Planned vs. Actual Attention

Ala Avoyan, Mauricio Ribeiro, Andrew Schotter, Elizabeth R. Schotter
Mehrdad Vaziri, Minghao Zou

August 3, 2022

Abstract

People often need to plan how to allocate their attention across different tasks. In this paper, we run two experiments to study a stylized version of this attention allocation problem between strategic tasks. More specifically, we present subjects with pairs of 2x2 games, and, for each pair, we give them 10 seconds to decide how they would split a fixed time budget between the two games. Then subjects play both games without time constraints, and we use eye-tracking to estimate the fraction of time they spend on each game. We find that subjects' planned and actual attention allocation differ and identify the determinants of this mismatch. Further, we argue misallocations can be relevant in games where a player's strategy choice is sensitive to the time taken to reach a decision.

JEL Classification: C72, C91, C92;

Keywords: Attention Allocation, Time Allocation, Eye-Tracking.

1 Introduction

People routinely plan how to split their time - and, hence, attention - between different tasks. This planning can require careful deliberation. However, we are often time constrained and, hence, have to plan quickly. This ability to plan under time pressure is crucial for many jobs, some of which require allocating attention across tasks with a strategic component. For instance, consider a sales manager that, in a given workday, has to decide the sales plan, motivate her team to implement it, and discuss the plan with other managers. When deciding the sales strategy, she has to consider the sales strategies of other companies in the market. When meeting with her team, she has to provide the right incentives to motivate them to carry out the sales strategy. When talking with other managers, she has to use her bargaining skills to get the support she needs from the other teams. If the manager's time is constrained, she has to decide how much attention to allocate to each of these different tasks.[1] Therefore, failure to correctly allocate time/attention can affect performance on the job because, as noted by Kahneman (2003), Rubinstein (2007, 2016), and others, the amount of time spent making a decision may lead to different choices.

While there has been some consideration of how people plan their time allocation —and hence their attention allocation—across non-strategic tasks (cf. Radner and Rothschild (1975)), less attention has been paid to how they allocate attention across strategic tasks, particularly when they face a time constraint. We conjecture that people allocate their time based on an (intuitive) assessment of the value and the complexity of the tasks they have to complete.[2] If the assessments are inaccurate, people may allocate too much (or too little) time to a task, which can affect the quality of their decisions.

In this paper, we study a stylized version of this attention allocation problem, namely how people allocate attention between 2x2 games.[3] We are interested in three questions:

1. **Planned versus Actual Attention**: are people good at planning their time/attention between games, i.e., is the fraction of time they plan to spend in each game similar to the fraction of

[1] There are many jobs in which a person needs to plan their schedule under a time constraint. Think of a portfolio manager that has to react to an unexpected shock that affects her clients' portfolios and, consequently, has to set up meetings with different people to discuss how to react to the shock. Or think of a physician working at an Intensive Care unit that has to plan how to allocate her time during a shift between several incoming patients.

[2] The value and complexity of a task both influence how much time one should allocate to it. For instance, suppose that the tasks in question are 2x2 games (as in this paper). If one game is strategically complex but yields tiny payoffs, while the other is strategically simple but yields huge payoffs, which of the two games should receive more time? Although we do not study such extreme cases in this paper, they are useful to illustrate the trade-offs one faces when allocating time between strategic tasks.

[3] Avoyan and Schotter (2020) study the attention allocation constraint and its effects on choice in an isolated game. Avoyan et al. (2022) study time allocation between non-strategic tasks (decision problems). We here focus on time allocation between strategic tasks (2x2 matrix games) and the individuals' ability to assess needed time accurately.

time they actually spend playing the games?

2. **Why Do Planned and Actual Attention differ**: if planned and actual time/attention allocation differ, what accounts for this difference?

3. **Time and Choice**: does time affect people's strategy choice in games, and are the effects heterogeneous? Are there games in which choices are more sensitive to the time spent reaching a decision and, for this reason, are more sensitive to time misallocation?

To address these questions, we conduct two experiments. In Experiment 1, we present subjects with different pairs of games. In each pair, we give subjects 10 seconds to decide what fraction of a fixed amount of time they want to allocate to thinking about each game. When this planning phase is over, subjects play both games in a pair without time constraints. Using eye-tracking, we estimate how much time a subject spent paying attention to a game and use this as a proxy of how much time they actually spent thinking about the game.[4] Eye-tracking also allows us to identify what features of the game attracted a subject's attention both in the planning and playing stages.

In Experiment 2, a different pool of subjects played each game presented to the subjects in Experiment 1 for 60 seconds. We use the choice process protocol introduced by Agranov et al. (2015) to track their decisions throughout the 60 seconds.[5]

Experiment 1 addresses Questions 1 and 2. We find that people are not good (instinctual) planners, i.e., they form inaccurate estimates of the fraction of time they will spend attending to each game in a pair. We show that this mismatch between planned and actual time allocations is a consequence of the fact that the salient attributes of a game (e.g., its lowest and highest payoffs) can be a poor indicator of its complexity. Since subjects are time-constrained when planning, these salient attributes crucially influence their planned attention allocations. Their actual attention allocations, however, are crucially influenced by the game's strategic complexity.

Experiment 2 addresses Question 3. We find that the time subjects spend attending a game affects their strategy choice in most but not all games we consider. In these games, therefore, time misallocation is payoff relevant.

[4] Eye-tracking data in the study of games has been used increasingly in economics. See, for instance, Knoepfle et al. (2009), Polonio et al. (2015) or Devetag et al. (2016). Meißner and Oll (2019) propose a taxonomy for the use of eye-tracking based on a synthesis of the existing eye-tracking literature, which they use to review the papers that study organizational research topics using eye-tracking.

[5] The choice process (CP) protocol allows one to elicit the whole path of a subject's best-response strategy in an incentive-compatible way (see Caplin and Dean (2011) and Caplin et al. (2011) for its theoretical work). We describe and explain the CP protocol in Section 2.2.

2 Experimental Design

As mentioned, we ran two experiments.[6] Experiment 1 (62 subjects) is the main experiment, which we use to understand the relationship between planned and actual attention and to identify what features of the games influence subjects' planned and actual time allocations. Experiment 2 (40 subjects) is an auxiliary experiment that allows us to assess the time-dependence of choices in the games played in Experiment 1.

The sessions of both experiments were conducted at the experimental lab of the Center for Experimental Social Science (CESS) at New York University during the Spring of 2018 (Experiment 1) and Fall of 2019 (Experiment 2), using the software z-Tree (Fischbacher (2007)) for Experiment 1 and the software oTree (Chen et al. (2016)) for Experiment 2. Subjects were recruited using the ORSEE recruitment program (Greiner (2015)) from the general undergraduate population. Eye-tracking data were collected via a Gazepoint 3 (GP3) eye tracker attached to the bottom of the computer screen (see Section 2.1.5 for further details).

Experiment 1 had 31 sessions with 2 subjects per session.[7] A session lasted about 40 minutes,[8] and subjects earned, on average, a payoff of \$27, which includes a \$10 show-up fee. In this experiment, the payoffs in the games were denominated in points (units) called Experimental Currency Units (ECUs). For payment, ECUs were converted to US dollars at the rate of 1 ECU = \$0.025.[9] Experiment 2 had one session that lasted approximately 50 minutes. Subjects earned, on average, a payoff of \$20, which included a \$7 show-up fee. The payoffs in the games were also denominated ECUs. For payment, ECUs was converted to US dollars at the rate of 1 ECU = \$0.01.

2.1 Experiment 1 (planned versus actual attention)

After providing consent, subjects are given written instructions, which are also read aloud. They are then introduced to the eye-tracking device and instructed to keep their heads as still as possible throughout the experiment, consisting of three parts. (The eye-tracking device, to be described in detail later, is non-intrusive and attached to the bottom of the computer monitor and hence does not involve wearing any head apparatus or placing one's head in a device to keep it still.)

[6] Instructions used in both experiments are in appendices C and D.

[7] The experimenter running the session needed to monitor the quality of the calibration during the entire session, hence we only had 2 subjects per session.

[8] This time does not include the time to calibrate subjects before they started the practice rounds of Experiment 1.

[9] The range of payoffs in the games used in this paper is between 0 to 1000 points, translating to 0 to 25 dollars.

2.1.1 Part 1

Part 1 has 12 rounds. In each round, subjects are shown a pair of 2 x 2 matrix games[10] on the computer screen for 10 seconds.[11] Subjects are then given 10 seconds to decide what fraction of a X seconds time budget they want to allocate to play each of the two games on the screen: Game 1 (on the left) and Game 2 (on the right). Since fractions must add up to 1, subjects only decide how much to allocate to Game 1. Notice that subjects do not play the games in Part 1.

Importantly, we do not reveal the value of X to subjects in Part 1. We chose not to do so because the amount of time that a subject spends playing a game can vary greatly across subjects. Hence, if we announced the value of X, some subjects would think that they have much more time than they need to solve both games, which would lead to a multiplicity of their optimal planned time allocations. For these subjects, therefore, a mismatch between planned and actual attention could not be interpreted as an incorrect time allocation, being rather a consequence of their belief that the time constraint they will face when playing the games is not binding.

We denote by α_{ik} **the fraction of time allocated by subject** i **in game pair** $k \in \{1, 2, ..., 12\}$ **to Game 1** (i.e., to the game on the left side of the screen). Therefore, $1 - \alpha_{ik}$ denotes **the fraction of time allocated by subject** i **in game pair** $k \in \{1, 2, ..., 12\}$ **to Game 2** (i.e., to the game on the right side of the screen).

To ensure that subjects understand how to read a game matrix and to familiarize them with the 10-second time constraint, they play three practice rounds before being presented with the 12 game pairs we are interested in. In the first practice round, subjects are presented with a pair of 2x2 matrix games containing letters in the place of payoffs (the screen is the same as in Figure 5a). In the two remaining practice rounds, subjects are presented with a pair of 2x2 matrix games containing 3-digit numbers as payoffs (see Figure 6a). In all practice rounds, subjects have 10 seconds to look at the game pair. After the 10 seconds, a new screen appears in which subjects are asked to state the fraction of X they want to allocate to Game 1 by inputting a number from 0 to 100 (see Figure 5b). The remaining fraction is then allocated to Game 2. After three practice rounds, the same steps are repeated in each of the 12 (non-practice) rounds of Part 1.

[10] The games used in the experiment represent a broad class of 2x2 games, including Prisoners' Dilemma (PD), Symmetric and Asymmetric Mixed Strategy games (MS), Games of Chicken (Ch), Battle of the Sexes (BoS), and others. The full list of games and game pairs presented to the subjects are in Appendix A.1.

[11] We gave subjects 10 seconds to plan their time allocation so to prevent them from solving both games in a pair since, if they did, their time allocation would be irrelevant. Although ex-ante we did not know that 10 seconds was a suitable amount of time, the average amount of time a subject spends playing a game is (roughly) 8 seconds. Therefore, on average, a subject needs 16 seconds to solve both games in a pair. Hence, the 10 seconds time constraint is below the average amount of time they need to solve both games, which is consistent with our goal. See Appendix A.1 Table 5 for the average amount of time spent playing each game.

2.1.2 Part 2

Part 2 provides incentives for subjects' time allocation decisions in Part 1. In Part 1, we tell subjects that, in Part 2, they will play both games from one of the game pairs under the time constraints implied by the fraction of time they allocated to each game in the pair. Importantly, we do not yet tell them which game pair will be selected (nor, as mentioned, what the value of X is).

At the beginning of Part 2, we reveal the selected game pair, namely Game Pair 1, and tell them they will have 90 seconds to play both games in the pair. (Game Pair 1 is then excluded from Part 3 of the experiment.) If (say) a subject allocated 40% of X to Game 1 in Game Pair 1 in the first part of the experiment, in Part 2, she would have 36 seconds to play Game 1 and 54 seconds to play Game 2. Time is not transferable in Part 2: if a subject has 36 seconds to play Game 1, but she enters her choice at the 30th second, the six remaining seconds are not added to the 54 seconds allocated to Game 2.

2.1.3 Part 3

In Part 3, subjects play the remaining 11 pairs ($k \in \{2, 3, ..., 12\}$) of games *without time constraints*. First, the subjects play game pairs 2, 3, and 4 in random order. Then, the subjects play the remaining game pairs ($k \in \{5, 6, ..., 12\}$) in random order. The order in both cases is randomized at the subject level. This (block) randomization scheme allows us to test whether the repetition of some games affects our main results. Notice that a subject plays Game Pair 1 in Part 2 and Game Pairs 2, 3, and 4 in Part 3, they have not played any game twice. Hence, if the repetition of a game affects our results, it will not affect the results for Game Pairs 2, 3, and 4.

In Part 3, the games in a game pair are displayed in the order on the screen as in Part 1, i.e., if a game in a game pair was displayed on the left in Part 1, it will also be displayed on the left in Part 3.[12] Moreover, subjects are no longer time constrained: they can take as much time as they want to examine the games and make their strategy choices. Once they are done attending to the two games, they hit a button that brings them to a new screen. On this new screen, they enter their strategy choices by clicking the corresponding A or B buttons in each game of the game pair (see Figure 6b for a sample screen).

2.1.4 Payments

The subjects' payoffs in Experiment 1 are determined by their strategy choices in two randomly drawn games, one from Game Pair 1 played in Part 2 and the other from a game pair played in

[12] We could have made subjects play each game in a game pair sequentially in Part 3 and recorded their response time as their actual time. Further studies could examine what would change in our results under this alternative protocol. Since, however, the primary goal of the experiment is to compare planned allocation in Part 1 to actual allocation in Part 3, we chose to keep Parts 1 and 3 as similar as possible. By doing so, we guarantee that any differences between planned and actual time allocation cannot be attributed to a change in how the game pairs are presented.

Part 3. A critical feature of the payment scheme we use is that subjects in Experiment 1 are told that they are not playing these games against other subjects in the current experiment. Instead, they are playing against a "previous opponent" who played the game without any time constraints in an auxiliary experiment.[13] For each game, we randomly picked a subject from this auxiliary experiment and her choice was assigned as the column player choice in Experiment 1. Therefore, a subject's payoff in Experiment 1 is determined by their strategy choice and the strategy choice of one of these column players. We introduce this "previous opponent" because we do not want our subjects to try to predict their opponent's time allocation and consequently best respond to it, engaging in a complicated time allocation game.[14] Therefore, we attempt to preempt this possibility by using the choices of an outside opponent that is not time-constrained.

This payment scheme can, however, lead to a different problem. A subject's choice can be biased if she knows that her choice does not influence the payoff of any other subject in the same session. For example, a pro-social subject might choose a non-pro-social strategy since she knows that no one is affected by her actions. To avoid such effects, we randomly divide the subjects in a session into two groups: Group 1 and Group 2. Each subject in Group 1 is matched with a subject in Group 2. The payoffs of a subject in Group 1 is determined by her choices and her outside opponents' choice. The subject in Group 2 she is matched with then receives the payoff of the outside opponent. This procedure ensures that although subjects play against an outside opponent, whose payment they cannot affect, their choice will influence the payoffs of a subject in the same session.

2.1.5 Eye-tracking procedure and data in Experiment 1

We use the Gazepoint 3 (GP3) eye-tracker, along with corresponding software Gazepoint Control and Gazepoint Analysis, to calibrate subjects and collect eye-tracking data. GP3 specifications include 0.5-1 degree of visual angle accuracy, 60 Hz update rate, 25 cm x 11 cm (horizontal x vertical) movement, and ± 15 cm range of depth movement.

During the experiment, subjects sit in front of a computer with a 19" screen placed directly in front of them with the eye-tracker mounted below the monitor. They are told that the eye-tracker would track their eyes and that they should keep their head as still as possible during the experiment. Other than that, the eye tracker is unobtrusive, and the subjects are not fixed in any way (e.g., we did not use a chin rest).

[13] In this auxiliary experiment, we had students in an undergraduate class at NYU choose a strategy in each of the games without any time constraint (these subjects played these games against each other, and they were assigned to be either row or column choosers).

[14] Konovalov and Krajbich (2019) and Frydman and Krajbich (2022) argue that response time contains additional information beyond the realized choice. They argue that subjects extract information about the other player's signal strengths' depending on the speed of their decision.

The camera inside the GP3 turns on as soon as we start Gazepoint Control to perform a subject's calibration. We calibrated the subjects once before the experiment started. During the experiment, a research assistant tracked the subject's eyes on a separate laptop. If there were any issues with eye-tracking, the research assistant would re-calibrate the subject.[15]

For each game pair, we first define two areas of interest (AOI). We partitioned the entire screen into two AOIs. One of these covers the entire game on the left, and the other covers the entire game on the right. In addition, we defined 16 AOIs centered over the 16 payoffs of the games in the pair (Figure 7a). Therefore, each cell in the game matrix contains two areas of interest, centered on the row and column players' payoff. AOIs around the payoff do not overlap and do not cover the entire matrix area. To answer our research questions, we record each subject's *dwell time* in an AOI, i.e., the total amount of time the subject spent looking at the AOI.[16]

As mentioned, we use eye-tracking in Experiment 1 to: (i) estimate the amount of time that people spend playing a game in Part 3; (ii) keep track of what features of the game attract the subject's attention in Parts 1 and 3. Eye-tracking data can be used for (i) and (ii) provided we assume that the time spent looking at a (feature of the) game is an adequate proxy for the amount of attention allocated to that (feature of the) game. The main objection to this assumption is that subjects can engage in parallel processing, i.e., they can stare at an AOI while thinking about something else. Although parallel processing cannot be ruled out, it does not seem as relevant in our setting because subjects need to read the games on the screen to process them. Moreover, even if a subject engages in parallel processing, provided that the time she spends in parallel processing is game-independent and increases in the time looked at a game, our main results remain valid.[17]

2.2 Experiment 2 (time-dependence of choice)

After providing consent, subjects are given written instructions, which are also read aloud. Subjects are then presented with the 19 games used in Experiment 1.[18] Each game is displayed separately on a computer screen for one minute. To keep track of the strategy choices of our subjects as they think about a game, we employ the choice process (CP) protocol introduced in Agranov et al.

[15] A subject's calibration process requires that the subject follow a dot on the screen. We used a 9-point calibration, i.e., the dot moves to 9 different points on the screen, and the subject is asked to follow the dot. We then check the accuracy of the movement before moving to the next steps. We only re-calibrated subjects in two sessions.

[16] In addition, we recorded the following transitions between AOIs: the number of times a subject's fixation moved to a different AOI in the same game and the number of times a subject's fixation moved from one game to the other.

[17] We could have avoided the potential distortions that parallel processing might introduce by presenting the games sequentially in Part 3 instead of simultaneously. As already argued, however, we wanted to make Parts 1 and 3 as similar as possible so that the differences in time allocation were not driven by differences in the presentation of the game pairs between Parts 1 and 3.

[18] Due to a programming error, Game 16 from Experiment 1 was coded as Game 16′ in Experiment 2 (see Appendix 4). We exclude these games from our calculations whenever the difference is relevant.

(2015).

In the CP protocol, subjects can select a strategy in the game —here, strategies A and B— by clicking a button with that label (see Figure 7b). The key feature of the protocol is that subjects can change their selection at any point during the 60 seconds.[19] On the screen, there is a timeline that depicts their choice history. To incentivize subjects to select their optimal strategy at each point in time, if a game is selected for payment, then we randomly choose a point in time and use their strategy choice at that point in the game to determine their payoff. Therefore, the CP protocol reveals the subject's chosen strategy in the game at each point in time.

Subjects' earnings in the experiment are given by the sum of their payoffs in four randomly drawn games. In each of these randomly drawn games, 1 second was randomly drawn and the strategy that the subject chose at that point in time was selected as the subject's choice in the game.[20] Similarly to Experiment 1, the strategy of a subject's opponent was the choice of an outside subject who played these games in a previous experiment without time constraints.

2.3 Comparison to Avoyan and Schotter (2020)

This paper is related to Avoyan and Schotter (2020) (henceforth, AS2020). AS2020 argue that the attention a person spends on a problem depends on what other problems the person is attending to. In particular, the more attention one pays to a game, the less attention is left to the other games. Consequently, if a person is playing different games, the choice that she makes in a game depends on the other games she is playing because these games are connected via the attention constraint. AS2020 then investigate what payoff features of the games determine the person's attention allocation across these games. In doing so, they introduce an elicitation method for planned attention, which we use in this paper.

Our research questions are, however, different from AS2020. We are interested in whether people, in fact, implement their planned attention allocation, i.e., whether their actual attention allocation coincides with their planned attention allocation. Although we use eye-tracking primarily to infer people's actual attention allocation, it also allows us to observe what features of the game people pay attention to.

Given that they address different questions, AS2020 and our paper use different criteria to select the set of games that are studied. While AS2020 require a large number of games and

[19] Subjects can change their choice without a cost as many times as they want, but they cannot see any additional information, e.g., their opponent's choice. A growing literature studies choice updating with and without frictions as subjects observe opponents' choices over time in various games. See, for example, Deck and Nikiforakis (2012), Friedman and Oprea (2012), Oprea et al. (2014), He and Zhu (2020), Avoyan and Ramos (2022). In these papers, however, subjects do receive information about their opponents' choices.

[20] If no choice had been made in the selected second, which could only occur in the time before the first choice was made, the subject's payoff in that game is zero.

controlled pairwise comparisons between the games to identify the features of the games that influence a subject's planned attention allocation,[21] we study a variety of games precisely to avoid that subjects play the same game many times, which can bias our estimate of the subject's actual attention in the game. We then chose to study games from some canonical game classes (such as Prisoner's Dilemma and the Battle of the Sexes games) because they are routinely faced by people and, hence, have been thoroughly studied, both theoretically and experimentally.[22]

Importantly, AS2020 and our paper share four game pairs. In two of these game pairs, the games are displayed in the same order on the screen. In the two other game pairs, the games are displayed in reverse order on the screen. When we examine the planned attention allocation in these pairs, we find that subjects' behavior in these pairs is statistically indistinguishable across the two papers, which suggests that the use of eye-tracking and the position of the games on the screen do not influence subjects' planned attention allocations.

3 Results

Using eye-tracking data from Part 3 of Experiment 1, we calculate, for each subject i and every game pair k, **the fraction of time subject i spent looking at Game 1 in game pair k**, which we denote by β_{ik}. Therefore, β_{ik} measures subject i's *actual attention* on Game 1 in game pair k. Recall that α_{ik} measure subject i's *planned attention* on Game 1 in game pair k. Therefore, we can study the (mis)alignment between planned and actual attention by comparing α_{ik} and β_{ik}.

Planned and Actual Attention: *Are decision makers good at planning their attention, i.e., are α_{ik} and β_{ik} similar?*

Figure 1 presents the scatter plots between α_{ik} and β_{ik} for each game pair separately and for all game pairs pooled together. Regarding the latter (last graph in Figure 1), we see no correlation between planned and actual attention in the aggregate. The correlation between planned and actual attention is also small for each game pair: its absolute value is below .2 and is not statistically significant.[23] Therefore, subjects do not accurately anticipate the fraction of time they will spend playing the games in a game pair.

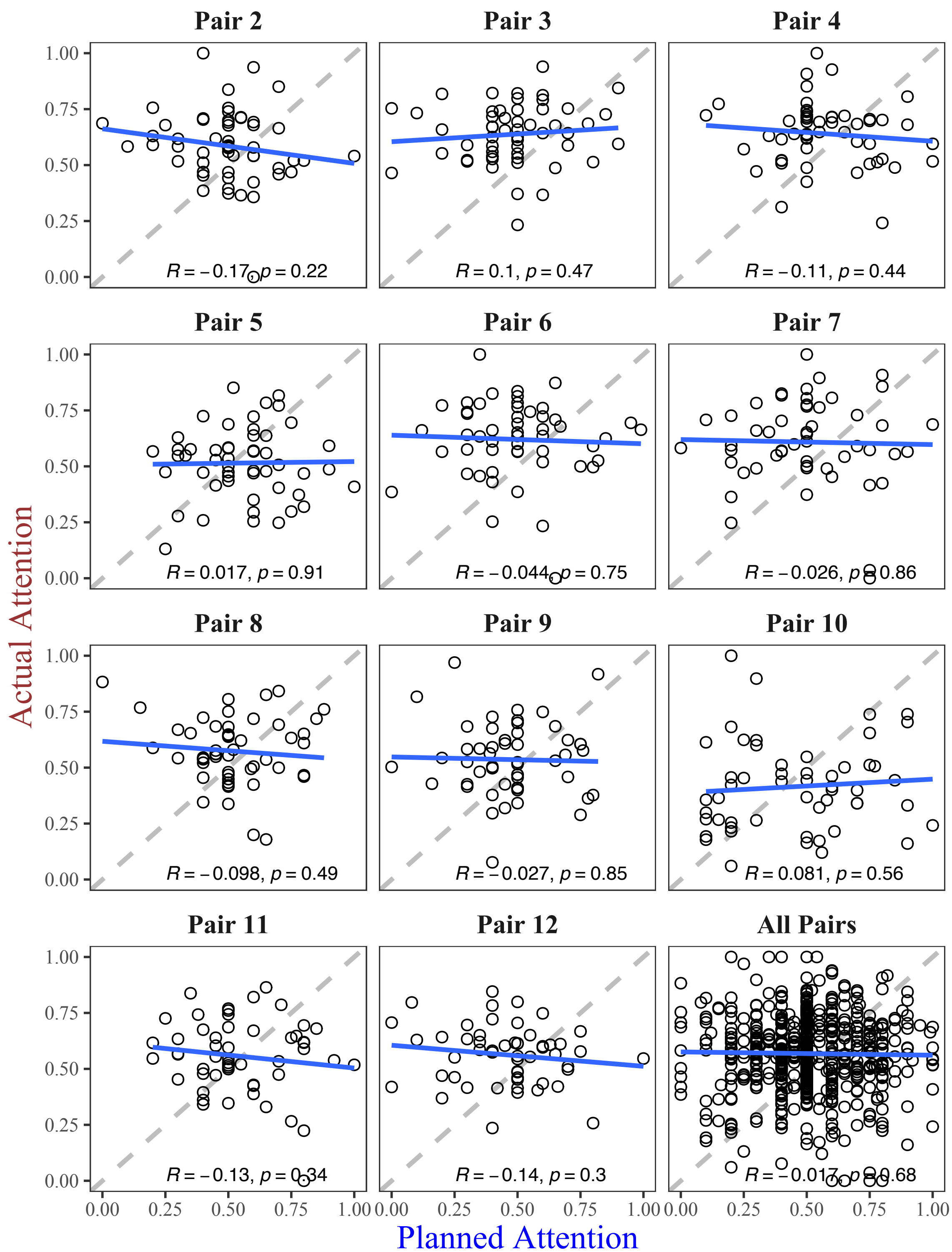
Moreover, this mismatch between planned and actual attention is not driven by a few subjects that are particularly bad at anticipating the fraction of time they will spend playing each game in a game pair. In fact, we plot in Figure 2a the distribution of subjects' average *error magnitude*,

[21] AS2020 study 34 games and 125 comparisons (120 between pairs and 5 between triples of games).

[22] We study 19 games and 12 pairwise comparisons. Of these 19 games, 9 are taken from the 34 games used in AS2020. The additional ten games introduce 3 types of games that are not present in AS2020: asymmetric mixed strategy, strict dominance, and trust/risk games.

[23] We find no difference in the results whether we look at Pairs 2, 3, and 4, which were presented first in Part 3, or at Pairs 4 to 12, presented later in Part 3.

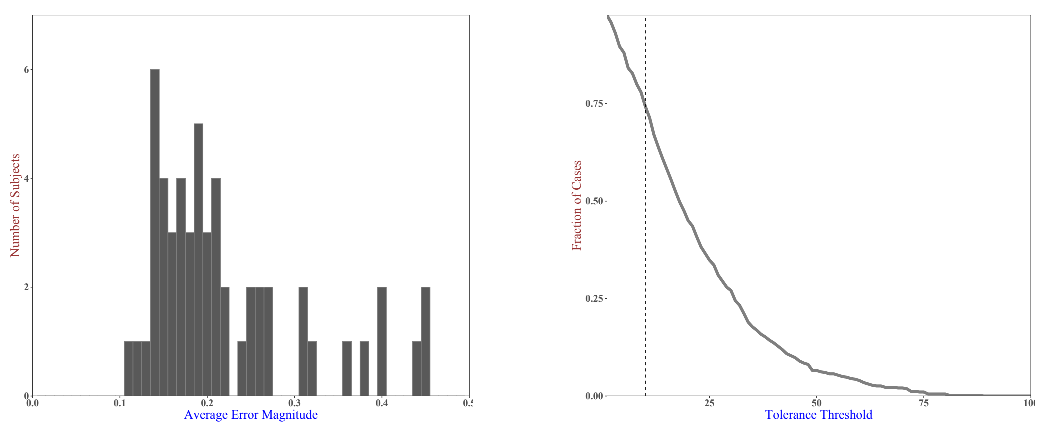
Figure 1: Planned vs Actual Attention



where subject i's error magnitude in a game pair is given by $|\alpha_{ik} - \beta_{ik}|$.[24] Although Figure 2a shows that there is heterogeneity across subjects — indicating that some subjects are better than others in anticipating the amount of time they will need in the playing stage —, even those subjects that are better planners have sizable discrepancies between planned and actual attention.

In Figure 2b, we plot the fraction of subjects whose average error magnitude is above a given *error tolerance threshold* for the discrepancy between planned and actual attention allocation. By definition, as the error tolerance threshold increases, the number of subjects whose average error magnitude is above the threshold decreases. Surprisingly, 74% of subjects are above an error tolerance threshold of 10%. Moreover, all subjects have error magnitudes as high as 10% in at least four game pairs. In fact, if we declare that subjects make a mistake in a game pair whenever their error magnitude in the game pair is at least as high as 10%, the mean and median number of mistakes made by subjects is 8 out of 11 (that is, 72%). Therefore, while some subjects perform better at anticipating the time they will spend playing each game in a game pair, subjects perform poorly overall.[25]

Figure 2: Differences between planned and actual attention



(a) Average difference

(b) Error tolerance threshold

Why Do Planned and Actual Attention differ?

We conjecture that the mismatch between planned and actual attention follows from the fact that subjects use different features of the games in a pair when planning their attention and when actually allocating attention. When planning, the time constraint forces subjects to focus on salient features of the game, such as maximum or minimum (own) payoffs.[26] They use these salient fea-

[24] A subject's average error magnitude is then obtained by averaging the error magnitude across game pairs.
[25] Error magnitudes are also heterogeneous across game pairs (see Appendix B, Figure 8).
[26] See Leland and Schneider (2015) for an analysis of salience in the play of 2x2 games.

tures to assess the value of the games in the game pair. The subject then allocate a larger fraction of time to the game they deem more valuable. When playing without time constraints, features of a game that are neglected when planning becomes relevant. Among these, strategic considerations are prominent: a strategically simple game with shiny objects (e.g., with large payoffs) might attract a lot of attention in the planning stage but require little attention in the playing stage.

To test our conjecture, we run two regressions: one where α_{ik} is the dependent variable, and the other where β_{ik} is the dependent variable. As independent variables in both regressions, we include the following features of the game pairs: the difference in maximum payoffs (between the games in the pair); the difference in minimum payoffs; the difference in equity concerns; and the difference in the number of pure rationalizable strategies. With the exception of the last variable, the others were identified to be relevant for planned allocation in AS2020.[27] More precisely, we estimate the following regressions:

$$a_{ik} = \gamma_1^a \Delta\text{Max}_k + \gamma_2^a \Delta\text{Min}_k + \gamma_3^a \Delta\text{Max}_k \cdot \Delta\text{Min}_k + \gamma_4^a \Delta\text{Equity}_k + \delta^a \Delta\text{Strategy}_k + \varepsilon_{ik}, \quad (1)$$

where $a \in \{\alpha, \beta\}$; ΔMax_k is the difference between the maximum payoffs (in dollars) of Games 1 and 2 in game pair k; ΔMin_k is the difference between the minimum payoffs (in dollars) of Games 1 and 2 in game pair k; ΔEquity_k is the payoff difference (in dollars) between the average inequity[28] of Games 1 and 2 in game pair k; $\Delta\text{Strategy}_k$ is the difference between the number of rationalizable pure strategies of Games 1 and 2 in game pair k. Table 1 presents the results of these regressions.[29]

Before interpreting Table 1, however, we want to highlight an important aspect of our regressions. To illustrate it, consider the ΔMax variable. If ΔMax increases by $\$m$, this could have happened in different ways. For instance, the maximum payoff in Game 1 can increase by $\$m$ while the maximum payoff in Game 2 remains the same; or the maximum payoff in Game 1 remains the same while the maximum payoff in Game 2 decreases by $\$m$. Our regression does not distinguish between these two cases, and, hence, it implicitly assumes that they are symmetric.

In the planning stage (first column of Table 1), subjects allocate more time to games with higher best and the worst possible outcomes as the coefficients of ΔMax and ΔMin are positive and statistically significant. The interaction between these variables, i.e., the variable ΔMax $\times$

[27] Since we use a different set of games and comparisons, some of the features studied in AS2020 are not examined here (see Section 2.3).

[28] To capture 'equity concerns' in a game, we use its *average inequity*, defined as the average difference between a player's own payoffs and her opponent's payoffs (in dollars) for each strategy profile.

[29] We consider alternative regression specifications in Appendix B.3.

Table 1: Explaining discrepancies between planned and actual attention

	Allocation:	
	Planned (α_{ik})	Actual (β_{ik})
ΔMax	0.37***	-0.06
	(0.116)	(0.102)
ΔMin	0.32*	0.62***
	(0.167)	(0.157)
ΔEquity	0.64*	0.54**
	(0.344)	(0.240)
ΔStrategy	-1.55	8.15***
	(2.73)	(2.01)
ΔMax$\times\Delta$Min	0.05***	0.05***
	(0.010)	(0.015)

Note: The standard errors are in parenthesis and they are clustered at the subject level; Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

ΔMin, is also significant but its magnitude is small. The coefficient of ΔEquity is only marginally significant, while the coefficient of ΔStrategy is not significant even at the 10% significance level, which suggests that strategic considerations are overlooked at the planning stage.

To calculate the full effect of ΔMax and ΔMin on planned attention, we need to consider their own coefficients and also the coefficient of their interaction term. For instance, the full effect of ΔMax on planned attention is given by:

$$\frac{\partial \alpha_{ik}}{\partial \Delta \text{Max}_k} = \gamma_1^{\alpha} + \gamma_3^{\alpha} \Delta \text{Min}_k.$$

As this partial derivative is a function of ΔMin_k, we calculate the effect locally at the average of this variable. We then learn that a 5 dollar increase in ΔMax_k leads to a 1.8 percentage point (pp) increase in α_{ik}. If we repeat the same exercise for ΔMin, we would get that a 5 dollar increase in ΔMin_k leads to a 1.6 percentage point increase in α_{ik}.

In the playing stage (second column of Table 1), the coefficient of ΔMin remains significant but not the coefficient of ΔMax. The coefficient of ΔEquity is also statistically significant. To understand how equity concerns might play a role, consider a Battle of the Sexes game. When subjects are planning under a time constraint, they might not recognize the distributional consequences of their choices. However, when they play, these distributional consequences become important.

As argued above, in certain games, strategic complexity might be hard to spot in the planning stage but become relevant in the playing stage.[30] If we use the number of (pure) rationalizable strategies of a game as a proxy for its strategic complexity, this seems to explain why the coefficient of ΔStrategy is significant when playing, despite not being significant when planning. Moreover, the effect of ΔStrategy is sizable. In fact, if Game 1 has two (pure) rationalizable strategies while Game 2 only has one, our results imply that Game 1 receives 8 percentage points more time than when both games have the same number of (pure) rationalizable strategies. For the sake of comparison, we would need to increase ΔMax by \$22 to get an eight percentage point increase in actual attention.

In summary, these regressions support our conjecture that, when planning, subjects are affected by the salient features of the games, and, when playing, they focus more on the strategic aspects of the games. Our results thus imply that the mismatch between planned and actual attention is a consequence of the fact that salient attributes of a game can be poor indicators of its strategic complexity.

What (else) do we learn from eye-tracking data? So far, we used eye-tracking to estimate the fraction of time our subjects spend in each game of a game pair. But eye-tracking data sheds further light on the attention pattern of subjects in Experiment 1. In this spirit, we examine the time subjects spend on each of the 16 AOIs described in Section 2.1.5 (see Figure 7a in Appendix A.2) to address following questions:

- Are subjects more likely to choose the strategy that they spend more time attending to?
- Do subjects spend more time on their own as opposed to their opponent's payoffs?
- Does the payoff magnitude influence the amount of time spent looking at it?
- Are subjects' attention drawn to 'shiny' or 'scary' things, such as maximum and minimum payoffs in a game?

To address the first question, we run a regression in which a subject's strategy choice in a game is the dependent variable, and the total time the subject spent looking at the strategy's payoffs is the explanatory variable. We code strategy A as 1 and strategy B as 0. We display the results of the regression in Appendix B.2, Table 6. Consistent with other papers that use eye-tracking to study decision-making, we find that a subject's likelihood of choosing a strategy is increasing in the amount of time they spend looking at payoffs associated with that strategy.[31] This suggests that

[30] There is now substantive literature that discusses the relationship between response times and strategic considerations (cf. Gill and Prowse (2017) and references therein). In fact, Gill and Prowse (2017) use the average amount of time people spend thinking about a situation as a measure of the complexity of the situation.

[31] See Orquin and Loose (2013) discussion of what they call the 'utility effect' and the references therein.

the time a subject spends looking at payoffs correlates with their behavior. A natural follow-up question is then: what are the features of a payoff that capture the attention of our subjects? Our three remaining questions are particular instances of this broad question. (Unlike the analysis of Table 1, here we are interested in absolute, not relative, time.)

We run two regressions: one to account for the time spent looking at an AOI when planning and the other for the time spent looking at an AOI when playing. As explanatory variables in these regressions, we include the magnitude of the payoff in the AOI; an indicator for whether the payoff in the AOI is a subject's own payoff; indicators for whether the payoff is a maximum or a minimum of the game; and an indicator for whether the payoff in the AOI is zero. More precisely, we estimate the following regressions:

$$\text{Time}_{ij}^{k} = \nu_1^k \text{ Payoff}_j + \nu_2^k \text{ Own}_j + \nu_3^k \text{ Max}_j + \nu_4^k \text{ Min}_j + \nu_5^k \text{ Zero}_j + \varepsilon_{ij}, \tag{2}$$

where Time_{ij}^{k} is the time (in seconds) that subject i spends on AOI_j, $j \in \{1, 2, ..., 16\}$ in Part $k \in \{1, 3\}$; Payoff_j is the payoff magnitude in AOI_j; Own_j is a dummy variable that equals 1 if the payoff in AOI_j is a player's own payoff, and 0 otherwise; Max_j (Min_j) is a dummy variable that is 1 if the payoff in AOI j is the maximum (minimum) of the corresponding game, and 0 otherwise; Zero_j is a dummy variable that is 1 if the payoff in AOI_j is zero, and 0 otherwise.

We display the regression results in Table 2. Consistent with other studies that use eye-tracking and mouse-tracking to understand behavior in games (cf. Polonio et al. (2015) and Devetag et al. (2016)), subjects spend more time on their own payoffs than that of their opponent when playing (Part 3). Subjects also spend more time on their own payoffs than on that of their opponent when planning.

The variable Payoff in Table 2 has a positive and significant effect on the time spent looking at a payoff when planning (model 1). However, the effect of payoff magnitudes in time spent looking at a payoff when playing is either positive and insignificant or negative and significant (models 2,4, and 6). Therefore, the higher the payoff, the more time subjects looked at it while allocating time, but not when playing.

To further understand the effect of the payoffs on subjects' attention, consider the three remaining indicators in our regression, i.e., the Maximum, Minimum, and Zero. If we control for payoff magnitude (last two columns of Table 2), the Maximum indicator coefficient has a positive and significant effect on time spent looking at a payoff when planning and when playing. That is, 'shiny' payoffs attract more attention in both parts. For instance, if 500 is the maximum payoff of a game, then it will receive more attention than if 500 were not the maximum payoff of the game, both in Parts 1 and 3.[32] Minimum and Zero indicator coefficients are not significant when planning but are negative and significant when playing. Therefore, subjects do not look as much at 'scary' payoffs when playing the games.

Table 2: Eye-tracking data regression results

	Dependent variable: Time					
	(1) Planned	(2) Actual	(3) Planned	(4) Actual	(5) Planned	(6) Actual
Payoff	0.008***	0.001	0.009***	0.001	0.006***	-0.011***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.003)
Own Payoff Indicator			0.150***	0.210***	0.150***	0.200***
			(0.020)	(0.028)	(0.020)	(0.028)
Max Indicator					0.068***	0.100***
					(0.025)	(0.035)
Min Indicator					-0.022	-0.140***
					(0.027)	(0.038)
Zero Indicator					0.034	-0.310***
					(0.050)	(0.070)

Note: The standard errors are in parenthesis and they are clustered at the subject level; Significance levels: $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

Time and Choice: *Does a decision maker's choice change over time?*

Now that we know that subjects do not accurately anticipate the fraction of time they will spend playing each game in a pair and have identified (some of) the reasons why, we examine whether time affects strategy choice in games, and whether these effects are game-dependent. For example, are there games in which choices are more sensitive to the time spent reaching a decision and, for this reason, are more sensitive to time misallocation?

Certainly, a subject's failure to appropriately anticipate the time she will spend attending to a game can only have payoff consequences if her choice of strategy in the game depends on the amount of time she spends attending to it, i.e., if her choices in a game are time-dependent. Put differently, if a decision-maker were to make the same strategy choice in a game regardless of the time she spends contemplating it, then a failure to accurately allocate time to such a game would be irrelevant for her payoffs. Therefore, it is crucial to identify in which games the subjects' choices are more time-dependent.

[32] This result does not contradict our interpretation of the results in Table 1. The fact that subjects spend more time looking at a payoff if it is a maximum payoff when playing does not conflict with the fact that the difference between the maximum payoffs of the games in a game pair does not explain actual attention allocation.

To do so, we use the data from Experiment 2 to create an aggregate *time profile of choices* for each of the games considered in this experiment. The aggregate time profile of choices for a game displays what fraction of subjects choose strategy B at each point in time. To illustrate, consider Figures 3a and 3b. On the x-axis, we have time (from 0 to 60 seconds); on the y-axis, we have the fraction of subjects that choose strategy B at each second (the remaining fraction of subjects at each point in time thus choose strategy A).

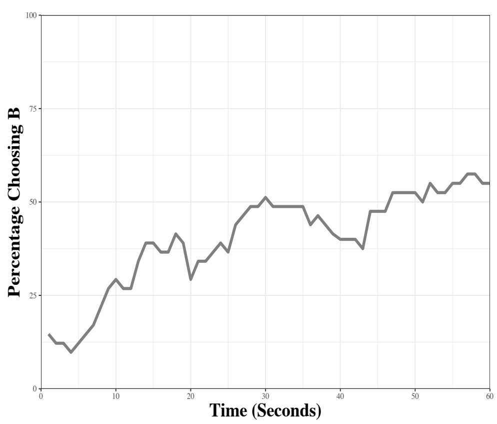
Figure 3: Time profile of two selected games.

Game 11

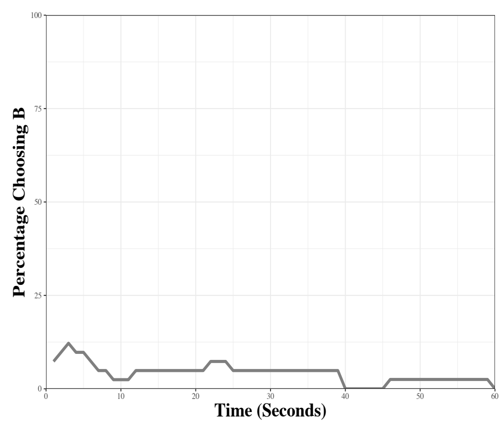
	A	B
A	$800, 500$	$0, 0$
B	$0, 0$	$500, 800$

Game 12

	A	B
A	$800, 800$	$0, 0$
B	$0, 0$	$500, 500$



(a) Battle of the Sexes



(b) Pure Coordination

The time profile of choices of Game 11, a Battle of the Sexes game, (Figure 3a) increases (roughly) monotonically. The probability that a randomly drawn subject from the population chooses strategy B in the first few seconds is 12%, while towards the last few seconds, the corresponding probability is 56%. Hence, a subject that anticipates spending less time in Game 11 is more likely to choose a different strategy than the one she would choose if she had allocated more time to it. The opposite is true for Game 12, a Pure Coordination game (Figure 3b). The likelihood of choosing strategy B is roughly constant throughout the 60 seconds. Therefore, a discrepancy between planned and actual attention in Game 12 is inconsequential.

In Appendix B.4, Figure 9, we plot the time profile of choices for all games we consider in this experiment. As one can check, in many of these games the choices of subjects vary considerably as time goes by.

To shed further light on the time-dependence of the subjects' choices in the games we study, we compare in Table 3 the fraction of B choices made at the first and last seconds of each of these

Table 3: Fraction of B choices at 1st and 60th Second

Game	*Type*	*1st second*	*60th second*	*p-value*
Game 1	Pure Coordination 1	0.08	0.05	1.000
Game 2	Battle of the Sexes 1	0.15	0.45	0.007
Game 3	Prisoners' Dilemma 1	0.38	0.70	0.007
Game 4	Mixed Strategy 1	0.17	0.45	0.016
Game 5	Mixed Strategy 2	0.32	0.57	0.043
Game 6	Strict Dominance 1	0.23	0.20	1.000
Game 7	Chicken Game 1	0.15	0.38	0.042
Game 8	Chicken Game 2	0.27	0.15	0.270
Game 9	Prisoners' Dilemma 2	0.23	0.68	0.000
Game 10	Strict Dominance 2	0.24	0.14	0.380
Game 11	Battle of the Sexes 2	0.15	0.55	0.001
Game 12	Pure Coordination 2	0.07	0.00	0.240
Game 13	Trust/Risk 1	0.53	0.60	0.650
Game 14	Strict Dominance 3	0.05	0.05	1.000
Game 15	Test/Control	0.075	0.15	0.480
Game 17	Mixed Strategy 3	0.23	0.6	0.002
Game 18	Equity	0.28	0.57	0.013
Game 19	Trust/Risk 2	0.34	0.45	0.490

Note: The p-values are the result of proportion tests.

games. We interpret this exercise as comparing subjects' early versus late choices.[33] Looking at Table 3, we see that in a few games, the first and last second's choices are not significantly different. Most of these games are strict dominance and pure coordination games with a Pareto dominant equilibrium.

On the other hand, Games 3 and 9, while possessing strictly dominant strategies, are Prisoners' Dilemma games and, hence, the dominant strategy B can lead to a socially inefficient outcome. We find that, in these games, subjects initially choose strategy B less often: 38% in Game 3 and 23% in Game 9. However, most subjects end up choosing strategy B, probably because they realize that it protects them against a possible defection from the column player. Therefore, a subject who allocates less time to these games is more likely to choose the cooperative strategy A, while if she had allocated more time to it, she would have chosen the dominant strategy B.[34]

[33] If we take the 5th second instead of the 1st second in Table 3 our results remain (roughly) the same. See Figure 9 in Appendix B.4 for the effect over the 60 seconds.

[34] This pattern of switching to a less cooperative strategy after some contemplation is similar to a result of Rand et al. (2012) for one-shot public goods game. The pattern is, however, controversial (see Krajbich et al. (2015), Tinghög et al. (2013), Bouwmeester et al. (2017), Kessler et al. (2017), Recalde et al. (2018), and Alós-Ferrer and Garagnani (2020)). As shown by Kessler et al. (2017), the magnitude of the payoffs matter. By varying the payoff of a Prisoner's Dilemma game and using the CP protocol of Agranov et al. (2015) to track subject's choice path, Kessler et al. (2017)

4 Conclusion

This paper focuses on the relationship between planned and actual attention in strategic decision-making. We find that, when presented with games in pairs, subjects fail to (instinctively) anticipate the fraction of time they will spend in each game of the pair, i.e., their planned attention allocation differs from their actual attention allocation. Our results suggest that this mismatch between planned and actual attention emerges from a difference in the determinants of attention between planning and playing.

This difference is partly driven by the different goals in each stage and partly driven by the time constraint in the first stage. When planning their attention under a time constraint subjects seem to overweight how valuable a game is and underweight its strategic complexity. Consistent with this interpretation, maximum and minimum payoffs play an important role in subjects' planned attention allocation, while the game's strategic complexity does not. When playing, however, subjects' actual attention allocation is primarily driven by strategic complexity: more complex games receive more attention in the playing stage. Therefore, our results suggest that the wedge between planned and actual attention is driven by the fact that salient indicators of the value of a game are not good predictors of its strategic complexity.

Finally, we argue that this mismatch between planned and actual attention will have payoff consequences in games where a subject's choice is sensitive to the time she spends thinking about the game. Since the sensitivity of choice with respect to time seems to be a common property of many tasks that have a strategic component, the mismatch between planned and actual attention is likely to have significant welfare consequences. The sales manager in our initial example should thus be particularly careful when planning their attention between tasks in which their final decisions are more sensitive to the time they allocate to them. A natural next step is to investigate whether our results apply to more realistic settings. If so, understanding the extent to which a person's experience in instinctively allocating her attention across tasks can close the gap between planned and actual attention is important, particularly when a person's choices in the tasks are sensitive to the time of deliberation.

find that, depending on the efficiency of cooperation, people can either switch from the selfish to the cooperative strategy, or from the cooperative to the selfish strategy.

References

Agranov, M., Caplin, A., and Tergiman, C. (2015). Naive play and the process of choice in guessing games. *Journal of the Economic Science Association*, 1(2):146–157.

Alós-Ferrer, C. and Garagnani, M. (2020). The cognitive foundations of cooperation. *Journal of Economic Behavior & Organization*, 175:71–85.

Avoyan, A. and Ramos, J. (2022). A road to efficiency through communication and commitment. *Available at SSRN 2777644*.

Avoyan, A., Ribeiro, M., and Schotter, A. (2022). Choice and time allocation in personal lotteries. *Working Paper*.

Avoyan, A. and Schotter, A. (2020). Attention in games: An experimental study. *European Economic Review*, 124. 103410.

Bouwmeester, S., Verkoeijen, P. P., Aczel, B., Barbosa, F., Bègue, L., Brañas-Garza, P., Chmura, T. G., Cornelissen, G., Døssing, F. S., Espín, A. M., et al. (2017). Registered replication report: Rand, greene, and nowak (2012). *Perspectives on Psychological Science*, 12(3):527–542.

Caplin, A. and Dean, M. (2011). Search, choice, and revealed preference. *Theoretical Economics*, 6(1):19–48.

Caplin, A., Dean, M., and Martin, D. (2011). Search and satisficing. *American Economic Review*, 101(7):2899–2922.

Chen, D. L., Schonger, M., and Wickens, C. (2016). otree—an open-source platform for laboratory, online, and field experiments. *Journal of Behavioral and Experimental Finance*, 9:88–97.

Deck, C. and Nikiforakis, N. (2012). Perfect and imperfect real-time monitoring in a minimum-effort game. *Experimental Economics*, 15(1):71–88.

Devetag, G., Di Guida, S., and Polonio, L. (2016). An eye-tracking study of feature-based choice in one-shot games. *Experimental Economics*, 19(1):177–201.

Fischbacher, U. (2007). z-tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, 10(2):171–178.

Friedman, D. and Oprea, R. (2012). A continuous dilemma. *American Economic Review*, 102(1):337–63.

Frydman, C. and Krajbich, I. (2022). Using response times to infer others' private information: an application to information cascades. *Management Science*, 68(4):2970–2986.

Gill, D. and Prowse, V. L. (2017). Strategic complexity and the value of thinking. *Available at SSRN 3041519*.

Greiner, B. (2015). Subject pool recruitment procedures: organizing experiments with orsee. *Journal of the Economic Science Association*, 1(1):114–125.

He, S. and Zhu, X. (2020). Real-time monitoring in a public goods game. *Available at SSRN 3548418*.

Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *American economic review*, 93(5):1449–1475.

Kessler, J., Kivimaki, H., and Niederle, M. (2017). Thinking fast and slow: generosity over time. *Preprint at http://assets. wharton. upenn. edu/˜ juddk/papers/KesslerKivimakiNiederle_GenerosityOverTime. pdf*.

Knoepfle, D. T., Wang, J. T.-y., and Camerer, C. F. (2009). Studying learning in games using eye-tracking. *Journal of the European Economic Association*, 7(2-3):388–398.

Konovalov, A. and Krajbich, I. (2019). Revealed strength of preference: Inference from response times. *Judgment and Decision making*, 14(4).

Krajbich, I., Bartling, B., Hare, T., and Fehr, E. (2015). Rethinking fast and slow based on a critique of reaction-time reverse inference. *Nature communications*, 6(1):1–9.

Krajbich, I., Oud, B., and Fehr, E. (2014). Benefits of neuroeconomic modeling: New policy interventions and predictors of preference. *American Economic Review*, 104(5):501–06.

Leland, J. W. and Schneider, M. (2015). Salience and strategy choice in 2× 2 games. *Games*, 6(4):521–559.

Meißner, M. and Oll, J. (2019). The promise of eye-tracking methodology in organizational research: A taxonomy, review, and future avenues. *Organizational Research Methods*, 22(2):590–617.

Oprea, R., Charness, G., and Friedman, D. (2014). Continuous time and communication in a public-goods experiment. *Journal of Economic Behavior & Organization*, 108:212–223.

Orquin, J. L. and Loose, S. M. (2013). Attention and choice: A review on eye movements in decision making. *Acta psychologica*, 144(1):190–206.

Oud, B., Krajbich, I., Miller, K., Cheong, J. H., Botvinick, M., and Fehr, E. (2016). Irrational time allocation in decision-making. *Proceedings of the Royal Society B: Biological Sciences*, 283(1822):20151439.

Polonio, L., Di Guida, S., and Coricelli, G. (2015). Strategic sophistication and attention in games: An eye-tracking study. *Games and Economic Behavior*, 94:80–96.

Radner, R. and Rothschild, M. (1975). On the allocation of effort. *Journal of Economic Theory*, 10(3):358–376.

Rand, D. G., Greene, J. D., and Nowak, M. A. (2012). Spontaneous giving and calculated greed. *Nature*, 489(7416):427–430.

Recalde, M. P., Riedl, A., and Vesterlund, L. (2018). Error-prone inference from response time: The case of intuitive generosity in public-good games. *Journal of Public Economics*, 160:132–147.

Rubinstein, A. (2007). Instinctive and cognitive reasoning: A study of response times. *The Economic Journal*, 117(523):1243–1259.

Rubinstein, A. (2016). A typology of players: Between instinctive and contemplative. *The Quarterly Journal of Economics*, 131(2):859–890.

Spiliopoulos, L. and Ortmann, A. (2018). The bcd of response time analysis in experimental economics. *Experimental economics*, 21(2):383–433.

Tinghög, G., Andersson, D., Bonn, C., Böttiger, H., Josephson, C., Lundgren, G., Västfjäll, D., Kirchler, M., and Johannesson, M. (2013). Intuition and cooperation reconsidered. *Nature*, 498(7452):E1–E2.

Appendix

A Further details on the experimental design

A.1 Game pairs and games

Table 4: Game Pairs used in Experiment 1

Pair 1	Game 1	vs	Game 2
Pair 2	Game 3	vs	Game 4
Pair 3	Game 5	vs	Game 6
Pair 4	Game 7	vs	Game 8
Pair 5	Game 9	vs	Game 4
Pair 6	Game 5	vs	Game 10
Pair 7	Game 11	vs	Game 12
Pair 8	Game 7	vs	Game 10
Pair 9	Game 13	vs	Game 14
Pair 10	Game 15	vs	Game 16
Pair 11	Game 17	vs	Game 16
Pair 12	Game 18	vs	Game 19

Table 5: Average amount of seconds spent on a game in Part 3

Game	***Seconds***	***Game***	***Seconds***	***Game***	***Seconds***
Game 3	12.2	**Game 9**	8.6	**Game 15**	4.3
Game 4	9.1	**Game 10**	4.7	**Game 16**	8.4
Game 5	10.7	**Game 11**	7.2	**Game 17**	9.9
Game 6	5.5	**Game 12**	3.6	**Game 18**	8.5
Game 7	10.9	**Game 13**	7.3	**Game 19**	7.4
Game 8	5.3	**Game 14**	5.7		

Figure 4: List of games used in Experiments 1 and 2

Game 1

	A	B
A	$800, 800$	$100, 100$
B	$100, 100$	$500, 500$

Game 2

	A	B
A	$800, 500$	$100, 100$
B	$100, 100$	$500, 800$

Game 3

	A	B
A	$300, 300$	$100, 400$
B	$400, 100$	$200, 200$

Game 4

	A	B
A	$400, 100$	$100, 400$
B	$100, 400$	$400, 100$

Game 5

	A	B
A	$300, 100$	$200, 200$
B	$100, 400$	$400, 300$

Game 6

	A	B
A	$300, 300$	$400, 400$
B	$200, 100$	$200, 300$

Game 7

	A	B
A	$800, 800$	$500, 1000$
B	$1000, 500$	$400, 400$

Game 8

	A	B
A	$800, 800$	$500, 1000$
B	$1000, 500$	$0, 0$

Game 9

	A	B
A	$800, 800$	$100, 1000$
B	$1000, 100$	$500, 500$

Game 10

	A	B
A	$800, 800$	$900, 900$
B	$700, 600$	$700, 800$

Game 11

	A	B
A	$800, 500$	$0, 0$
B	$0, 0$	$500, 800$

Game 12

	A	B
A	$800, 800$	$0, 0$
B	$0, 0$	$500, 500$

Game 13

	A	B
A	$0, 600$	$900, 600$
B	$400, 500$	$400, 500$

Game 14

	A	B
A	$700, 800$	$500, 500$
B	$600, 200$	$400, 500$

Game 15

	A	B
A	$500, 500$	$500, 500$
B	$500, 500$	$500, 500$

Game 16

	A	B
A	$400, 500$	$400, 400$
B	$600, 600$	$300, 700$

Game 17

	A	B
A	$300, 600$	$600, 300$
B	$600, 300$	$300, 600$

Game18

	A	B
A	$200, 0$	$200, 0$
B	$200, 400$	$199, 900$

Game 19

	A	B
A	$0, 300$	$600, 300$
B	$100, 200$	$100, 200$

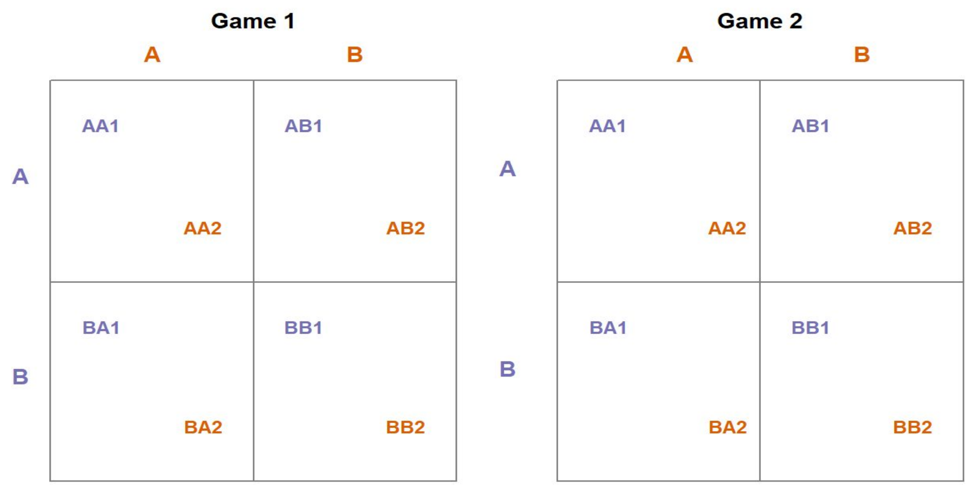
Game 16′

	A	B
A	$400, 500$	$400, 400$
B	$600, 600$	$500, 500$

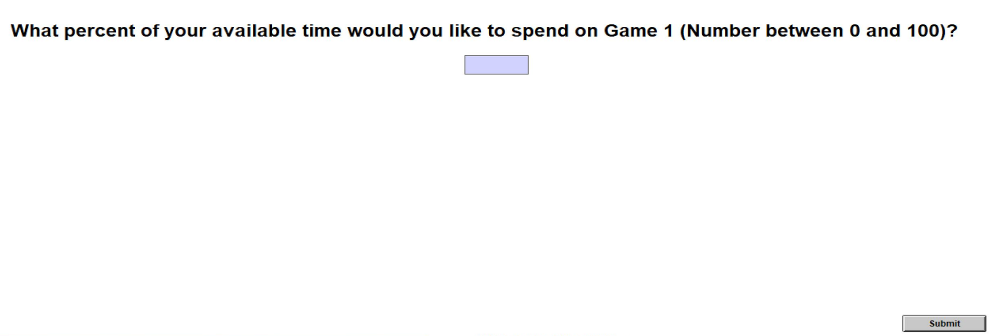
Due to a programming error in Experiment 2, subjects played Game 16′ instead of playing Game 16.

A.2 Screenshots

Figure 5: Sample screens

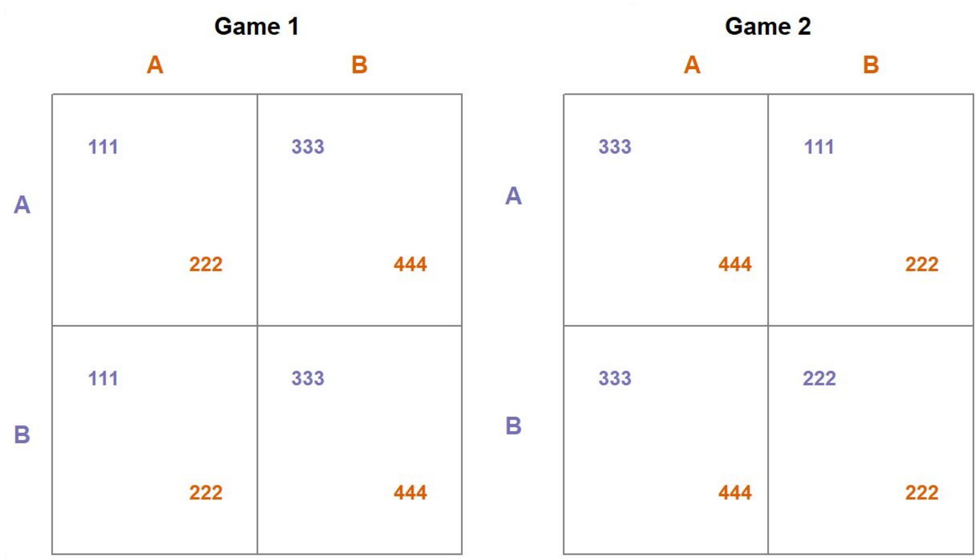


(a) Practice Screen (Experiment 1)

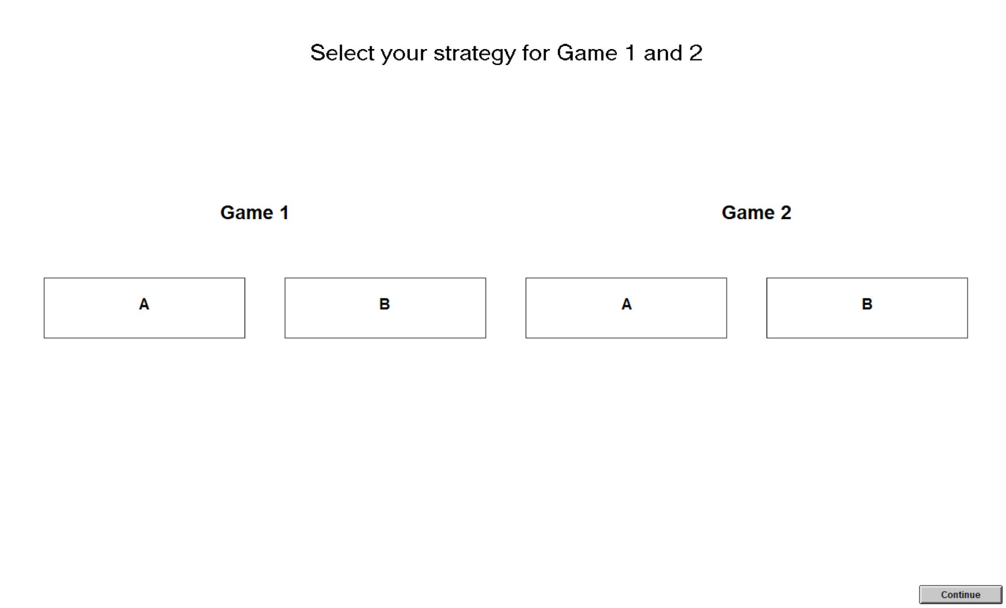


(b) Submission Screen Part 1(Experiment 1)

Figure 6: Sample screens cont.

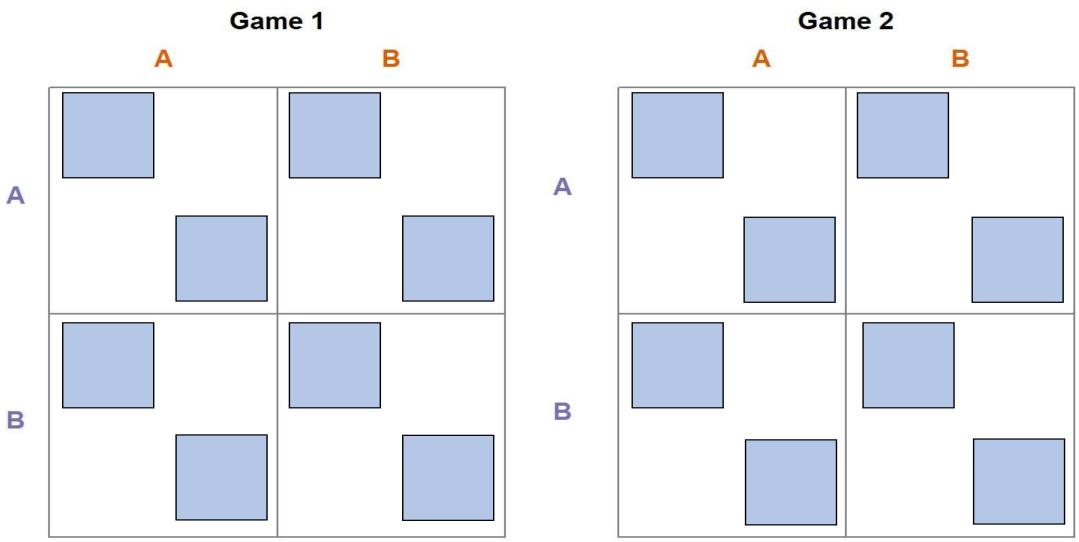


(a) Sample Practice Screen (Experiment 1)

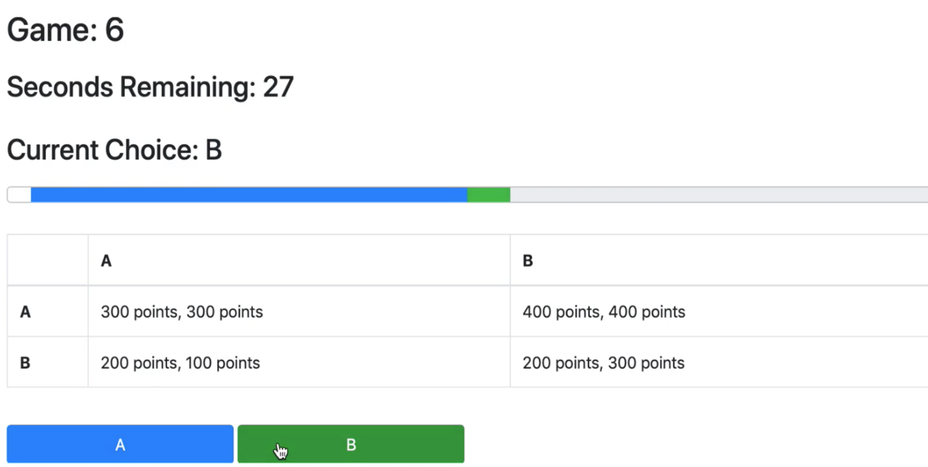


(b) Submission screen Part 3 (Experiment 1)

Figure 7: Sample screens cont.



(a) Areas of interest (AOI) around the payoffs



(b) Sample Screen from Experiment 2

B Additional figures and tables

B.1 Error magnitudes by game pair

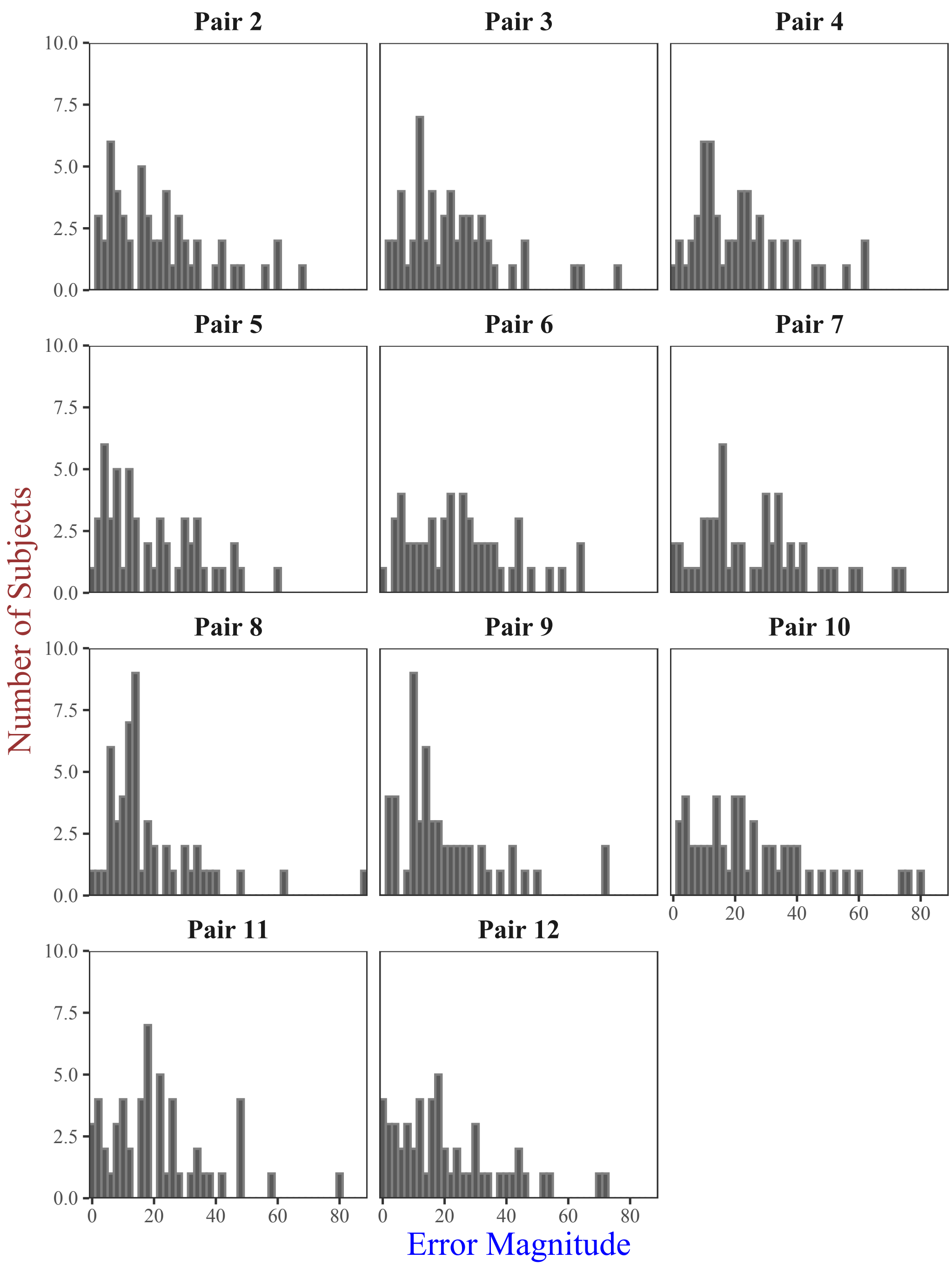


Figure 8: Error magnitudes by game pair

B.2 Time spent on strategies and consequent choice

Table 6 presents the results of a regression where the dependent variable is the choice of a strategy in a game (strategy A is coded as 1 and strategy B as zero), and the independent variables are the time (in seconds) spent looking at the payoffs associated with strategies A and B in the game.

Table 6: Time spent on strategies and consequent choice

	Dependent variable:
	Choice A
Time on A	0.031^{***}
	(0.010)
Time on B	-0.040^{***}

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

B.3 Alternative regression specifications

In Section 3, we examined variables that Avoyan and Schotter (2020) determined to be relevant when people plan their attention allocation. In addition, we included a strategy variable to the regressions to capture strategic considerations.

In this section, we evaluate the effects of 3 alternative payoff-related variables: ΔAverage, ΔVariance, and ΔExpectedDifference. ΔAverage is defined as

$$\Delta\text{Average} = \text{Average}_{Game_1} - \text{Average}_{Game_2},$$

where Average_{Game_1} and Average_{Game_2} are the average own payoffs (in dollars) in Games 1 and 2. Similarly, ΔVariance is defined as

$$\Delta\text{Variance} = \text{Variance}_{Game_1} - \text{Variance}_{Game_2},$$

where Variance_{Game_1} and Variance_{Game_2} are the variance of own payoffs (in dollars) in Games 1 and 2. Finally, ΔExpectedDifference is defined as

$$\Delta\text{ExpectedDifference} = \text{ExpectedDifference}_{Game_1} - \text{ExpectedDifference}_{Game_2},$$

where $\text{ExpectedDifference}_{Game_1}$ and $\text{ExpectedDifference}_{Game_2}$ are the absolute difference in the expected payoffs (in dollars) from choosing strategy A versus strategy B in Games 1 and 2 when we assume that the column player randomizes uniformly over her strategies.

Table 7 presents the results of running similar regressions to the ones in equation (1), Section 3, but where we replace the payoff-related variables by each of the three variables just defined.[35]

The coefficient of ΔAverage is positive when planning and negative when playing. However, neither of these coefficients is statistically significant. These results suggest that using the difference in average own payoffs, instead of more specific payoff variables such as differences in maximum and minimum own payoffs, hides too much of the variation of a change in payoffs.

The variable ΔExpectedDifference is inspired by a recent literature that, in the context of value-based decisions, shows that people spend more time in decisions between alternatives that yield similar payoffs than in decisions between alternatives that yield dissimilar payoffs (cf. Oud et al. (2016)). This pattern points to an inefficiency in time allocation since people allocate too much time to decisions in which the payoff difference between a correct and an incorrect choice is small.[36]

This literature raises the following question in our setup: if the absolute difference between the expected payoffs of strategies A and B in Game 1 is smaller than that of Game 2, do subjects spend more time in Game 1 when playing? What about when planning?

Table 7: Alternative regression specifications

	Dependent variable: Allocation					
	(1)	(2)	(3)	(4)	(5)	(6)
	Planned	Actual	Planned	Actual	Planned	Actual
$\Delta Strategy$	−0.480	3.500**	−2.400	7.700***	−1.100	4.000**
	(2.600)	(1.700)	(2.600)	(1.600)	(2.500)	(1.700)
ΔAverage	0.240	−0.230				
	(0.190)	(0.160)				
ΔVariance			0.013	−0.081***		
			(0.012)	(0.014)		
ΔExpected Difference					0.400*	−0.400*
					(0.230)	(0.210)

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

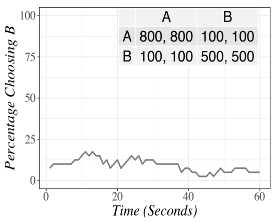
The coefficient of ΔExpected difference is positive and marginally significant when planning, while it is negative and marginally significant when playing. Therefore, when planning, if the expected payoff difference between strategies A and B is higher in Game 1 than in Game 2, subjects allocate more time to Game 1. When playing, the opposite is true, which is in line with the results of the literature we just discussed. These results highlight yet another difference between planned and actual attention allocations.

[35] We chose to replace the payoff-related variables in equation (1) for the ones we discuss here to avoid introducing colinearity between regressors.

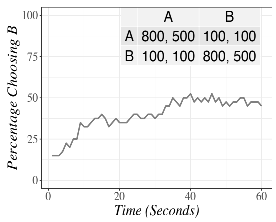
[36] See also Krajbich et al. (2014). Additionally, see Konovalov and Krajbich (2019), Frydman and Krajbich (2022) for a discussion on how response times can be used to reveal the strength of preferences, and Spiliopoulos and Ortmann (2018) for a discussion about the applications of response time in economics.

B.4 Time profiles (Experiment 2)

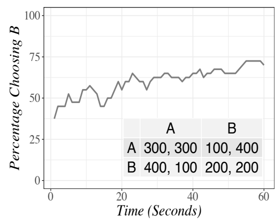
Figure 9: Time profile for all games in Experiment 2



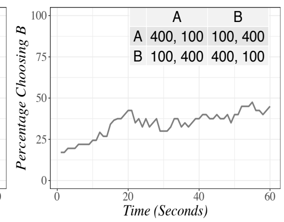
(a) Game 1



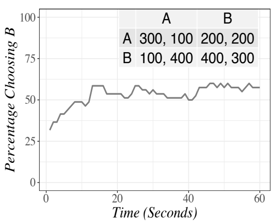
(b) Game 2



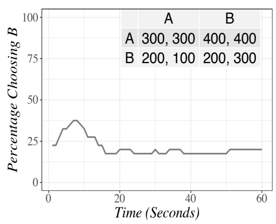
(c) Game 3



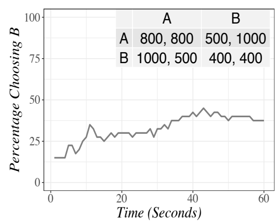
(d) Game 4



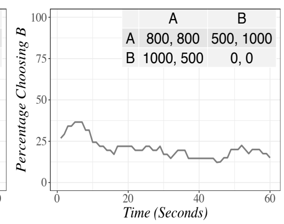
(e) Game 5



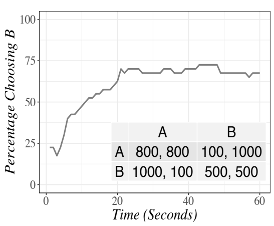
(f) Game 6



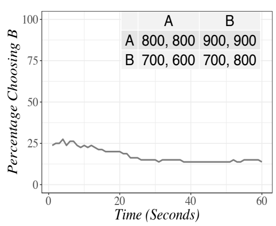
(g) Game 7



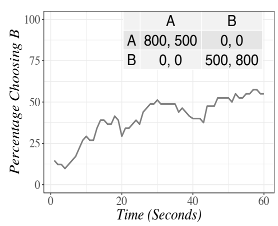
(h) Game 8



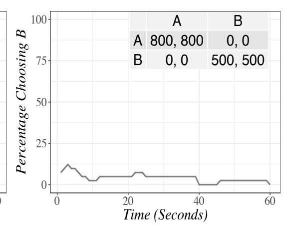
(i) Game 9



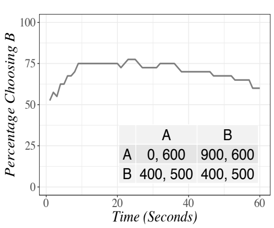
(j) Game 10



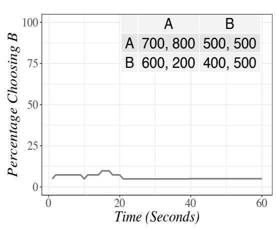
(k) Game 11



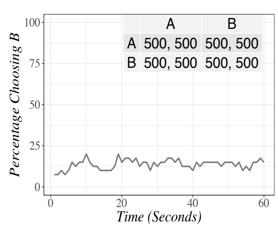
(l) Game 12



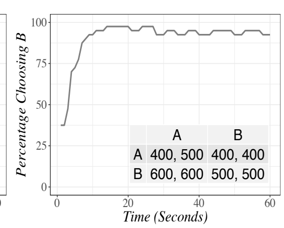
(m) Game 13



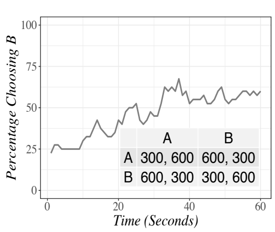
(n) Game 14



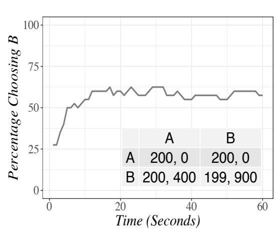
(o) Game 15



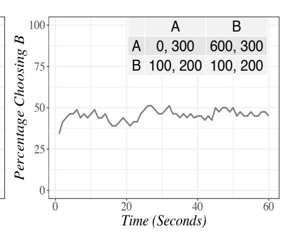
(p) Game 16’



(q) Game 17



(r) Game 18



(s) Game 19

C Instructions for Experiment 1 (For online publication)

Instructions

This is an experiment in decision-making. Funds have been provided to run this experiment, and if you make good decisions, you may be able to earn a substantial payment. The experiment will be composed of three tasks which you will perform one after the other.

All of the tasks below will require an eye tracker, a device that records your eye movements as you look at the computer screen during the experiment. The eye tracker we use is non-intrusive in that nothing will be attached to you or your eyes in any way. The eye tracker is simply a small device that sits on the computer desk as you engage in the experiment and keeps track of where your eyes are focusing. The only constraint that the eye tracker places upon you during the experiment is the requirement that you keep your head relatively still during the experiment and try not to move your head to keep your eyes on the screen in front of you. Before and during the experiment, we will have an assistant help you and tell you if you need to adjust your head position to better focus on the screen.

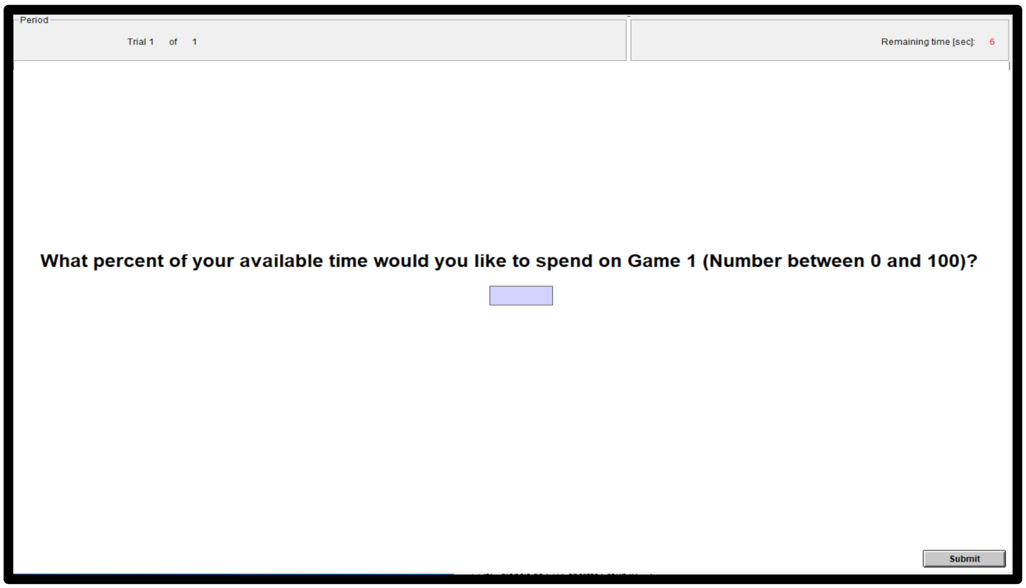
Task 1: Time Allocation

In all of the rounds in the experiment, you will be presented with a description of two games, Game 1 and Game 2. Each game will describe a situation where you and another person have to choose between two choices that jointly determine your payoff and the other player's payoff. These games will be presented to you as "payoff matrices," describing the choices of you and your opponent and the associated payoffs. We will go into more detail later.

At the beginning of any round, the two games will appear on your computer screen, and you will be given 10 seconds to inspect them. When the 10 seconds are over, you will not be asked to play these games. At the end of the experiment, if this particular pair is chosen to be played, you will have X seconds to make a choice in each of the two games. Your task now is to decide what fraction of these X seconds to allocate to thinking about Game 1 and what fraction to allocate to thinking about Game 2. The exact pair of games selected for payment will be determined randomly.

After the 10 seconds allowed for inspecting the two games are over, a new screen will appear for 10 seconds. On this screen, you will need to enter a number between 0 and 100 representing the percentage of the X seconds you would like to use for Game 1 (the remaining fraction will be used for Game 2). If you do not enter a number within the 10-second limit, you will not be paid for that pair if, in the end, this is the one that counts for your payoff. In other words, be sure to enter your number within the time given to you.

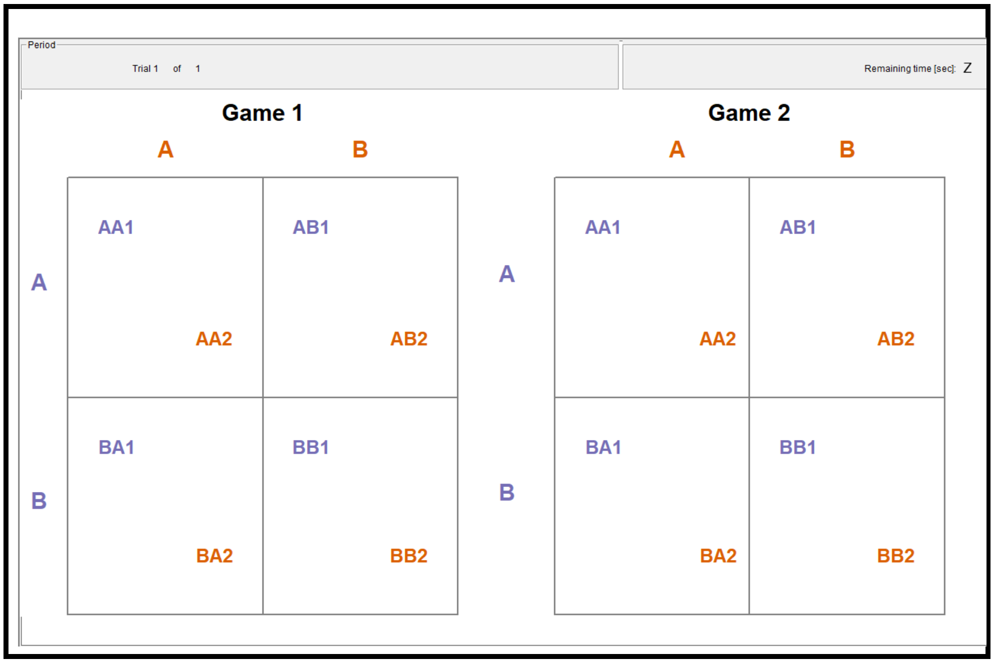
The screen will appear as follows:



The total amount of time you will have, X seconds, to think about both games will not be large, but we are not telling you what X is. We want you to report the ***relative*** amount of time you would like to use on each game.

The Games

You will be asked to allocate time between two games represented as game matrices which will appear on your computer screen as follows:



On this screen, we have two game matrices labeled Game 1 and Game 2. Each game has two choices for you and your opponent, A and B. ***You will be acting as the Row chooser (Player 1) in all games, so we will describe your payoffs and actions as if you were the Row player.***

Take Game 1. In this game, you have two choices, A and B. The entries in the matrices describe your payoff and that of your opponent, depending on the choice both of you make. For example, say that you and the person you are playing with both choose A. If this is the case, the cell in the upper left-hand corner of the matrix is relevant. In this cell, you see AA1 in the upper left-hand part and AA2 in the bottom right corner. The first payoff in the upper left corner is yours (AA1), while the payoff in the bottom right-hand corner (AA2) is the payoff to the column chooser, your opponent. The same is true for all the other cells, which are relevant when different choices are made: the upper left-hand corner payoff is your payoff, while the bottom right payoff is that of the person you are playing with. Obviously, in the experiment, you will have numbers in each cell of the matrix, but we have used letters for descriptive purposes.

After you are finished making your time allocation for a given pair of games, you will be given a wait screen which will allow you to rest before moving on to a new pair of games. Then, when you are ready for the next game pair, click the continue button, and you will be shown a new pair of games.

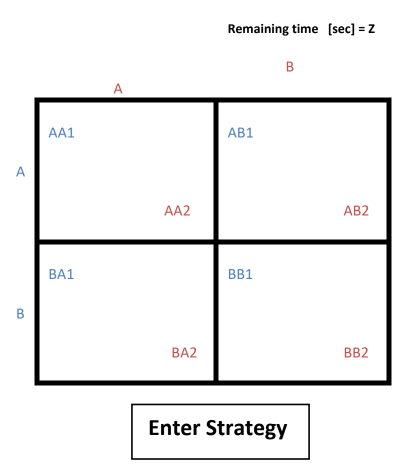
Please pay attention to your screen at all times since you will want to be sure that you see the screen when a new pair of games appear. Also, between games, try not to move your head too much to keep the eye tracker in alignment.

During Tasks 1 and 2, where time limits are placed on your actions, you will see a timer at the top of the screen. This timer will count down how much time you have left for the task you are currently engaged in. For example, the screen shown above says you have Z seconds left before the screen goes blank, and you are asked to make a time allocation.

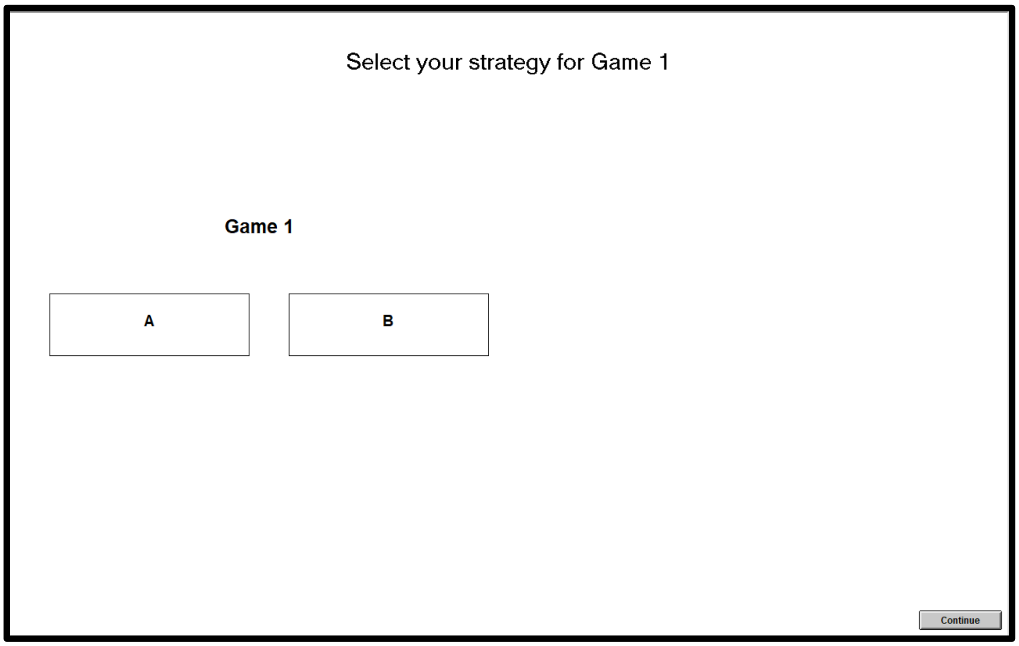
Task 2:

In Task 2, you will play one and only one of the pair of games you saw in Task 1 by choosing a Row (A or B) for each game. Someone else will select the column (we will describe later how your payoffs in the experiment will be determined). You will play these games sequentially, one at a time, starting with Game 1. You will be given an amount of time to think about your decision here, equal to the amount of time you allocated to it in Task 1. So if in Task 2, for a given game pair, you decided to allocate a fraction α to thinking about Game 1, you will have TimeGame1 = $\alpha \cdot X$ seconds to make a choice for Game 1. Then, you will have TimeGame2 =$X - \alpha \cdot X$ to select a choice for Game 2. We will have a time count down displayed on the top of your screen.

When you play Game 1, you will see the following screen.



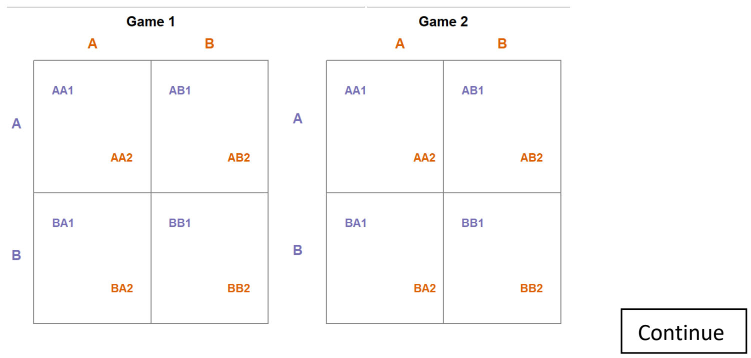
To enter your choice, you simply click on **Enter Strategy** button at any point time before the allotted time expires**.** Note again that a counter will be on the top of the screen that will tell you how much time you have left to enter your choice. If you fail to choose before the elapsed time, your decision will not be recorded for that game. Once you press the button, you will be taken to the next screen to enter your strategy.



You will then play Game 2 and have the time you allocated to Game 2 to make a choice for that game.

Task 3: Game Playing

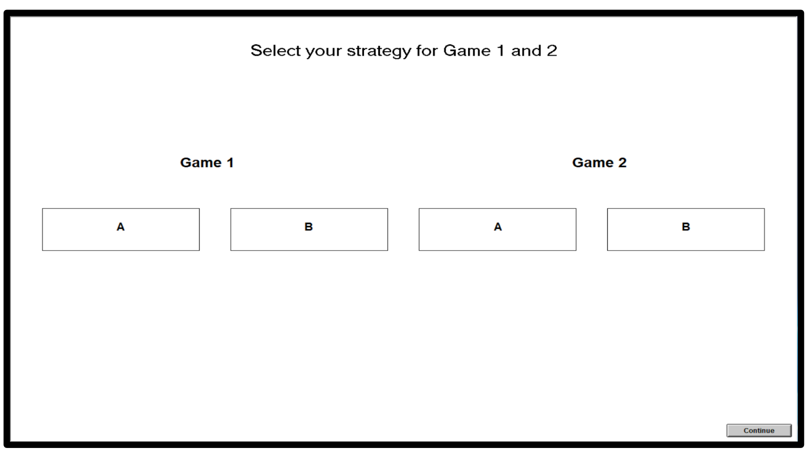
When you are finished with Tasks 1 and 2, we will move on to Task 3. The game pairs you play in this task will be the same games you saw in Task 1 (except for the one pair of games you already played in Task 2), but they will be shown to you in random order. For each game, you will have to choose a strategy (A or B). You will not be time-constrained, so you can take as much time as you want to make your strategy choice. Your screen will appear as follows for any pair of games.



In Task 3, you can take as much time as you wish in deciding what choice to make in each game and when you have decided, you press the continue button at the bottom of the screen. Then, a new screen will appear with two windows where you can enter your choices for Games 1 and 2.

Note that in this task, instead of having one game on the screen at a time, you will have both games shown to you, and when you are ready to make a choice in both games, you will click the continue button.

The screen for making choices in these games will appear as follows:



When you make your selections and press the continue button, you will enter a wait screen. Then, when you are ready to proceed to the next game pair, you can press the continue button, and you will be presented with the next pair of games. You will do this for each pair of games except the one you already played in Task 2. ***Remember that we will use the eye tracker during the entire experiment, so try to keep your head still.***

Payoffs

Your payoff in the experiment will be determined as follows:

1. Before you did this experiment, we had a group of other subjects play these games and make their choices without time constraints. In other words, all they did in their experiment was to make choices for these games and could take as much time as they wanted to choose. Call these subjects "Previous Opponents."
2. You will be paid what you earn in one of the games played in Task 2 and one of the games played in Task 3 (drawn at random). Since you do not know what games will be chosen for payoffs, it is to your advantage to allocate your time across the game pairs in Task 1 in a way that you feel is best. Likewise, when making choices in Task 3, since any one of the games may be relevant for your payoff, you also have an incentive to choose as best you can.
3. To determine your payoff in this experiment, we will take your choice of a row and match it against the choice of a column by one Previous Opponent playing the opposite role as you in the game.
4. To determine your payoff, we will then divide the subjects in the room into two groups called Group 1 and Group 2. Subjects in Group 1 will receive the payoff they just determined by playing against their Previous Opponent. However, Group 2 will be given the payoff of the Previous Opponent matched with a member of Group 1 rather than their own payoffs. Since you do not know which group you will be in, Group 1 or Group 2, it is important when playing the game that you make the choice which you think is best given the game's description.

Finally, the payoffs in the games you will be playing are denominated in units called Experimental Currency Units (ECUs). For payment purposes, each ECU will be converted into US dollars at the rate of 1 ECU = 0.025 $US. You will also be paid $10 for showing up to the experiment.

You will have three practice rounds that will not count towards your payoff.

D Instructions for Experiment 2 (For online publication)

Instructions

This is an experiment in decision-making. Funds have been provided to run this experiment, and if you make good decisions, you may be able to earn a substantial payment.

In each round, you will be presented with a two-person decision problem (game) in which you will be asked to choose between two actions labeled A and B. You play with another person who will also choose between A and B actions. Depending on your choice and that of your pair member, each of you will earn money.

To illustrate what a game will look like, consider Table 1 below. (This is just a hypothetical example; the payoffs in your games will not be exactly the same as portrayed here):

		Your Opponent's Decision	
		A	B
Your Decision	A	1000, 225	5, 25000
	B	80, 10,000	225, 10,000

In this game, you have two choices: Row A and Row B. The entries in the table describe your payoff and that of your opponent in points, depending on the choice both of you make. For example, say that you and your opponent both make choice A. The cell in the upper left-hand corner of the table is relevant since it is the cell in the table associated with the choice A for both you and your opponent. In this cell, you see two amounts, 1000 points and 225 points. The first payoff on the left is your (the Row chooser's) payoff (1000), while the payoff to the right (225) is the payoff to the column chooser. The same is true for all the other relevant cells when different choices are made: the first payoff is your payoff, while the second payoff is that of your opponent. For example, if you choose Row B and your opponent chooses Column A, then the cell in the lower left-hand corner of the table is relevant, and you will receive a payoff of 80 points while your opponent will receive a payoff of 10,000 points.

In each round of the experiment, you will have a new game on the screen, and it will remain on the screen for 1 minute. At each instant during that minute, we ask you to think of what choice you would like to make (Row A or Row B). Press the A or B button placed below the decision problem to enter your decision. Put differently, as you look at the game during the 1 minute, you may start out thinking that a particular decision is best but later change your mind about which row to choose. We allow you to change your mind by pressing the button associated with what you consider the better choice at that instant. At the end of the minute, we will choose one instant (one second) at random and enter the choice you made at that second as your payoff-relevant choice for the game to be used against the choice of your opponent.

It is in your best interest to make sure that you indicate the row that you think is best given your deliberations at every second because the computer will choose one second at random to determine your payoff. So always make sure you have indicated the decision you think is best as time goes on. You are free to change your mind as time proceeds.

There are several things to note about your payoff in the experiment:

1. If you do not have a decision entered and the computer chooses that second as payoff relevant, you will receive a zero payoff in that case. This is only relevant at the very beginning of the round before you have made your very first choice. For example, say you take 3 seconds to make your first choice, and the computer chooses your decision at second 2 as the payoff-relevant one. Since you had not made a choice at that time, you will get zero points for that game. To avoid this, we urge you to make the first decision as fast as you can when a new round starts to avoid the chance of a zero payoff. You can change it at any time if you choose to.
2. The opponent you face will be taken from a set of randomly chosen people who played these games without any time limit but who made only one choice and did not have to decide, as you do, during 1 minute. So for each such game, your opponent thought about the game and made one choice as a column chooser. Your decision of a row will be matched with their column choice.
3. Between rounds, we will not inform you of your round payoff. You will have to finish all games before you observe your payoff.
4. Finally, we will randomly choose 4 games as relevant for your payoff. You will receive the sum of your payoffs in those 4 games. The points will be converted into dollars at the end of the experiment at the rate of 1 point = $ 0.01. In addition, you will receive a $7.00 show-up fee.