you will get 10 points.

You may now start this block by clicking the "Next" button below.

Next

(Part Two Instructions)

Loading Screen
Block 1 of 8
Question 1 of 15

Your Grid: 100-Dot Grid | Computer Player: 50:65

Reminder: In all rounds of this block:

- Computer 50:65 will accept **50%** of Red deals
- Computer 50:65 will accept **65%** of Blue deals
- A 100-Dot grid consists of 100 dots, with 8 more red dots if the deal is "Red" and 8 more blue dots if the deal is "Blue".

Reminder: In all rounds of Part 2:

It is equally likely that the deal is Red or Blue.

- If either (or both) you or the Computer Player rejects a deal of any color, you will receive 30 points.
- If both you and the Computer Player Accept a Red deal, you will get 90 points.
- If both you and the Computer Player Accept a Blue deal, you will get 10 points.

When you click the Next button below, you will be shown the above information, in addition to the dot grid. You will then have up to 30 seconds to make your decision.

Next

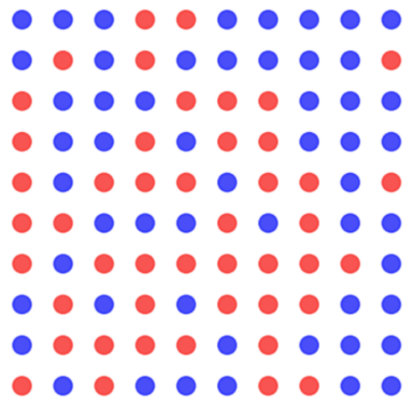
(Part Two Instructions)

Block 1 of 8

Question 1 of 15

Your Grid: 100-Dot Grid | Computer Player: 50:65

Time Remaining: 17 seconds



Accept   Reject

Reminder: In all rounds of this block:

- Computer 50:65 will accept 50 % of Red deals
- Computer 50:65 will accept 65 % of Blue deals

- A 100-Dot grid consists of 100 dots, with 8 more red dots if the deal is "Red" and 8 more blue dots if the deal is "Blue".

Reminder: In all rounds of Part 2:

It is equally likely that the deal is Red or Blue.

- If either (or both) you or the Computer Player rejects a deal of any color, you will receive 30 points.
- If both you and the Computer Player Accept a Red deal, you will get 90 points.
- If both you and the Computer Player Accept a Blue deal, you will get 10 points.

(Part Two Instructions)

End of Block 8: Beliefs

Before moving onto the next block, we'd like to ask for your beliefs about how often a Player of *the other role type* chose to Accept in the previous block (when they had a 100-Dot image and played a Computer 30:80 (note that since this other player was of the other role type, this meant the computer accepted 30% of Red deals and 80% of Blue deals).

Specifically, we're interested in what percent of Red deals and Blue deals you think a randomly selected Blue Player accepted in the last block. This other player is selected at random from other human subjects who completed this same experiment on Prolific. Recall that Blue Players have the exact same setup as you, however they earn 90 points when a Blue deal is made, and 10 points when a Red deal is made.

If either of these questions is selected at random for payment, you will earn more points if the error in your belief (the distance between your reported belief and the actual percentage) is small. If you wish, you can view the specific relationship between your error and your points is demonstrated on a graph by clicking this link.

If you are roughly correct, you will earn close to 100 points. As your error becomes larger and larger, your payment will become lower and lower. If your error is more than 50 percentage points, you will receive 0 points.

This payment mechanism was designed so that it is financially in your best interest to report your true beliefs. So, **the best thing you can do to maximize your expected earnings is to simply state your true beliefs about what you think the other player will do. Any other guess will decrease the amount you can expect to earn.**

Recall that in the previous block, this player had a 100-Dot grid and played against a Computer 30:80.

What percent (out of 100) of Red deals do you think this Blue player accepted in this last block?

What percent (out of 100) of Blue deals do you think this Blue player accepted in this last block?

Next

(Part Two Instructions)

Note: The 11-20 Game, CRT, and Demographic questions are identical to those in Experiment 1, and are thus excluded below.

Survey Page 3 of 3

For questions 1-6 below, we describe a type of round you faced in Part Two. Select the option that best describes your typical strategy for that type of question. If you need help recalling the instructions for this part of the experiment, you can click on the following link: (Part Two Instructions)

1. You had a 100 Dot grid and the computer was Computer 30:80

----

2. You had a 225 Dot grid and the computer was Computer 30:80

----

3. You had a 100 Dot grid and the computer was Computer 50:65

----

4. You had a 225 Dot grid and the computer was Computer 50:65

---

5. When you had the 100 Dot task, how did your strategy depend on which computer you were playing?

6. When you had the 225 Dot task, how did your strategy depend on which computer you were playing?

---

7. Please explain as clearly as possible what your strategy was in general in the games in Part Two of this experiment. When did you try harder to avoid making mistakes? What type of mistakes did you try to avoid making (accepting the wrong deals, or rejecting the right deals)?

8. What do you think this experiment was trying to study?

Next

F Instructions: Timer Payment Mechanism

F.1 Practice

Practice Timer Task

You will see the following instructions before playing the timer task:

On the next screen you will see a clock, like the one below. The time from this clock is in milliseconds and uses your computer's clock. You will have one chance to stop this clock. The right-most two digits are then your random number, between 0 and 99. If this random number is strictly lower than your earnings in points, you will earn a $10 bonus payment.

4409

On the next page, you will be able to practice this task. Recall this is just to show you how the timing mechanism works and will not affect any actual payments.

→

Click "Stop" below to stop the timer. Remember you can only click the "Stop" button once. The last two digits will be your random number. If this random number is strictly lower than your earnings in points, you would earn the $10 bonus payment. Once you have stopped the clock, go the next page to read a summary.

16418

Stop

→

Your random number was 16418.

The last two digits were 18. If this number is strictly lower than your earnings in points, you would be awarded the $10 bonus payment. If it is not strictly lower, you would not earn the bonus payment.

You can try this task again as many times you want by going to the next page. Feel free to stop whenever you want. Note that when you do this to determine your bonus, you will not be able to try this task more than once.

→

F.2 Payment

Please log in.

Prolific ID

→

Thank you for completing the experiment!

On the next screen you will be shown a summary of your results, including how many points you earned.

After this, whether or not you win the $10 bonus payment will be randomly determined via the timer mechanism described in the experimental instructions. Recall that your number of points will be equal to your probability, in percent, of winning the bonus payment.

→

Out of all of the questions in parts 1-3 of the experiment, Question 5 of Block of Part 2 was randomly selected for payment.

If desired, instructions for this round can be found here.

In this question, you were shown a grid, and the other player was shown a grid.

You were a Player and you chose to Accept. The grid in this question was actually Red.

Your opponent chose Reject. Your earnings from this question are thus 30 points.

If any of the above is inconsistent with your records, please reach out to the experimenter via Prolific message.

→

On the next screen you will see a clock, like the one below. The time from this clock is in milliseconds and uses your computer's clock. You will have one chance to stop this clock. The right-most two digits are then your random number, between 0 and 99. If this random number is strictly less than your earnings in points (which was 30), you will earn a $10 bonus payment. This bonus payment will be awarded on Prolific within 24 hours.

1874

IMPORTANT: To prevent subjects from retaking the lottery, once you move onto the next screen, you will be unable to restart this survey. Please do not refresh the screen or attempt to restart the survey.

Please re-enter your Prolific ID below if you agree with these conditions.

→

Click "Stop" below to stop the timer. Remember you can only click the "Stop" button once. If you leave this page before clicking stop, the timer will stop at the moment you leave the page.

The last two digits will be your random number. If this random number is strictly lower than your earnings in points (which was 30), you will earn the $10 bonus payment. Once you have stopped the clock, please go the next page to get confirmation on your earnings.

4561

Stop

→

Your random number was 4561.

The last two digits were 61. Recall your earnings were 30 points.

Since your random number was greater than or equal to 30, you have not earned the $10 bonus payment.

Thank you for completing this experiment. On the next page, you can find a summary of your results below for your records, if you so choose.

→