Cognitive Load and Strategic Sophistication

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Abstract

We study the relationship between the cognitive load manipulation and strategic sophistication. The cognitive load manipulation is designed to reduce the subject's cognitive resources that are available for deliberation on a choice. In our experiment, subjects are placed under a large cognitive load (given a difficult number to remember) or a low cognitive load (given a number which is not difficult to remember). Subsequently, the subjects play a one-shot game then they are asked to recall the number. This procedure is repeated for various games, where a new number is given for each game. We find a nuanced and nonmonotonic relationship between cognitive load and strategic sophistication. This relationship is consistent with two effects. First, subjects under a high cognitive load tend to exhibit behavior consistent with the reduced ability to compute the optimal decision. Second, the cognitive load tends to affect the subject's perception of their relative standing in the distribution of the available cognitive resources. The net result of these two effects depends on the strategic setting. Our experiment provides evidence on the literature which examines the relationship between measures of cognitive ability and strategic sophistication.

Keywords: bounded rationality, experimental economics, working memory load, beauty contest, strategic sophistication, rational inattention

JEL: C72, C91

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1 Introduction

Models of strategic sophistication have greatly improved our understanding of play in games.[1] These models posit that subjects exhibit heterogenous sophistication in their thinking of the game. An open question relates to the origin of these strategic levels and whether they arise from a fundamental trait of the subjects. A natural candidate for the source of the strategic levels is the measured cognitive ability of the subject. This has prompted researchers to investigate the relationship between measured cognitive ability and strategic sophistication.[2]

However, one difficulty in employing measures of cognitive ability is that subjects with different measures of cognitive ability are possibly also different in other ways. As such, it might not be possible to distinguish between an alternate hypothesis that an unobserved characteristic is responsible for the level of strategic sophistication, and cognitive ability is merely correlated with this characteristic. Here, rather than measure cognitive ability, we manipulate the cognitive resources available to the subject via cognitive load. Cognitive load experiments often direct subjects to make a decision in one domain while simultaneously manipulating the cognitive resources available to reflect on the decision.

The cognitive load manipulation is designed to occupy a portion of the working memory capacity of the subject. Working memory can be conceptualized as the cognitive resources available to temporarily store information so that it can be used in decision making. Therefore, working memory is instrumental in the execution of deliberative thought.[3] Several studies have found that measures of cognitive ability are positively related to measures of working memory capacity.[4] Further, reducing the available working memory of a subject via cognitive load, reduces the cognitive resources available for deliberation, and can be regarded as similar to the condition of having a diminished cognitive ability. Additionally, given the within-

[1]For instance, Stahl and Wilson (1994,1995), Nagel (1995), Costa-Gomes, Crawford, and Broseta (2001), Costa-Gomes and Crawford (2006), Camerer, Ho, and Chong (2004). See Crawford, Costa-Gomes, and Iriberri (2013) for an updated overview of the field.

[2]See Bayer and Renou (2012), Burnham et al. (2009), Brañas-Garza, Paz Espinosa, and Rey-Biel (2011), Carpenter, Graham, and Wolf (2013), Devetag and Warglien (2003), Georganas, Healy, and Weber (2010), and Gill and Prowse (2012).

[3]See Alloway and Alloway (2013).

[4]For instance, see Conway, Kane, and Engle (2003), Kane, Hambrick, and Conway (2005), Oberauer et al. (2005), and Süß et al. (2002). See Burgess et al. (2011) and Cole et al. (2012) for recent advances in understanding the neurological basis of this relationship.

subject design of our experiment, we are able to observe the behavior of each of the subjects in different cognitive load treatments. As a consequence, our results are not possibly driven by unobserved characteristics which are only related to cognitive ability.[5]

Although we expected that the cognitive load manipulation would produce uniformly less strategically sophisticated behavior, we find a nuanced and nonmonotonic relationship between cognitive load and strategic sophistication. In fact, our results are consistent with recent advances in the literature. While much of the research on the source of strategic sophistication focuses on measures of cognitive ability, recent research emphasizes the role of the perception of the strategic sophistication of the opponent. For instance, Agranov, Potamites, Schotter, and Tergiman (2012) find that the strategic sophistication of the subject is related to the perceived strategic sophistication of their opponents.[6]

In our experiment, we directed subjects to play various one-shot games while under a cognitive load manipulation. In particular, they played ten 3×3 games, a variation of the $11-20$ game (Arad and Rubenstein, 2012), and a variation of the beauty contest game (Nagel, 1995). We note that our version of the $11 - 20$ game is relatively simple, the beauty contest is relatively complicated, and the 3×3 games have various levels of complexity.

The subjects played these games under either a low or a high cognitive load. Subjects in the low load were directed to commit a three digit binary number to memory and subjects under a high load were directed to commit a nine digit binary number to memory. Subsequently, the subjects were asked to recall the number. Additionally, some treatments also informed the subjects of the load of their opponent.

Through a single manipulation of the available cognitive resources, we observe behavior consistent with two effects. First, subjects under a high cognitive load had difficulty making the computations associated with optimal play. In this regard, high load subjects can be considered less sophisticated than low load subjects. Second, subjects under a high load behaved in a way which is consistent with the view that they were aware that they were

[5] Although we note that the research finds that the cognitive load manipulation is more effective on subjects with a higher measure of cognitive ability (Carpenter et al., 2013).

[6] Also see Alaoui and Penta (2014), Palacios-Huerta and Volij (2009), and Slonim (2005). On the other hand, de Sousa, Hollard, and Terracol (2013) find evidence that many subjects are not sensitive to the apparent sophistication of their opponents.

relatively disadvantaged in the distribution of available cognitive resources. Therefore, high load subjects can be considered to be more sophisticated than low load subjects. We find that the net result of these two effects depends on the strategic setting.

The effect of the constrained ability to make calculations dominates the other effect when, in the relatively complicated beauty contest game, the high load subjects selected less strategic actions. This is consistent with the view that the diminished ability of the high load subjects to compute the optimal strategy in the relatively complicated game. We also see that the ability to best respond to stated beliefs, a measure of the sophistication of their actions, and a measure of the sophistication of the beliefs of their opponent's actions of the high load subjects in the 3×3 games are differentially less sensitive to the complexity of the game, as measured by the number of their own dominated strategies. These results are consistent with the view that the high load subjects were less strategically sophisticated.

On the other hand, the effect of the reduction in their perceived standing in the distribution of available cognitive resources dominates the other effect in our version of the $11-20$ game, which is relatively uncomplicated. Here, high load subjects selected a more strategic response, consistent with the expectation that they were paired with a more cognitively able subject. We also find that high load subjects, better than low load subjects, conditioned their behavior on the information regarding the load of their opponent. These results are consistent with the view that high load subjects were more strategic than low load subjects.

Overall, we find a nuanced and nonmonotonic relationship between available cognitive resources and strategic sophistication. We hope that our findings are helpful in the efforts to improve the models of strategic sophistication.

1.1 Related literature

The economics literature increasingly regards the brain as an object worthy of study in that, subject to its limitations and heterogeneity across subjects, it is the source of economic behavior. This line of inquiry has investigated topics ranging from the effects of sleep on strategic behavior (Dickinson and McElroy, 2010, 2012), to optimal search patterns (Sanjurjo, 2012a, 2012b), to neurological studies of the brain during choice (Coricelli and Nagel, 2009, 2012), to novel elicitation methods designed to measure the reasoning of subjects (Agranov, Caplin, and Tergiman, 2013; Burchardi and Penczynski, 2014; Chen et al., 2010; Crawford, 2008). In particular, there is a growing literature which investigates the relationship between measured cognitive ability and economic preferences[7] and the relationship between measured cognitive ability and behavior in games.[8] To the extent that subjects under a high cognitive load are similar to the condition of having a low cognitive ability, our results provide evidence on the relationship between cognitive ability and strategic sophistication.

There is an extensive literature on the cognitive load manipulation in nonstrategic settings. The research finds that subjects under a high cognitive load are more impulsive and less analytical (Hinson, Jameson, and Whitney, 2003), they are more risk averse and are more impatient (Benjamin, Brown, and Shapiro, 2013), they make more mistakes on a forecasting task (Rydval, 2011), they exhibit less self control (Shiv and Fedorikhin, 1999; Ward and Mann, 2000, Mann and Ward, 2007), they fail to process available information (Gilbert, Pelham, and Krull, 1988; Swann et al., 1990), they perform worse on gambling tasks (Hinson, Jameson, and Whitney, 2002), they perform worse on spatial judgment tasks (Duffy, Smith, Allred, and Crawford, 2014), they make different choices in allocation decisions (Cornelissen, Dewitte, and Warlop, 2011; Hauge et al., 2009, Schulz et al., 2014), and they have different evaluations of the fairness of outcomes (van den Bos et al., 2006).[9] This literature finds that the behavior under a cognitive load is consistent with the condition that the subjects have fewer cognitive resources available for deliberative thought.

On the other hand, there does not exist many instances of studies of the strategic behavior

[7] See Andersson et al. (2013), Arruñada, Casari, and Pancotto (2012), Beauchamp, Cesarini, and Johannesson (2011), Benjamin et al. (2013), Ben-Ner, Kong, and Putterman (2004), Brañas-Garza, Guillen, and Lopez del Paso (2008), Branstätter and Güth (2002), Burks et al. (2009), Chen et al. (2013), Cokely and Kelley (2009), Dohmen et al. (2010), Frederick (2005), Millet and Dewitte (2007), and Oechssler, Roider, and Schmitz (2009).

[8] See Ballinger et al. (2011), Baghestanian and Frey (2012), Bayer and Renou (2012), Brañas-Garza, Garcia-Muñoz, and Hernan Gonzalez (2012), Brañas-Garza et al. (2011), Carpenter et al. (2013), Chen et al. (2010), Gill and Prowse (2012), Grimm and Mengel (2012), Jones (2011), Jones (2008), Kiss, Rodriguez-Lara, and Rosa-García (2014), Palacios-Huerta (2003), Proto, Rustichini, and Sofianos (2014), Putterman, Tyran, and Kamei (2011), Rydval (2011), Rydval and Ortmann (2004), and Schnusenberg and Gallo (2011).

[9] Deck and Jahedi (2013) study several effects at a time and find that subjects under a cognitive load are less patient, more risk averse, perform worse on arithmetic tasks, and are more prone to anchoring effects.

which employ the cognitive load manipulation. To our knowledge, Milinski and Wedekind (1998), Roch et al. (2000), Cappelletti, Güth, and Ploner (2011), Buckert, Oechssler, and Schwieren (2013), Duffy and Smith (2014), and Carpenter, Graham, and Wolf (2013) are the only such examples. We note that all but the last of these are not designed to investigate models of strategic sophistication. For instance, Buckert, Oechssler, and Schwieren (2013) find that high load subjects in a repeated Cournout oligopoly game are more likely to select the less sophisticated imitation heuristic. Milinski and Wedekind (1998) find that high load subjects in the repeated prisoner's dilemma game employ less complicated strategies than low load subjects. Duffy and Smith (2014) find that low load subjects in a finitely repeated multi-player prisoner's dilemma game exhibit more defection near the end of play and they are better able to condition their strategy on previous outcomes. However, these studies do not lend themselves to the study of strategic sophistication, as the games are repeated and the subjects receive feedback about the strategic outcomes.

In contrast to the other studies, Carpenter et al. (2013) induce a differential cognitive load in subjects then observe the strategic behavior of the subjects. The subjects played a sequential game that can be solved by backwards induction. The subjects also provided both actions and beliefs in the beauty contest game. The authors find that subjects under a high cognitive load are less strategic in that they are less able to perform backwards induction. Additionally, the authors find that high load subjects believe that their beauty contest opponents would select a higher number and the authors observe a larger deviation from the best response to these beliefs. Our most comparable result is that we find that high load subjects are less strategic in that they select a higher number in the beauty contest. While our beauty contest results coincide with those of Carpenter et al., we also note that we find that, depending on the type of the game, high load subjects can be considered to be more sophisticated.

We also note that there are methodological differences between Carpenter et al. and our paper. First, Carpenter et al. employs a between-subjects design, whereby subjects are exclusively observed in a single cognitive load treatment. This design introduces possible differences in payments across treatments, since the memorization task was incentivized. By contrast, we employ a within-subjects design, whereby each subject played some games under a high load and other games under a low load. Therefore, the differences which we observe are not possibly driven by differences in the payments across the cognitive load treatments.

In our view, this paper makes two contributions to the literature. First, we provide additional evidence that the cognitive load manipulation affects strategic behavior. Second, we find that the relationship between strategic sophistication and available cognitive resources is nuanced and nonmonotonic. In fact, this nuanced relationship is achieved through only a single cognitive load manipulation. We view our results as providing indirect evidence which could inform the research on the relationship between measures of cognitive ability and strategic sophistication. In particular, our results suggest that a lower measure of cognitive ability will not necessarily produce less sophisticated behavior, because the ability to make computations and the perception of the relative standing in the ability to make computations have opposite effects on behavior.

2 Method

A total of 308 subjects participated in the experiment. The subjects were drawn from the experimental economics subject pool at Rutgers University-New Brunswick and the sessions were conducted in the Wachtler Experimental Economics Laboratory. The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007).[10] Sessions lasted from 60 to 75 minutes.

2.1 Specification of the games

We directed subjects to play a series of games: ten 3×3 games, an adaptation of the $11 - 20$ game, and an adaptation of the beauty contest game. These games were used because they provide different estimates of the strategic sophistication of the subjects. The subjects were not given feedback about the outcomes of the games. The subjects were told that they would be randomly and anonymously rematched in each of the games.

[10] The z-Tree code is available from the corresponding author upon request.

First, we directed subjects to play 10 simultaneous action 3×3 games. These games are simplified versions of games used by Costa-Gomes and Weizsacker (2008), Rey-Biel (2008), and Bayer and Renou (2012).[11] In these games, each subject was matched with another subject and both made a selection among three possible actions. In addition to selecting an action, we also elicited the point beliefs of the subjects about the action of the other player. Each of the 3×3 games has an original version (labeled A) and a transposed version of the original game (labeled B). In other words, the A and B versions are strategically equivalent but the roles have been switched. From the perspective of the games as specified in the appendix, subjects played all 10 games as either a row or a column player. Therefore, each subject played both roles in each of the 5 strategically equivalent games. We note that the game was always presented so that the subject was the row player and the opponent was the column player. As a result, every player selected among actions labeled Top, Middle, and Bottom, and selected beliefs about the action of the opponent which were labeled Left, Center, and Right. Throughout the experiment, 10 points were equivalent to \$3.50. Correct beliefs were rewarded with 4 points. See the appendix for a screenshot of the choice in the 3×3 games.

We also used a variant of the $11 - 20$ game (Arad and Rubenstein, 2012). Subjects were randomly matched with another subject and selected an integer between 1 and 10. The subjects received the amount selected, where again 10 points were equivalent to \$3.50. However, the subject received a bonus of 10 points if they selected a number exactly one digit lower than their opponent. Hereafter, we will refer to this game as the *1 − 10* game.

Finally, we employed a version of the beauty contest game (Nagel, 1995). Each subject selected a half-integer between 0 and 10. The subject who selected the number closest to 2/3 of the average in the session received \$30.

2.2 Memorization task

Before play in every game, the subjects were given up to 15 seconds to commit a number to memory. The subjects were told that after the game, they would be asked for the number. These numbers were always composed of a string of either 0 or 1, where the first digit was

[11] See the appendix for the precise specification of the games used and a screen shot.

always a 1. In the high load treatment, we required the memorization of a 9 digit string, for example: 101110001. In the low load treatment, we required the memorization of a 3 digit string, for example: 110. We employed a within-subject design whereby the subjects faced an alternating load of high and low. Half of the subjects were given the high load first, and half were given the low load first. A new number was randomly given in each of the games. The subjects were not given feedback about the results of the memorization task.

2.3 Controlling for beliefs

Of the 308 subjects, 144 were given information about the load of their opponents in the 3×3 games and the $1 - 10$ game.[12] This took the form of a screen which stated that the other player "will have to remember a: Big (Small) Number." Additionally, during the decision in the 3×3 games, the subjects were also reminded of the load of their opponent.[13] In order to give subjects a consistent sequence of stimuli, prior to the beauty contest game, these subjects were given a screen which stated that roughly 50% of the other subjects were given a big number and roughly 50% were given a small number. In order to minimize the effect of the load on processing this information, the subjects were informed of the load of their opponent prior to the memorization task.

2.4 Experimental timeline and details

Before the incentivized portion of the experiment, we provided four unincentivized tasks: two practice memorization tasks and two simple addition tasks. First, the subjects were given two unincentivized practice rounds with the memorization task, one with a large number and one with a small number. Then, in order to illustrate the extent to which the loads can affect the ability to make basic computations, we provided a memorization number, then we directed the subjects to sum two randomly selected integers between 11 and 40, then we asked for the memorization number. The subjects performed this addition task under both a low and a

[12] For studies which have controlled for or manipulated the beliefs of the opponents, see Agranov et al. (2012), Alaoui and Penta (2014), de Sousa, Hollard, and Terracol (2013), Georganas, Healy, and Weber (2010), Palacios-Huerta and Volij (2009), and Slonim (2005).

[13] See the appendix for a screen shot.

high cognitive load.

Subsequently, we provided the subjects with instructions on 3×3 games.[14] We directed the subjects to play the 3×3 games under a differential cognitive load. Before each of these games, we gave the subjects the memorization number, then we presented the game, then we asked for the memorization number. The instructions stated that, should the subject perform X of the 10 memorization tasks correctly in the 3×3 games then the computer would randomly select the maximum of either 0 or $X - 7$ outcomes of the 3×3 games for payment.

Between each of the ten 3×3 games, the subjects were forced to take a 20 second rest. During this rest period, the subjects were not able affect the screen which read, "Rest!!! Because a new game will start soon." Also note that, across sessions, we randomized the order in which the subjects were presented the 3×3 games.

After the 3×3 games, the subjects were directed to play the $1 - 10$ game and the beauty contest game, under the alternating cognitive load which continued from the previous stages. The subjects were told that they would be paid the amount of the $1 - 10$ game and the beauty contest game only if the memorization task was performed correctly for both of these games. Note that we did not load the subjects when they were reading the instructions for the $1 - 10$ game and the beauty contest game.

After the beauty contest memorization task was completed, the subjects were directed to indicate their gender, whether they are an economics major, whether they have taken a game theory course, an optional estimate of their grade point average (GPA), and a rating of the difficulty in recalling the large and the small memorization numbers. These difficulty ratings were solicited on a scale of 1 ("Very Difficult") to 7 ("Not Very Difficult"). Subsequently, the subjects were told their amount earned and they were paid in cash. The subjects earned an average of \$17.67 ($SD = 6.11$).

2.5 Discussion of the experimental design

Despite that Duffy and Smith (2014) find that their cognitive load manipulation affects behavior, here we employ a different design. First, we employ a within-subject design, rather

[14] These instructions are available from the corresponding author upon request.

than a between-subject design. This is notable because research suggests that the effects of the cognitive load manipulation can be lasting (Dewitte et al., 2005). In order to mitigate the effects of the load of previous rounds, we employed a mandatory rest-period between games. Second, unlike Duffy and Smith (2014), which employs a memorization number composed of digits ranging from 0 to 9, we restrict attention to numbers composed exclusively of either 0 or 1. This design was intended to mitigate the interaction between the game payoff numbers and the the memorization task numbers.

While we could observe that subjects were not able to employ any obvious memorization aids (cell phones, writing the number on paper, etc.) we cannot say with certainty that no subject used a memorization aid. For instance, with an appropriate positioning of the free body parts (feet, legs, elbows, wrists, and fingers on left hand) one could possibly devise a code to aid memorization. In our view, this possibility is not as advantageous as it first appears. This is because the subject must remember the code, and this will occupy cognitive resources. So, while this remains a possibility, we do not regard it to be a serious problem.

Additionally, we designed the experiment so that the responses to the games were as simple as possible. For instance, in the 3×3 games we elicited the point beliefs of the action of the opponent rather than more sophisticated measures of beliefs. This procedure has a drawback that our measures of beliefs are coarse. On the other hand, the task is sufficiently simple so that the memorization task was not likely to affect the ability to comply with the elicitation procedure. Additionally, we elicited responses to the beauty contest, which were the 21 half-integers between 0 and 10 rather than, as is more standard, the integers or real numbers between 0 and 100. More generally, we designed the experiment so that every response in the games took a different format than that required for the memorization task. In the 3×3 games, the $1 - 10$ game, and the beauty contest game, the responses involved clicking on the corresponding button, whereas the memorization task required entering a sequence of digits.

We employed a simplified version of the 3×3 games originally used by Costa-Gomes and Weizsacker (2008), Rey-Biel (2008), and Bayer and Renou (2012). The original games have integer payoffs which range from 10 to 98. We employed a simplified version where payoffs are integers which range from 1 to 11. This design was intended to reduce the computational difficulty in deciding on an action.

We now discuss the equilibrium details of the games. The 3×3 games each have a single pure strategy Nash Equilibrium. The $1-10$ game does not have a pure strategy equilibrium, but has a unique mixed strategy equilibrium. In equilibrium, the player selects 10 with probability 0.1, 9 with probability 0.2, 8 with probability 0.3, and 7 with probability 0.4. The beauty contest game has a Nash Equilibrium where every player selects 0.[15] Although the $1-10$ game has a mixed strategy equilibrium, the beauty contest is a more complicated game. First, there are several opponents in the beauty contest game, whereas there is only a single opponent in the $1-10$ game. Second, the best response in the $1-10$ game is obvious: select one fewer than your opponent. This is in contrast to the beauty contest where the best response is less straightforward. Finally, there are many decision rules in the beauty contest: the pure strategy Nash Equilibrium or successive elimination of dominated strategies. By contrast, in the $1-10$ game there is only a single decision rule: select one fewer than your opponent. This is because the game possesses neither a pure strategy Nash Equilibrium nor a dominated strategy.

Finally, note that we do not load the subjects during the instructions of the $1-10$ game and the beauty contest game because this could reduce the comprehension of the instructions.[16]

3 Results

3.1 A preliminary look at the cognitive load effects

The subjects reported a significant difference in the difficulty in recalling the large number ($M = 5.93$, $SD = 1.23$) and the small number ($M = 6.83$, $SD = 0.52$) according to a Wilcoxon signed-rank test, $W = 6798.5$, $p < 0.001$. There are also significant differences between the treatments in the length of time which they spent committing the number to

[15] A reviewer pointed out that there is another equilibrium which results from the discrete nature of the action space. In this equilibrium, every player selects 0.5.

[16] We acknowledge that this design leaves open the possibility that the subject could decide on an action during the instruction stage, thereby reducing the efficacy of the cognitive load.

memory. Recall that the subjects were given up to 15 seconds in order to commit the number to memory.[17] The low load subjects had significantly more of the 15 seconds remaining ($M = 12.80$, $SD = 2.96$) than the high load subjects ($M = 4.83$, $SD = 4.27$), according to a Wilcoxon-Mann-Whitney rank-sum test $Z = 46.70$, $p < 0.001$. The subjects were each given 12 incentivized memorization tasks, 6 as high load and 6 as low load. Subjects in the low load were correct in 99.03% (1830 of 1848) of the attempts and the subjects in the high load were correct in 96.75% (1788 of 1848) of the attempts.[18]

Despite these differences between the treatments, we do not find evidence that the subjects in the high load treatment were unusually impaired. Recall that we posed 2 simple, unincentivized arithmetic questions to each subject, one under a high load and one under a low load. Given 616 arithmetic questions, only 21 incorrect responses were given, 14 under the high load and 7 under the low load. These are not significantly different ($\chi^2(1) = 2.42$, $p = 0.12$). Thus, we do not find evidence that the high load significantly impaired the subjects.

3.2 The 3×3 games

We first examine the relationship between cognitive load and a basic measure of the sophistication: whether the subjects played a best response to their stated beliefs. In the analysis which follows, the dependent variable obtains a value of 1 if the subject played a best response to their beliefs, and a 0 otherwise.

Since the 3×3 games vary in their complexity, we include a two such measures. One independent variable specifies the number of the subject's own dominated strategies. This variable ranges from 0 to 2. Another independent variable specifies the number of the dominated strategies of their opponent. This variable also ranges from 0 to 2.

We account for the load by employing a high load dummy variable, which obtains a value of 1 if the subject was under a high load and a 0 otherwise. Additionally, we include a dummy

[17] The z-Tree output specified the time remaining when the Click to Proceed button was pressed. However, there were instances where the output suggested that the decision was made with 99999 seconds remaining. This output seems to have occurred if the "Click to Proceed" button was pressed before the clock could begin. In the stage in which the number was given to the subjects, we recoded the 3 instances of the 99999 output as 16, because 15 seconds were allotted.

[18] According to a chi-square test, these are significantly different, $\chi^2(1) = 23.10$, $p < 0.001$

variable indicating whether the subject had taken a game theory course, whether the subject reported being an economics major, and whether the subject is female. We refer to this collection of variables as *Demographics*. We also account for self-reported GPA. Recall that GPA is optional and only 216 of 308 subjects provided a response.

Finally, we include controls for the information given to the subject. In particular, we control for the case where the subject was not given any information about their opponent, whether the subject was told that their opponent was under a high load or whether the subject was told that their opponent was under a low load. From this categorical variable, we are able to determine the behavioral effect of the information about the load of the opponent. We can therefore estimate the difference in behavior for subjects who were told that their opponent was under a high load and those who were told that their opponent was under a low load. We perform this difference for three conditions: all subjects who were told the load of their opponent, only high load subjects who were told the load of their opponent, and only low load subjects who were told the load of their opponent. We present the estimates these differences at the bottom of the summary of the analysis.

Since we have 10 observations for every subject, we employ a repeated measures analysis. We estimate an exchangeable covariance matrix, clustered by subject. In other words, we assume a unique correlation between any two observations involving a particular subject. However, we assume that observations involving two different subjects are statistically independent. The regressions are estimated using Generalized Estimating Equations (GEE). Since GEE is not a likelihood-based method, Akaike's Information Criterion is not available. Therefore, we provide the Quasilikelihood information criterion (QIC).[19] We summarize this analysis in Table 1.

[19] For more on QIC, see Pan (2001).

Table 1 Repeated measures regressions: Best response to stated beliefs

	(1)	(2)	(3)
High load	0.0551	0.0622	0.0607
	(0.187)	(0.188)	(0.226)
Own dominated strategies	0.487***	0.492***	0.563***
	(0.0704)	(0.0709)	(0.0881)
Other dominated strategies	−0.0421	−0.0432	−0.0779
	(0.0591)	(0.0597)	(0.0757)
High load*Own dominated strategies	−0.167**	−0.169**	−0.231**
	(0.076)	(0.0765)	(0.0907)
High load*Other dominated strategies	0.0327	0.0339	0.0295
	(0.0891)	(0.0900)	(0.114)
Self-reported GPA	–	–	0.307**
			(0.124)
Demographics	*No*	*Yes*	*Yes*
Observations	3080	3080	2160
QIC	3812.39	3789.93	2639.42
Informed that opponent is high load minus opponent is low load	−0.344***	−0.349***	−0.388***
	(0.117)	(0.117)	(0.136)
Informed that opponent is high load minus opponent is low load for high load subjects	−0.370**	−0.383**	−0.404**
	(0.151)	(0.153)	(0.185)
Informed that opponent is high load minus opponent is low load for low load subjects	−0.317*	−0.315*	−0.373*
	(0.178)	(0.179)	(0.203)

The repeated measures regressions estimate an exchangeable covariance matrix, clustered by subject. We do not provide the estimates of the intercepts, the individual demographics variables, or the covariance estimates. Regressions (1) and (2) have 3080 observations (308 subjects in 10 periods) and regression (3) has 2160 observations (216 subjects in 10 periods). QIC refers to the Quasi-likelihood information criterion. The bottom three terms provide the estimates of the differences in behavior from being informed that the opponent was high load or low load. Finally, * denotes significance at $p < 0.1$, ** at $p < 0.05$, and *** at $p < 0.01$.

In all three specifications, the Own dominated strategies variable is positive and significant. In other words, subjects were more likely to best respond to their stated beliefs if there was a larger number of own dominated strategies. Further, we find that the High load-Own dominated strategies interaction is negative and significant in every specification. This implies that the high load subjects were less sensitive to the changes in the complexity of the game, as measured by the number of their dominated strategies. Also note that we find a positive relationship between Self-reported GPA and best responding to stated beliefs.

Additionally, we note that the effect of the information of the load of the subjects is negative and significant for all three estimates in each specification. This implies that subjects were less likely to best respond to their beliefs if they were told that the opponent was under a high load rather than if they were told that their opponent was under a low load. This is perhaps a consequence of the subjects having a lower confidence in their beliefs for high load rather than low load opponents. Finally, note that this difference is significant for high load subjects at 0.05 and significant for low load subjects at only 0.1.

Next we explore the relationship between cognitive load and a commonly used measure of strategic sophistication, $L2$. In the strategic sophistication literature, $L1$ subjects are defined to be those best responding to the least sophisticated $L0$ types. Typically in matrix games, the $L0$ types are assumed to select each available action with an equal probability. In our setting, this would imply that the subject selects each action with probability $\frac{1}{3}$. Further, $L2$ types best respond to $L1$ types.

In the analysis below, the dependent variable, $L2$ classification, obtains a value of 1 if the subject selected an action consistent with $L2$ behavior, and a 0 otherwise. Other than the dependent variable, the analysis is identical to that summarized in Table 1. This analysis is summarized in Table 2.

Table 2 Repeated measures regressions: $L2$ classification

	(1)	(2)	(3)
High load	-0.0075	-0.0006	-0.0614
	(0.176)	(0.177)	(0.214)
Own dominated strategies	0.612^{***}	0.618^{***}	0.666^{***}
	(0.0668)	(0.0673)	(0.0842)
Other dominated strategies	0.105^{*}	0.106^{*}	0.0427
	(0.0591)	(0.0596)	(0.0741)
High load*Own dominated strategies	-0.179^{**}	-0.180^{**}	-0.232^{**}
	(0.0767)	(0.0774)	(0.0920)
High load*Other dominated strategies	0.0600	0.0608	0.121
	(0.0837)	(0.0845)	(0.1080)
Self-reported GPA	–	–	0.217
			(0.140)
Demographics	No	Yes	Yes
Observations	3080	3080	2160
QIC	3905.04	3886.15	2718.96
Informed that opponent is high load minus opponent is low load	-0.247^{**}	-0.251^{**}	-0.240^{**}
	(0.105)	(0.106)	(0.121)
Informed that opponent is high load minus opponent is low load for high load subjects	-0.289^{**}	-0.300^{**}	-0.337^{*}
	(0.145)	(0.145)	(0.174)
Informed that opponent is high load minus opponent is low load for low load subjects	-0.205	-0.202	-0.143
	(0.159)	(0.160)	(0.188)

The repeated measures regressions estimate an exchangeable covariance matrix, clustered by subject. We do not provide the estimates of the intercepts, the individual demographics variables, or the covariance estimates. Regressions (1) and (2) have 3080 observations (308 subjects in 10 periods) and regression (3) has 2160 observations (216 subjects in 10 periods). QIC refers to the Quasi-likelihood information criterion. The bottom three terms provide the estimates of the differences in behavior from being informed that the opponent was high load or low load. Finally, * denotes significance at $p < 0.1$, ** at $p < 0.05$, and *** at $p < 0.01$.

For games which are less complex, as measured by the number of the subjects' own dominated strategies, the subjects were more likely to select the $L2$ action. However, high load subjects were less sensitive to the number of their own dominated strategies. We also note that, unlike the previous analysis, here the GPA variable is not significant.

We are also able to examine the effect of the information about the load of the opponent. The estimates for the high load subjects are negative and significant. In other words, high load subjects were less likely to play the $L2$ action if they were told that their opponent was under a high load rather than a low load. On the other hand, the estimates for the low load subjects are not significant. In other words, there is no evidence that the low load subjects conditioned their action on the information of the load of their opponent.[20]

Now rather than analyze actions, we analyze beliefs. One measure of the sophistication of beliefs is whether the subject expressed beliefs that their opponent would play their Nash equilibrium action. In the analysis below, the dependent variable, Nash beliefs, obtains a value of 1 if the subject reported the belief that their opponent would play their Nash action, and a 0 otherwise. Other than the dependent variable, the analysis is identical to that summarized in Tables 1 and 2. We summarize this analysis in Table 3.

Table 3 Repeated measures regressions: Nash beliefs

	(1)	(2)	(3)
High load	0.258	0.265	0.237
	(0.235)	(0.236)	(0.282)
Own dominated strategies	0.310***	0.311***	0.330***
	(0.0546)	(0.0550)	(0.0627)
Other dominated strategies	0.908***	0.913***	0.900***
	(0.0744)	(0.0749)	(0.0913)
High load*Own dominated strategies	−0.198**	−0.199**	−0.217**
	(0.0838)	(0.0843)	(0.0983)
High load*Other dominated strategies	0.152	0.153	0.149
	(0.0945)	(0.0949)	(0.1164)
Self-reported GPA	−	−	0.403***
			(0.148)
Demographics	*No*	*Yes*	*Yes*
Observations	3080	3080	2160
QIC	3684.46	3677.35	2590.92
Informed that opponent is high load minus opponent is low load	−0.082	−0.086	−0.186
	(0.112)	(0.112)	(0.128)
Informed that opponent is high load minus opponent is low load for high load subjects	−0.291*	−0.302**	−0.355*
	(0.153)	(0.154)	(0.193)
Informed that opponent is high load minus opponent is low load for low load subjects	0.127	0.129	−0.0166
	(0.168)	(0.169)	(0.192)

The repeated measures regressions estimate an exchangeable covariance matrix, clustered by subject. We do not provide the estimates of the intercepts, the individual demographics variables, or the covariance estimates. Regressions (1) and (2) have 3080 observations (308 subjects in 10 periods) and regression (3) has

[20] We note that the above analysis with Nash equilibrium actions, rather than $L2$ actions, is qualitatively similar to that presented above, however the estimates of the effect of the information of the load of the opponent is not significant for either high or low load subjects.

2160 observations (216 subjects in 10 periods). QIC refers to the Quasi-likelihood information criterion. The bottom three terms provide the estimates of the differences in behavior from being informed that the opponent was high load or low load. Finally, * denotes significance at $p < 0.1$, ** at $p < 0.05$, and *** at $p < 0.01$.

As in the previous two analyses, we find evidence that subjects were sensitive to the number of their own dominated strategies and that high load subjects were differentially insensitive to this feature. Additionally, we find that the GPA variable is positive and significant.

We also analyze the effect of the information about the load of their opponents on their stated beliefs. We find evidence that high load subjects were less likely to express Nash beliefs if their opponent was under a high load rather than under a low load. However, we do not find evidence of the analogous relationship for low load subjects.

We summarize our findings from the 3×3 games. We find that high load subjects were less able to make computations as they were less sensitive than low load subjects to the complexity of the game, as measured by the number of their own dominated strategies. This lack of sensitivity was measured by the likelihood of best responding to their stated beliefs, the likelihood of selecting the $L2$ action, and the likelihood of reporting the belief that their opponent would play their Nash equilibrium action. In this regard, the high load subjects were less sophisticated than low load subjects. On the other hand, we find that high load, not low load subjects, better conditioned their responses on the information about the load of their opponent. In this regard, the high load subjects were more sophisticated than low load subjects.

3.3 The $1 - 10$ game

Recall that the $1 - 10$ game is relatively simple and provides a straightforward measure of strategic sophistication. It would seem natural that the least sophisticated subject ($L0$) would select 10. The subject who best responds to the $L0$ subjects ($L1$) would select 9. The subject who best responds to $L1$ subjects ($L2$) would select 8, and so on. As such, the response is negatively associated with the strategic sophistication of the subject.

Now we examine behavior in the $1 - 10$ game. Recall that in one condition, which we refer to as the *No information* condition, subjects were not told the load of their opponent. In the other condition, which we refer to as the *Information* condition, subjects were told the load of their opponent. As the response in the $1-10$ game was bounded above at 10 and below at 1, we perform tobit regressions with the action as the dependent variable, subject to these bounds.[21] We include a dummy variable indicating whether the $1-10$ game was played under a high load. We also consider the demographic variables and the self-reported GPA. In the first two regressions, we restrict attention to the No information condition. In the last two regressions, we restrict attention to the Information condition. In the Information regressions, we include a dummy variable indicating whether the subject was told that their opponent was under a high load, and the interaction of this dummy with their own load. We summarize this analysis in Table 4.

Table 4 Tobit regressions: Choice in the $1-10$ game

	No information		Information	
	(1)	(2)	(3)	(4)
High load	-0.631^{**}	-0.526^{*}	-0.606	-0.767
	(0.286)	(0.308)	(0.493)	(0.604)
Self-reported GPA	–	0.210	–	0.610
		(0.391)		(0.561)
Told opponent high load	–	–	0.00985	-0.195
			(0.491)	(0.611)
Told opponent high load*High load	–	–	0.570	0.872
			(0.696)	(0.867)
Demographics	*Yes*	*Yes*	*Yes*	*Yes*
Observations	164	112	144	104
-2 Log Likelihood	597.84	383.06	546.42	395.19

The tobit regressions are performed with an upper bound of 10 and a lower bound of 1. We do not provide the estimates of the intercepts or the individual demographics variables. Note that * indicates significance at $p < 0.1$ and ** indicates significance at $p < 0.05$.

In the No information regressions, the High load variable is negative and significant. This implies that in the sessions where the subjects were not given information about the load of

[21] We run tobit regressions since 28 of the 164 subjects in the No information condition selected the upper bound of 10 and 2 selected the lower bound of 1. Additionally, 29 of the 144 subjects in the Information condition selected the upper bound and 1 selected the lower bound.

their opponent, high load subjects selected a more sophisticated response. However, in the Information regressions, the High load variable is not significant. Therefore, we cannot conclude that there is a relationship between the load and behavior in the Information condition.

We also note that the GPA variable is not significant in either treatment. From this we infer that $1-10$ choice is not associated with a measure of cognitive ability. Also, in the Information regressions, the variables related to the load of the opponent are not significant. Therefore, we do not find evidence that the information of the load of the opponent affected behavior.

Whereas Table 4 presents an analysis restricted to one of the two information conditions, below we consider them together. As we did not find evidence that information about the opponent's load was related to behavior, we do not include it in the analysis summarized below. However, we do include a variable indicating whether the decision was made in the Information condition or not. We summarize this analysis in Table 5 below.[22]

Table 5 Tobit regressions: Choice in the $1-10$ game

	(1)	(2)	(3)	(4)
High load	-0.477^{**}	-0.624^{**}	-0.641^{**}	-0.537
	(0.223)	(0.305)	(0.304)	(0.363)
Self-reported GPA	–	–	–	0.411
				(0.336)
Information condition	–	-0.168	-0.205	-0.197
		(0.316)	(0.314)	(0.362)
Information condition*High load	–	0.315	0.353	0.218
		(0.446)	(0.445)	(0.520)
Demographics	*No*	*No*	*Yes*	*Yes*
Observations	308	308	308	216
-2 Log Likelihood	1155.01	1154.51	1148.44	789.02

The tobit regressions are performed with an upper bound of 10 and a lower bound of 1. We do not provide the estimates of the intercepts or the individual demographics variables. Note that * indicates significance at $p < 0.1$ and ** indicates significance at $p < 0.05$.

Again, we note that the GPA variable is not significant. Additionally, the variables associated with the Information condition are not significant. However, we find evidence that

[22] We run tobit regressions because 57 of the 308 subjects selected the upper bound of 10 and 3 selected the lower bound of 1.

the subjects under a high load gave a significantly lower response in the $1-10$ game. In regressions (1), (2), and (3), the High load variable is negative and significant. To the extent that smaller responses are associated with a greater strategic sophistication, this is consistent with the contention that the high load subjects were more strategic than low load subjects in the $1-10$ game.

3.4 The beauty contest game

Recall that lower responses in the beauty contest are associated with greater strategic sophistication. Also recall that choice in our beauty contest was bounded above by 10 and below by 0. Therefore, we run tobit regressions with choice in the beauty contest as the dependent variable, subject to these bounds.[23] In the information condition for the beauty contest, the subjects were simply reminded of the distribution of the loads within the session. As a result, for the Information condition regressions, we do not include a variable indicating the load of their opponent. The analysis is otherwise equivalent to that summarized in Table 4. We summarize this analysis in Table 6.

Table 6 Tobit regressions: Choice in the beauty contest game

	No information		Information	
	(1)	(2)	(3)	(4)
High load	0.625	0.933**	−0.716**	−0.762**
	(0.384)	(0.432)	(0.329)	(0.382)
Self-reported GPA	–	−2.076***	–	−0.0842
		(0.547)		(0.507)
Demographics	*Yes*	*Yes*	*Yes*	*Yes*
Observations	164	112	144	104
-2 Log Likelihood	742.74	490.19	600.92	431.48

The tobit regressions are performed with an upper bound of 10 and a lower bound of 0. We do not provide the estimates of the intercepts or the individual demographics variables. Note that ** indicates significance at $p < 0.05$, and *** indicates significance at $p < 0.01$.

[23] Despite that in our sample, only 8 subjects selected the upper bound and none selected the lower bound, we run tobit regressions. We do so in order to facilitate the comparision to the analysis of the $1-10$ behavior. Further, the tobit analysis is similar to that with an OLS specification. The OLS analysis is available from the corresponding author upon request.

In regression (2) of the No Information regressions, the High load variable is positive and significant. This suggests that subjects in the No Information condition under the high load were less strategic than subjects under a low load. We also note that the GPA variable in the No Information regression is negative and significant. In regressions (3) and (4), the High load variable is negative and significant. This suggests that subjects in the Information condition under high load were more strategic than subjects under a low load. We finally note that the GPA variable is not significant in the Information regressions.

In order to get an overview of all of the data, as with Table 5, we run an analysis of the sessions together. Therefore, we perform an analysis nearly identical to that presented in Table 5. We summarize this analysis in Table 7.

Table 7 Tobit regressions: Choice in the beauty contest game

	(1)	(2)	(3)
High load	0.655*	0.644*	0.788*
	(0.356)	(0.357)	(0.418)
Self-reported GPA	–	–	−1.057***
			(0.387)
Information condition	0.354	0.328	0.267
	(0.368)	(0.368)	(0.432)
Information condition*High load	−1.316**	−1.321**	−1.467**
	(0.520)	(0.520)	(0.598)
Demographics	*No*	*Yes*	*Yes*
Observations	308	308	216
-2 Log Likelihood	1366.33	1362.66	941.87

The tobit regressions are performed with an upper bound of 10 and a lower bound of 0. We do not provide the estimates of the intercepts or the individual demographics variables. Note that * indicates significance at $p < 0.1$, ** indicates significance at $p < 0.05$, and *** indicates significance at $p < 0.01$.

First, we note that GPA is negative and significant. This implies that higher GPA subjects selected a more strategic response in the beauty contest game. We also note that the High load variable is positive and significant in all three specifications. Additionally, we note that the High load-Information condition interaction is negative and significant. This suggests that high load subjects in the Information condition were more strategic than were high load subjects in the No Information sessions. This is consistent with view that the information about the distribution of the cognitive load was used by the high load subjects but not by the low load subjects. In other words, here again we find evidence that high load subjects better used information than the low load subjects.

4 Conclusion

We have described an experiment where subjects played a sequence of games designed to measure their strategic sophistication while under a differential cognitive load. These games included ten 3×3 games, the $1 - 10$ game, and the beauty contest game. Through our single cognitive load manipulation we observed a nuanced relationship between available cognitive resources and strategic sophistication. This behavior is consistent with two effects. First, subjects under a high cognitive load had difficulty in making the computations associated with optimal play. Second, subjects under a high load were aware that they were relatively disadvantaged in the cognitive ability distribution. The net result of these effects depended on the strategic setting.

We see the first effect dominating the second effect when, in the relatively complicated beauty contest game, the high load subjects played less strategically.[24] This behavior is consistent with the diminished ability of subjects to compute the optimal strategy in this complicated setting. Additionally, we see this effect in that the subjects in the 3×3 games were less sensitive to the complexity of the game, as measured by the number of their own dominated strategies. We observe this differential sensitivity in the likelihood of best responding to stated beliefs, the likelihood of observing L2 behavior, and the likelihood of stating beliefs that their opponent will play their Nash equilibrium action.

On the other hand, we see the second effect dominating the first effect when, in the relatively uncomplicated $1-10$ game, the subjects selected a more strategic response, expecting to be paired with a more cognitively able subject. We also find that high load subjects, better than low load subjects, conditioned their behavior on the load of their opponent. For instance in the 3×3 games, high load subjects made more use of the information of the load of their

[24] In support of our contention that the beauty contest is more complicated than the $1 - 10$ game, we note that GPA is related to choice in the beauty contest but not in the $1 - 10$ game.

opponents than did the low load subjects. Also in the beauty contest game, high load subjects who were reminded of the distribution of the load of their opponents selected a more strategic action than the low load subjects who were not reminded of the distribution. These results are consistent with the contention that high load subjects were more strategic than low load subjects.

We hope that this research is helpful in suggesting improvements in existing models of strategic sophistication. Our evidence suggests that constraints on cognitive resources can affect the computations involving optimal behavior but also the perception of the subjects' relative standing in the distribution of cognitive resources. Our research corroborates previous research that these two effects are important in the study of games. In particular, our results suggest that a lower measure of cognitive ability will not necessarily produce less sophisticated behavior, particularly when the ability to make the necessary computations is not a binding constraint.

We also hope that this research will encourage the use of the cognitive load manipulation in any setting in which cognition plays a crucial role in behavior. Perhaps the most obvious application of cognitive load is in the rational inattention literature.[25] Rational inattention models assume that decision makers are unable to process all available information. However, decision makers optimally allocate their limited attention. It would seem profitable to investigate these models in the laboratory, by manipulating the limits of attention via cognitive load.

We acknowledge that there is much work to be done on this topic. For instance, we were not able to observe the order in which the subjects provided their action and their beliefs in the 3×3 games. In the future, it could be profitable to observe if there is a relationship between the cognitive load manipulation and the order of the selection of actions and beliefs. We also hope to learn whether there is a differential effect of not soliciting beliefs. Perhaps the solicitation of beliefs prompts the high load subjects to be aware of the strategic considerations, where that would possibly not occur if beliefs were not solicited. We also do not know if a different

[25] See Sims (2003), Reis (2006), Mackowiak and Wiederholt (2009), Wiederholt (2010), Bordalo, Gennaioli, and Shleifer (2014), Dahremöller and Fels (2012), and Persson (2012). See Cheremukhin, Popova, and Tutino (2014) for an experiment involving rational inattention.

means of controlling for beliefs would yield lead to qualitatively similar behavior. Finally, we are interested to learn the implications of a more difficult high load (more than 9 binary digits) and a less difficult low load (less than 3 binary digits).

Appendix

In the games below, 10 points are equivalent to \$3.50. Games 1A and Game 1B: both players have 2 dominated strategies. The game is adapted from Game 1 of Bayer and Renou (2012).

Game 1A

	Left	Center	Right
Top	8, 4	5, 7	3, 6
Middle	6, 8	4, 9	1, 2
Bottom	7, 1	2, 5	2, 4

Game 1B

	Left	Center	Right
Top	2, 8	3, 1	8, 7
Middle	6, 6	4, 3	9, 5
Bottom	5, 4	1, 1	7, 3

Games 2A and 2B: one player has a dominated strategy and the other player has two. The game is adapted from Game 3 of Bayer and Renou (2012).

Game 2A

	Left	Center	Right
Top	8, 8	3, 5	1, 9
Middle	9, 2	5, 3	6, 4
Bottom	4, 1	7, 6	2, 8

Game 2B

	Left	Center	Right
Top	4, 5	6, 3	7, 7
Middle	3, 9	9, 8	2, 4
Bottom	5, 6	10, 1	9, 2

Games 3A and 3B: one player has two dominated strategies, the other player does not have any dominated strategies. The game is adapted from Game VS1R of Rey-Biel (2008).

Game 3A

	Left	Center	Right
Top	1, 9	2, 6	4, 3
Middle	4, 4	5, 4	5, 4
Bottom	7, 3	7, 5	6, 8

Game 3B

	Left	Center	Right
Top	10, 2	2, 10	7, 11
Middle	7, 3	6, 4	7, 10
Bottom	6, 6	1, 7	9, 8

Games 4A and 4B: one player has one dominated strategy, other player does not have a dominated strategy. The game, adapted from Game VS2R of Rey-Biel (2008), is dominance solvable.

Game 4A

	Left	Center	Right
Top	6, 6	4, 8	4, 9
Middle	4, 8	11, 3	3, 5
Bottom	1, 10	10, 6	3, 8

Game 4B

	Left	Center	Right
Top	11, 1	1, 8	7, 5
Middle	4, 8	4, 8	1, 11
Bottom	6, 5	5, 7	2, 5

Games 5A and 5B: neither player has a dominated strategy. The game is adapted from Game VSNDR of Rey-Biel (2008).

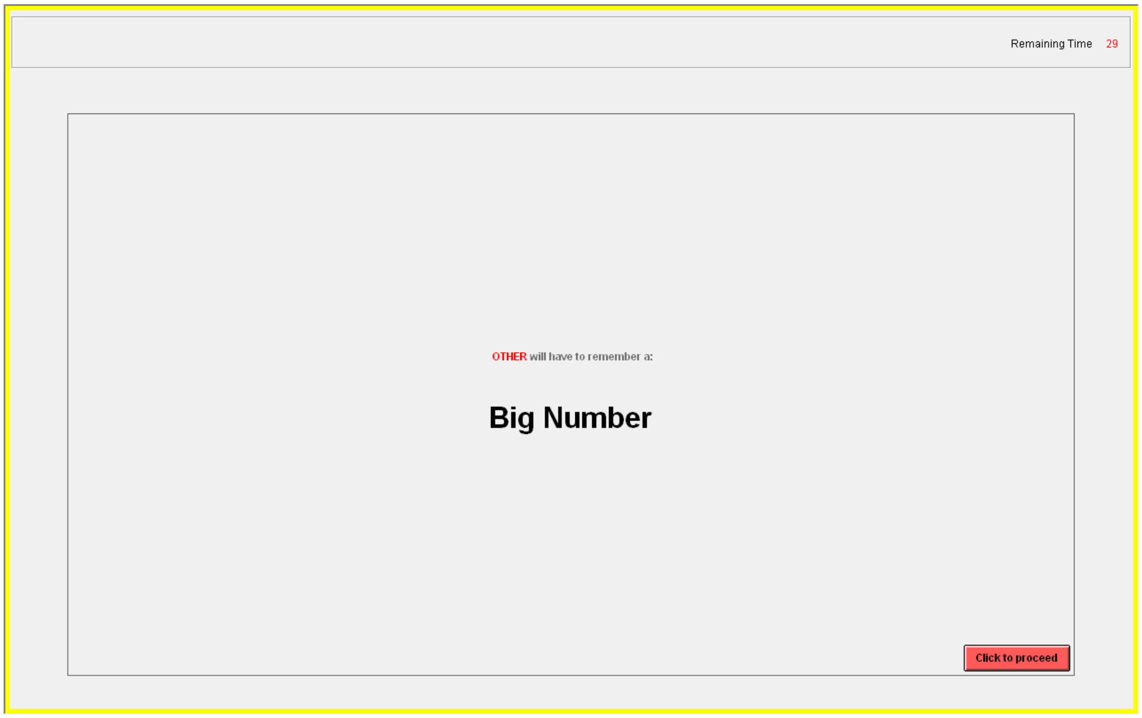
Game 5A

	Left	Center	Right
Top	8, 6	2, 6	1, 11
Middle	4, 6	7, 6	3, 6
Bottom	2, 7	2, 5	4, 4

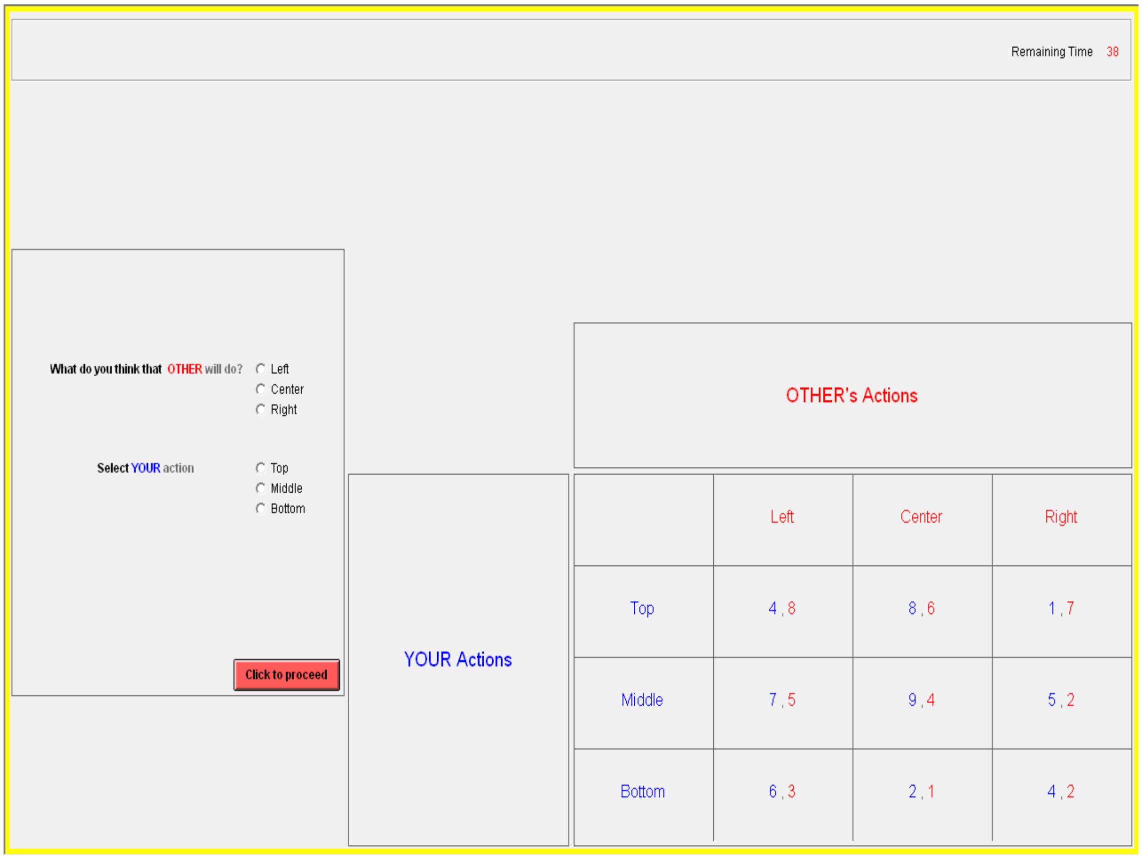
Game 5B

	Left	Center	Right
Top	3, 10	5, 5	3, 9
Middle	4, 9	2, 9	4, 9
Bottom	9, 5	3, 8	2, 7

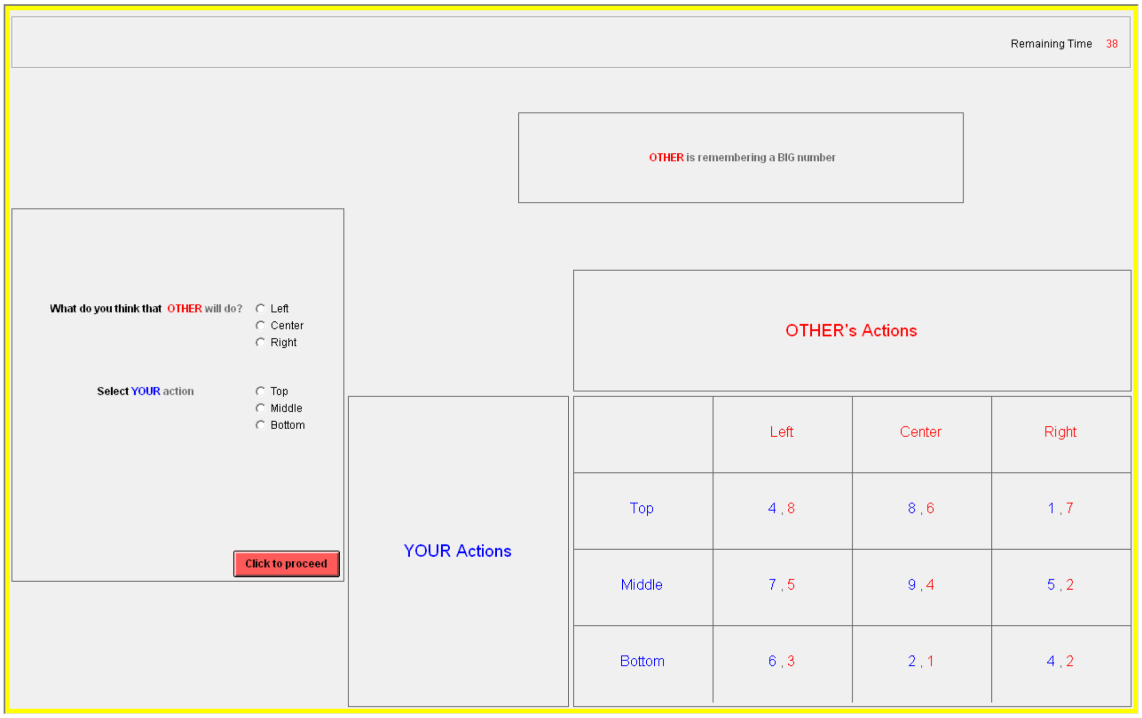
Screen indicating the load of the opponent:



The screen during 3 × 3 games without information of the load of the opponent:



The screen during 3×3 games with information of the load of the opponent:



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