Market competition for decision rights: An experiment based on the "Hat Puzzle Problem"

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Abstract

This paper investigates the conventional wisdom that market competition for the rights to perform decision-making tasks improves aggregate performances in all relevant tasks by diverting decision rights to individuals who are better able to utilise them. To do so, I use an experiment that embeds asset markets into the Hat Puzzle Problem game. I show that players' performances in the game will depend on their ability to employ sophisticated counterfactual reasoning and provide a behavioural framework that illustrates how market competition can improve aggregate performances in the game. Contradictory to the conventional wisdom, I find that market competition exacerbates aggregate performances and diverts decision rights to players who are less able to utilise them. I provide some evidence that the failure of markets can be linked to the formation of price "bubbles", which distort the markets' allocation of decision rights.

JEL Classifications: C90, C70, G10, L11.

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1 Introduction

Most economies use market mechanisms to allocate productive resources such as the *rights* (e.g., contracts, permits, licenses) for performing specific decision-making tasks. A familiar example is the market for corporate governance where managers compete for the rights to manage the corporate resources of a targetted firm (Jensen and Ruback (1983)).[1] The *conventional wisdom* that often

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[1] Other examples include "seats" on the New York Stock Exchange, which up to 2007 were traded on secondary markets (see Keim and Madhavan (2000)). An intriguing example from the 17th to 19th centuries is the British Army's purchase system, where commissioned ranks and responsibilities were sold at pre-determined prices (see Brereton (1986)).

guides the implementation of such mechanisms is the idea that if individuals' utilities only depend on the expected payoffs from the tasks and payoffs are increasing with performances, then well-structured markets could improve *aggregate performances* in all relevant tasks by diverting decision rights to individuals who are better able to utilise them. The is based on the allocative property of markets, diverting commodities to those who value them more.

In most circumstances, the conventional wisdom is natural when performances in the tasks depend on factors such as private information, background training and domain of expertise. What is less obvious is whether the conventional wisdom still holds in cases where performances depend on innate decision-making abilities such as individual *sophistication* (e.g., logical reasoning, strategic thinking, problem solving skills). Indeed, decision-making experiments suggest that people are sometimes overconfident in their own abilities (e.g., Camerer and Lovallo (1999)), assign intrinsic values to the rights for making decisions (e.g., Bartling et al. (2014)) and are vulnerable to "focusing failures" (e.g., Tor and Bazerman (2003), Idson et al. (2004)). Such behavioural biases suggest that even under ideal market conditions, the person who values the decision right the most might not be the one who is best abled to utilise it.[2,3] Indeed, Tirole (2015) in his Nobel prize lecture articulates how market competition, despite its virtues, could sometimes have undue consequences.

Against this backdrop, the natural concern for any economic designer (e.g., social planner, regulator, manager) is whether the conventional wisdom is expected to hold when performances in each task depend on individual sophistication. Such concerns are furthermore compounded in situations of strategic interactions where decisions made for one task influence those of other tasks.

This paper presents an experimental design that puts the conventional wisdom to the test.[4] To do so, I use the decision-making tasks from the "Hat Puzzle Problem" (HPP) game, a variant of an often cited logical reasoning problem.[5] The design involves three treatments, BASE1, BASE2 and TRADE. Market competition is introduced into TRADE through a two-stage setup. Briefly, players in TRADE are first endowed with the relevant information about the HPP game and one *token*, which represents their rights to performing and receiving the payoff for a task in the HPP game. Thereafter, players enter double auction asset markets where tokens are traded.[6] After

[2] Proponent of market mechanisms often refer to the "market selection hypothesis" (e.g., Alchian (1950), Friedman (1953)) to illustrate how the less able individuals are *eliminated* by the competitive and evolutionary forces of the market. However, DeLong et al. (1990, 1991) show that this is not always the case.

[3] On the topic of corporate governance, Martynova and Renneboog (2008) find that operating performances of acquired firms often do not improve ex-post takeovers.

[4] The allocative property of markets is a subject matter of extensive experimental scrutiny (e.g., Plott and Sunder (1982, 1988)). Players' valuation for commodities in most such market experiments are exogenously defined by the experimenter. The market for decision rights is different given that players' valuation for the commodity (i.e., decision rights) will be endogenously determined by their expected payoffs from performing the tasks.

[5] Variants of the HPP game are often found in graduate game theory textbooks (e.g., Fudenberg and Tirole (1991), Myerson (1991), Osborne and Rubinstein (1994)), discussions about common knowledge (e.g., Geanakoplos (1992), Samuelson (2004)) and epistemological reasoning (e.g., Fagin et al. (2004)). It can be described as follows: Three girls are each wearing a black hat. Each girl observes all other hats but her own. An observer remarks "there is at least one black hat" and asks if the girls knew their hat colour. All reply (publicly) with "negative". The observer asks a second time and the girls again reply with "negative". However, when the observer asks a third time the girls now reply with "black". How did the girls know?

[6] I use double auction asset markets as it seems the least restrictive form of market interactions. Furthermore, prior single period experiments (e.g., Smith (1962), Gode and Sunder (1993)) show that prices in double auction

all transactions are completed, only players with $x \geq 1$ tokens will proceed into the HPP game, performing the equivalent of $x \geq 1$ decision-making tasks. Aggregate performances in TRADE will refer to the decisions made for all tasks and will be benchmarked against the control treatments (BASE1 and BASE2) where markets are omitted.

I use the HPP game for the following three reasons. Firstly, when modelled as a Bayesian game with incomplete information, the *predicted behaviour* for each task owner is independent of the treatment variations. Secondly, adherence to the predicted behaviour is Pareto optimal for all players. This implies that performances in each task can be reduced to a binary outcome, depending on whether the task owner adheres to the predicted behaviour. In this case, between treatment comparisons only need to focus on the *EQ frequency*, the ratio of tasks that are performed in accordance to the predicted behaviours. Here, a higher EQ frequency corresponds to superior aggregate performances. Finally, the predicted behaviour is due to an intricate process of counterfactual reasoning. This provides the link between players' sophistication and their decisions in the HPP game. Furthermore, permutations within the HPP game allow me to vary the complexity of the predicted behaviour. Indeed, prior investigations by Weber (2001) and Bayer and Chan (2009) used the HPP game to study "steps of iterative reasoning".[7] On this matter, the authors find that people are often heterogenous in their abilities to perform such reasoning and the proportion who are able to do so, decreases with the complexity of the HPP game task.

Given the above discussions, how would the experimental design put the conventional wisdom to the test? Assuming that the population of players can be partitioned into *Sophisticated* and *Unsophisticated* types, both of which only differ on their abilities to know the predicted behaviour, the intuition is as follows. Given that adherence to the predicted behaviour is Pareto optimal, expected payoffs for each task will be higher for Sophisticated relative to Unsophisticated types. When markets are introduced, this difference should lead to incentive compatible trade, with Sophisticated types purchasing tokens and Unsophisticated types selling tokens. In line with the conventional wisdom, aggregate performances in the HPP game are improved as markets divert tokens to players who are better able to utilise them, the Sophisticated types.

Are players' types reflected in their pricing behaviours? Kluger and Wyatt (2004) shed some light on this matter with an experiment that embeds the Monty Hall problem into asset markets.[8] Their design can be summarised with the following thought experiment. Assume there to exist an asset that allows one to switch doors in the Monty Hall problem for a winning prize of \$100. Given their posteriors, Sophisticated and Unsophisticated types should value the asset at \$67 and \$50, respectively. The authors find that market prices converged to \$50 when all subjects

markets converge fairly quickly to the competitive equilibrium.

[7]The authors used the HPP game to investigate the *k-level* model (e.g., Nagel (1995), Costa-Gomes et al. (2001), Camerer et al. (2004)). Though behaviours in this study may also involve some elements of the k-level model, such discussions will be omitted as they divert from the main research agenda.

[8]The Monty Hall Problem is inspired by a popular TV game show, where the host Monty Hall hides a winning prize behind one of three closed doors. Contestant are invited to open a door. However, before the door is actually opened, Monty is pre-committed to opening a non-prize door and then offers the contestant the chance to switch her choice to the other unopened door. The dominant strategy in this problem is to always switch as it offers the contestant a 2/3 chance of picking the prize door.

are Unsophisticated (as judged by their decisions in the Monty Hall problem). However, prices converged to \$67, when there are at least two Sophisticated types.

Though the findings of Kluger and Wyatt (2004) suggest that it might be possible for players' types to be reflected in their pricing behaviours, the Monty Hall problem is unique in such that the Unsophisticated type's price is *instinctive.* In fact, personal experiences suggest that people who know the Monty Hall solution often have prior knowledge of the problem - it is difficult to reason about the solution if one is not adequately trained in Bayesian probability. In this case, it is not clear whether the Monty hall problem captures private knowledge or innate abilities. The HPP game is different in the sense that reasoning is an integral part of the predicted behaviour and it is possible to arrive at the solution without prior knowledge.

The findings in this paper are summarised as follows. EQ frequencies are significantly lower in TRADE relative to the control treatments. Furthermore, subjects in TRADE with more tokens are significantly less likely to adhere to the predicted behaviours. These findings suggest that market competition exacerbates aggregate performances in the HPP game and that markets do not divert decision rights to individuals who are better abled to utilise them. To better understand the above, I focused on market prices and provide some evidence that the failure of markets might be due to the behaviours of Unsophisticated types who bid up prices above their competitive equilibrium, a phenomenon known as "Bubbles" - Sophisticated types find it profitable to sell at such prices. As a consequence, market competition often diverted decision rights to Unsophisticated types, allowing them to have an "outsized" influence on aggregate performances. Finally, I provide some anecdotal evidence that "focusing failures" might explain the pricing behaviours of Unsophisticated types.

Taken together, this experiment finds little support for the conventional wisdom and has important implications for any economic designer considering the best mechanism to allocate decision rights. However, I should caution that this study considers a specific class of decision-making tasks where individual sophistication is integrate to their performances. The conventional wisdom may very well hold in other classes of tasks where effort, domain of expertise or private information is integral to performances.

This study also contributes to a broader range of research topics. For example, previous studies have investigated the impact of market mechanisms on coordination games (e.g., Van Huyck et al. (1993), Crawford and Broseta (1998)), the public goods game (e.g., Broseta et al. (2003)) and the Ultimatum game (e.g., Shachat and Swarthout (2013)). However, most such studies use one-sided markets where scarce participation rights are auctioned off. Two-sided markets such as those in TRADE are potentially more complicated given the opportunities for resale of participation rights.[9,10] There is also the broader discussions as to how behavioural biases at the individual level might affect economic outcomes at the aggregate level (e.g., Fehr and Tyran (2005, 2008), Bao et al.

[9]Plott and Williamson (2000) also considers a two-stage decision where decision rights to the second stage "Battle of sexes" (BoS) game are embedded into asset markets. They find that prices in the markets are correlated to behaviours in the BoS. However, due to a different research agenda, the authors do not control for the influence of markets on the BoS.

[10]Kogan et al. (2011) investigate the impact two-sided markets on the coordination game. However, their design use Arrow-Debreu markets where the value of assets depend on outcomes in the game.

Hat / State	s_1	s_2	s_3	s_4	s_5	s_6	s_7
Hat 1	Black	Red	Black	Black	Black	Red	Red
Hat 2	Black	Black	Red	Black	Red	Black	Red
Hat 3	Black	Black	Black	Red	Red	Red	Black

Players at the true state $s \in S$ see all other hats but their own and are publicly reminded that there is at least one black (B) hat. Each state $s' \in S$ is equally likely.

Table 1: States of nature (S)

(2012)). This study shows that markets could sometimes attenuate the impact of individual level behavioural biases on aggregate level measures. Finally, this experiments contributes to the body of research that considers the influence of complexity on asset pricing (e.g., Carlin et al. (2013), O'Brien and Srivastava (1991)).

The rest of this paper is organised as follows. Section 2 details the experiment design, Section 3 describes the models considered in this study and the working hypotheses, Section 4 details the experimental procedures, Section 5 reports the experimental results and Section 6 concludes. The experiment instructions are provided in the appendices and the data is available upon request.

2 Experiment design

To jointly describe the three treatments, I will first introduce the *generic framework*. Thereafter, I will show how the three treatments can be differentiated through restrictions to the generic framework.

2.1 The generic framework

There are $N = \{1, 2, 3\}$ set coloured hats with $M = \{1, 2, 3..., m\}$ set members under each hat. Denote player i_j as the $j \in M$ member of hat $i \in N$. Nature first chooses the true state $s \in S := \times_{i \in N} H_i \setminus \{R_1, R_2, R_3\}$, where $H_i \in \{R_i, B_i\}$ denotes hat i's colour - Red (R) and Black (B) - and each states $s' \in S$ is equally likely. At each $s \in S$, players observe all other hat colours but their own and are publicly reminded that *there is at least one B hat*. Denote $b_i(s) = 0, 1, 2$ as the total number of B hats observed by player i_j. Given their prior over S, players should ascertain their hat to be B if $b_i(s) = 0$ and remain uncertain if $b_i(s) > 0$. Furthermore, uncertain players should assign equal posteriors to either colour. Finally, each player is endowed with *one* token and a working capital loan of 6000 "ECU", the fictitious currency.

To better visualise the above, the states of nature are presented on Table 1. Here, if $s = s_1$, then $b_1(s_1) = b_2(s_1) = b_3(s_1) = 2$. However, players have different private information. Player 1_j assigns equal posteriors to the states s_1 and s_2, Player 2_j to the states s_1 and s_3, and Player 3_j to the states s_1 and s_4. Nevertheless, Aumann (1976) "agreement theorem" shows that for any $s \in S$, it can only be common knowledge that there is at least one B hat.

Given the information asymmetry, the generic framework consists of two stages, the "Trading stage" followed by the "HPP game". However, players' participation in the Trading stage will depend on some common parameter $\Gamma \in \{0, 1\}$. Specifically, players only enter the Trading stage if $\Gamma = 1$ and go directly into the HPP game if $\Gamma = 0$.

The Trading stage consist of N set markets where players trade tokens for capital but only with those other players under the same hat. Trade is facilitated by the continuous double auction (CDA) mechanism for a duration of 120 seconds, short-sales are prohibited and players only observe activities in their own market. There is a price ceiling of 1000 ECU on the bid and ask prices.[11] Denote by $x_{i_j} \geq 0$ and $L_{i_j} \geq 0$, player i_j's inventories of tokens and capital, respectively, at the end of the Trading stage.

Only players with $x_{i_j} \geq 1$ tokens will enter the HPP game, where they face the task of deducing their own hat colour within $t = 1, 2, 3, 4$ periods. Note that $x_{i_j} = 1$ for all players whenever $\Gamma = 0$. At each periods $t \leq 3$, they are presented with the question "Do you know your hat colour?" to which they have up to 240 seconds to simultaneously and independently respond with: "My Hat is Red" (a_R), "My Hat is Black" (a_B) or "No! I will decide in a later period" (a_N). Each player ends the HPP game upon choosing actions a_R or a_B, and only progresses to period $t+1$ if she had chosen a_N in period t. Actions at period t are *public information* at period $t + 1$. Specifically, players will observe the relative frequencies to which those other players with one, two, three,...,six tokens under each i hat had chosen a_R, a_B, a_N or "awaiting results" (i.e., ended the HPP game at some period $t' < t - 1$). Finally, players who make it to period 4 are presented with the same question but restricted to choosing either a_R or a_B.[12]

Payoffs are realised when players avoid or end the HPP game. The loan is repaid and tokens, where applicable, are *each* redeemed at $\pi_{i_j} > 0$, a rate that depends on their decisions in the HPP game. The token redemption rate can be summarised as follows: Each token has an initial value of 950 ECU and decreases by 50 ECU each time the player chooses a_N and a further 700 ECU if the player is incorrect in her hat colour prediction. For example, a player under a black hat who chooses a_N in periods 1 and 2, and a_B in period 3 will redeem her tokens at the rate $\pi_{i_j} = 950 - 2(50)$. If she is instead under a red hat, the rate will be $\pi_{i_j} = 950 - 2(50) - 700$. Intuitively, players should always seek to ascertain their true hat colour in the soonest possible period. Finally, payoffs when $\Gamma = 1$ are $\Pi_{i_j} = L_{i_j} - 6000$ and $\Pi_{i_j} = L_{i_j} - 6000 + \pi_{i_j} x_{i_j}$ if $x_{i_j} = 0$ and $x_{i_j} > 0$, respectively. When $\Gamma = 0$, payoffs are simply $\Pi_{i_j} = \pi_{i_j}$

2.2 BASE1, BASE2 and TRADE

Given the generic framework, the three treatments are differentiated as follows: BASE1 ($\Gamma = 0$; $m = 1$), BASE2 ($\Gamma = 0$; $m = 6$) and TRADE ($\Gamma = 1$; $m = 6$). To see how market competition

[11] The price ceiling serves to limit the experimental cost given that I cannot impose negative cash transfer on experimental subjects (i.e., the loan of 6000 ECU has to be returned). Nevertheless, it has no implications on the theoretical predictions.

[12] Briefly, Weber (2001) and Bayer and Chan (2009) both consider a $\Gamma = 0$ and $m = 1$ versions of the generic framework with the exception that players are restricted to choosing a_B or a_N in the HPP game. Also, the HPP game ends for *all* players upon any player choosing a_B. These differences imply that comparisons to their findings will not be prudent.

for decision rights are embedded into TRADE, notice that tokens represent players' participation rights to the HPP game and payoffs from the HPP game are scaled by the number of tokens owned. This is equivalent to a setting where players trade their decision rights but are restricted to making the same decisions for all tasks owned. I employ this restriction to maintain the consistency of decision-making structure and the predicted behaviour across all treatment.[13] BASE1 and BASE2 serve as natural controls to TRADE and correspond to the extreme cases, one where a single player purchases all tokens within her market (BASE1) and the other where no trade occurs (BASE2).

3 Models and hypotheses

The predicted behaviour for each player will be detailed in the following subsection. For the ease of exposition, I will define a player to be in *agreement* if she adheres to the predicted behaviour and the *agreement frequency* as the ratio of agreement players in the HPP game. Building on this, I define an *EQ* event to occur if a token is owned by an agreement player and the *EQ Frequency* as the ratio of EQ events against the total number of tokens - x EQ events occur whenever a player with x tokens is in agreement. Both frequencies must be equivalent in BASE1 and BASE2 but not necessarily in TRADE. The agreement frequency assigns uniform weights to the behaviours of all players and is informative as to how players play the HPP game. In contrast, the EQ frequency assigns greater weights to the behaviours of players with more tokens and provides a measure of aggregate performances in the HPP game.

In the following, I will first introduce the Bayesian model to show how EQ and agreement frequencies are independent of the treatment variations. To do so, the model assumes all players to *rational* and *sophisticated*, and this being a common knowledge fact. Borrowing from Myerson (1991) description of players, a rational player is one who seeks to maximise some value function, here assumed to be her individual payoff. A sophisticated player is one who knows everything there is to know about the game and makes the same inferences as the designer of the game would make.

Thereafter, I will introduce a simple behavioural model that allows for heterogeneity amongst the sophistication of players - they are still assumed to be rational. In doing so, the model offers predictions as to how EQ and agreement frequencies could differ across treatments. These predictions will form the basis of the test hypotheses.

3.1 The Bayesian model

First consider the optimal period t action for players who are *certain* and *uncertain* of their hat colour. This is trivial for the former - choose a_B or a_R if they know their hats to be B or R, respectively - but less obvious for the latter as it depends on whether uncertain players expect to ascertain their their true hat colour at some later period $t' > t$. Assuming that they always do,

[13] In the absence of this restriction, players in TRADE can employ "hedging" strategies.

uncertain players should always choose a_N.[14]

I will now illustrate with the $s = \{B_1, B_2, B_3\}$ case in BASE1, the "indirect communication" process (Geanakoplos and Polemarchakis (1982)) by which uncertain players ascertain their own hat colour. Here, each player observes $b_i(s) = 2$ and remains uncertain in period 1 - she chooses a_N. Observing the public information - the previous period's public actions, players in period 2 will deduce there to be at least two B hats - otherwise the player under the B hat would have chosen a_B in period 1. However, each player already knows this and there should be no revisions to her posteriors - she again chooses a_N. Nevertheless, if it is common knowledge that all players applied the same reasoning, it therefore becomes common knowledge that there is at least two B hats. Finally in period 3, each player deduces from the public information her hat to be B - otherwise the two other players under the B hats would have chosen a_B in period 2. This process of reasoning and counterfactual reasoning can be extended to any $s \in S$ and predicted behaviour for player i_j is to choose a_N at periods $t < b_i(s) + 1$ and at period $t = b_i(s) + 1$, choose a_B or a_R if $H_i = B_i$ or $H_i = R_i$, respectively.[15] Adherence to the predicted behaviour corresponds to the Pareto optimal token redemption rate $\pi_i^* = 950 - 50b_i(s)$.

Since all players choose their actions independently and simultaneously, the predicted behaviours for each HPP game player in BASE2 and TRADE must be identical to BASE1. They are also identical at each t for all i hat players. By backward deduction, players in market $i \in N$ of TRADE should expect to ascertain their hat colour at period $b_i(s) + 1$, independent of what colour this might be. This corresponds to equilibrium price $p_i^* = \pi_i^*$, where risk-neutral players are indifferent between buying and selling tokens.[16]

Substituting p_i^* and π_i^* where relevant leads to the equilibrium payoff $\Pi_i^* = 950 - 50b_i(s)$ - one can in equilibrium write $L_{i_j} = 6000 - p_i^*(x_{i_j} - 1)$. As such, the predicted behaviour or equilibrium payoff for each player i_j only depends on $b_i(s)$ and are independent of the treatment variations.

3.2 Behavioural model and hypotheses

The predicted behaviour is trivial when $b_i(s) = 0$ but exponentially more complicated as $b_i(s)$ increases. Being in agreement therefore depends on players' sophistication and the body of experimental evidence in strategic interactions suggests that people are often heterogenous in their abilities to apply such sophisticated reasoning (see Crawford et al. (2013) for a survey). The behavioural model therefore assumes that players observing $b_i(s) > 0$ can be broadly partitioned into *Sophisticated* and *Unsophisticated* types - the $b_i(s) = 0$ case is trivial. Both types are rational and

[14]Uncertain players face the intra-period decision of ending (i.e., choosing a_B or a_R) the HPP game at period t with the expected redemption rate of $\pi'_{i_j} = 950 - 50(t-1) - 0.5(700)$ or choosing a_N with the expectation of ascertaining one's hat at period $t' > t$. The expected rate with the latter is $\pi''_{i_j} = 950 - 50(t' - 1)$. Given that $\pi'_{i_j} < \pi''_{i_j}$ for any t', uncertain players should always choose a_N.

[15]Notice that players only deduce their own hat colour through the public actions of the B hat players. In fact, the public action of the R hat player will be irrelevant to all players.

[16]It is difficult to determine the equilibrium price for risk-adverse players. For example, Tirole (1982) show that risk-adverse rational players will only trade when there is an expected profit from doing so. This leads to a no-trade outcome.

use Bayesian updating but differ on their abilities to know the predicted behaviour. Furthermore, Sophisticated types in the absence of the common knowledge conditions, face “strategic uncertainty” with interpreting the purposeful nature of other’s (i.e., the B hat players) public action. Face with such uncertainty, some hold negative ex-ante expectations as to ascertaining their true hat colour. To account for such expectations, I further partition Sophisticated types into the *P-Sophisticated* and *N-Sophisticated* types, referring to those who hold positive and negative ex-ante expectations, respectively.

Uncertain N-Sophisticated and Unsophisticated types should always end the HPP game (choose a_B or a_R) in the first period, with the expected token redemption rate of $950 - 0.5(700) = 600$.[17] By this logic, such types will only purchase additional tokens at prices $p_i \leq 600$. In contrast, P-Sophisticated types are assumed to follow the predicted behaviour till faced with information that causes them to revise their expectations.[18] Upon such revision, the P-Sophisticated type should immediately end the HPP game. By definition, P-Sophisticated types will only purchase tokens at prices $p_i \leq p_i^*$.

Given the assumed behaviours for all types, EQ frequency in BASE1 will depend on the proportion of P-Sophisticated types. In principle, the *intensity* of public information in the HPP game increases with the number of players under hat. This is because each player observes the aggregate actions under each hat. Whilst unlikely, this increase may mitigate issues of strategic uncertainty for Sophisticated types.[19] I check for this with the following hypothesis test:

Hypothesis 1 *EQ frequencies in BASE1 and BASE2 are equal.*

Notice that at prices $p_i \in (600, p_i^*]$, it is incentive compatible for P-Sophisticated types to buy tokens and all other types to sell tokens. Furthermore, N-Sophisticated types observing transactions at this price range may realise that only P-Sophisticated types are purchasing tokens and thus revise their ex-ante expectations (i.e., become P-Sophisticated types). Inline with the conventional wisdom, market competition should therefore divert tokens towards P-Sophisticated types, who through their decisions drive improvements in aggregate performances. This leads me to the next two hypotheses:

Hypothesis 2 *EQ frequency in TRADE is higher than those in BASE1 and BASE2.*

Hypothesis 3 *Agreement probabilities for the $b_i(s) > 0$ cases in TRADE are higher for players with $x_{i_j} > 1$ relative to those with $x_{i_j} = 1$ tokens.*

[17]Choosing a_N is strictly dominated as they incur the cost of 50 ECU with no expected future revisions to their posteriors.

[18]Suppose that a P-Sophisticated type Ann in BASE1 observes $b_i(s) = 2$. In period 2, Ann observes that the two other B hat players chose a_B in period 1. Ann immediately deduces that they had deviated from their respective predicted behaviour, but is uncertain as to whether they had done so because they had observed one or two other B hats. Unable to discriminate between the two cases, Ann no longer expects to correctly deduce her own hat colour.

[19]This is somewhat similar to the “wisdom of the crowd” effect, the idea that the aggregated decision of a crowd is more reliable than that of a single player within the crowd.

Both hypotheses examine the two facets of the conventional wisdom which had motivated this study. Hypothesis 1 investigates whether market competition improves aggregate performances in the HPP game. Hypothesis 2 investigates whether market competition diverts decision rights to individuals who are better able to utilise them.

A caveat to the above discussions is the assumption that Unsophisticated types recognise their own limitations in their pricing behaviours. If this is not the case, such types might purchase tokens at prices above 600 or p_i^*. It is not difficult to see how "bubble prices" (i.e., transactions above p_i^*) could have undue consequences on EQ frequency, given that Sophisticated types should strictly prefer to sell their tokens at such prices. In this case, it is possible for markets to exacerbate aggregate performances in the HPP game.

4 Experimental procedures

A total of 108 inexperience subjects (36 per treatment) were recruited from the undergraduate cohort at the University of Exeter in 2012 and 2013, through the ORSEE (Greiner (2015)) platform. The sessions (2 per treatment) were programmed and conducted with the *z-Tree* (Fischbacher (2007)) software, and involved one practice round followed by ten experimental rounds. In addition to a fixed show-up payment, subjects' experimental earnings were computed as their average payoff over all ten rounds and converted into cash at a pre-determined exchange rate. Finally, subjects were required to complete the non-incentivised Cognitive Reflect Test (Frederick (2005)) or CRT, and report their current course of study.[20,21] The above details are summarised on Table 2, where the differences in show-up payments and exchange-rates were due to the longer anticipated sessions in TRADE, which required a higher show-up payment. I find no significant between-treatment differences of CRT scores (Kruskal-Wallis, $\rho = 0.686$). However, there seems to be a higher proportion of business school and STEM subjects in TRADE relative to the other two treatments - subjects were recruited on a first come basis. I will control for this in the econometric analysis.

A pilot trial with the software prompted minor modifications to the HPP game. Here, subjects were sometimes classified as being in agreement even when they had indicated their behaviours to be random - subjects provided feedback to the design at the end of the pilot session. To minimise such coincidences, I included an "outside option" to BASE1 and BASE2. In addition to the actions a_B, a_R and a_N, subjects could also choose "Toss a Coin, I will never know" (a_C). In doing so, she ends the HPP game with a fixed cost of 250 ECU, on top of any prior deductions incurred with choosing a_N. However, only the experimenter will know that she had chosen a_C whilst all other subjects will observe that she had chosen a_B or a_R with equal probability.[22] The action a_C

[20]Subjects were also asked " do you have prior familiarity with the decision-making task in the experiment?". Here, 22%, 17% and 3% of subjects in BASE1, BASE2 and TRADE, respectively, responded with positive. However, the ambiguity of the question implies that subjects may have either interpreted it as prior familiarity with the HPP game or market competition for decision rights. It is therefore difficult to give meaning to such statistics.

[21]The CRT involves three questions where the instinctive answer is wrong. I use it to control for abilities at the individual level. Concerned that the HPP game might be easier for subjects with background training in game theory or advance mathematics, I also elicited their course of studies.

[22]Assume that subject A under a red hat chooses a_N at period 1 and a_C at 2, and the computer thereafter randomly

	BASE1 ($n = 36$)	BASE2 ($n = 36$)	TRADE ($n = 36$)
Academic Schools (% of subjects enrolled in)			
Business school	44%	36%	64%
STEM	8%	3%	14%
Humanities	25%	17%	0%
Biomedical and life science	11%	8%	6%
Social sciences	3%	28%	17%
Others	8%	8%	0%
Show-up payment (£)	5	5	8
Exchange rate (ECU per £1)	67	67	100
Mean total payment (£)	16.65	16.87	15.65
Experiment duration (minutes)	90	95	130

Subjects' academic schools were determined through their reported course of studies. Economics students study at the business school. STEM refers to the school of science, technology, engineering, and mathematics.

Table 2: Payoff Parameters and Demographics

will always be dominated in the Bayesian model and does not influence the predicted behaviour - choosing a_C never counts towards an agreement. It will however be dominant for subjects who do not expect to ascertain their true hat colour. This outside option was excluded from TRADE as an equivalent already existed, the ability to sell one's token.

Each treatment employed fixed matching of subjects. For efficient comparisons, two sequences of states ($s \in S$) were randomly generated prior to the experiment proper and administered accordingly to the respective sessions. This ensured that the number of subjects observing zero, one, or two B hats were identical across all treatments.[23]

To avoid confusion, the notion of tokens were omitted from BASE1 and BASE2 instructions. Subjects in TRADE were informed that they required at least one token to participant in the HPP game, that their payoffs from the HPP game were scaled by the number of tokens owned and that they had to return the loan of 6000 ECU at the end of the round - there were 21 (6%) bankruptcy cases in TRADE.[24] Finally, subjects received feedback as to their payoffs and hat colours at the end of each round.

chooses a_B for her. All other subjects in period 3 will observe A to have chosen a_B in period 2. Subject A's tokens will be redeemed at $950 - 50 - 250 = 650$ ECU.

[23]Each subject had observed one and two B hats at least three times in the experiment.

[24]TRADE subjects were first presented with the other hat colours and given up to 100 seconds to acknowledge their observations before proceeding into the Trading stage. This delay was introduced to allow subject time to contemplate their behaviours. To avoid boredom, subjects who avoided the HPP game could also passively observe the decisions of those other subjects who participated in the HPP game through their computer screens.

5 Results

5.1 Do markets for decision rights improve aggregate performances in the HPP game?

The discussions henceforth will omit the subscripts i and j, and refer to b_0, b_1 and b_2 as cases where subjects observed zero, one and two B hats, respectively. The agreement and EQ frequencies are reported on Panels A-D of Table 3. For example, 16 of the 24 subjects who observed b_1 in round I of BASE1 were in agreement. Similarly, of the 24 subjects TRADE subjects who observed b_1 at start of round I, only 19 proceeded to the HPP game, out of which 11 were in agreement whilst 12 EQ events were observed.

As an empirical warm-up, I first investigate the influence of increasing the number of subjects under each hat on aggregate performances in the HPP game (Hypothesis 1).

Result 1 *Increasing the number of subjects under each hat has no significant influence on aggregate performances in the HPP game.*

Support. Aggregated - pooling over all b cases - EQ frequencies in BASE1 and BASE2 are 0.54 and 0.53, respectively (Fisher Exact (FE), $\rho = 0.76$). Pooled EQ frequencies in BASE1 (BASE2) for the b_0, b_1 and b_2 cases are 1.00, 0.70 and 0.14 (1.00, 0.66 and 0.16), respectively (FE, $\rho \geq 0.51$ in each b comparison).

Expectedly, all BASE1 and BASE2 subjects were in agreement for the b_0 case and proportionally less for the b_1 case. To better understand deviations for the latter, I consider the special case involving subjects under a R hat who observed b_1 - 84 subjects in each treatment.[25] Here, 86% and 74% (FE, $\rho = 0.08$) of BASE1 and BASE2 subjects, respectively, progressed to period 2. Amongst these, 92% and 94% (FE, $\rho = 0.75$), respectively, were in agreement. A similar phenomenon is observed for B hat subjects observing b_1. Here, 77% and 85% (FE, $\rho = 0.17$) of BASE1 and BASE2 subjects, respectively, progressed to period 2, amongst which 82% and 75% (FE, $\rho = 0.29$), respectively, were in agreement.

The above observations with the b_1 case are consistent with the behavioural predictions that subjects who did not expect to ascertain their hat colour (i.e., Unsophisticated and N-Sophisticated types) will choose to end the HPP game in the first period.[26] More importantly, they lend support to the conjecture that changes in the intensity of public information do not influence the proportion of P-Sophisticated types.

As for the b_2 case, 50% and 40% (FE, $\rho = 0.10$) of subjects in BASE1 and BASE2, respectively, deviated from the predicted behaviour in very first period. This high attrition rate points to some

[25] This case is special given that subjects in BASE1 would have observed one other subject under the B hat choosing a_b in period 1 whilst those in BASE2 subjects would have observed six other subjects doing so.

[26] Amongst these subjects only 51% and 19% (FE, $\rho = 0.04$) from BASE1 and BASE2, respectively, chose the outside option a_C. It is not clear why this ratio is seemingly different across treatments or why it is not higher. Perhaps given that the payoffs were computed from the loss domain, developments from *Prospect theory* (Kahneman and Tversky (1979)) might explain why subjects often preferred the "riskier" option (i.e., choosing a_B or a_R) to the "safer" one (i.e., a_C).

	Panel A: BASE1 (Agreement/EQ Events)				Panel B: BASE2 (Agreement/EQ Events)			
Round	b_0	b_1	b_2	Total.	b_0	b_1	b_2	Total.
I	12(1.0)	16(.67)	-	28(.78)	12(1.0)	16(.67)	-	28(.78)
II	12(1.0)	21(.88)	-	33(.92)	12(1.0)	18(.75)	-	30(.83)
III	-	17(.71)	1(.08)	18(.50)	-	16(.67)	1(.08)	17(.47)
IV	-	7(.58)	4(.17)	11(.31)	-	8(.67)	3(.13)	11(.31)
V	-	7(.58)	2(.08)	9(.25)	-	7(.58)	5(.21)	12(.33)
VI	-	7(.58)	5(.21)	12(.33)	-	5(.42)	3(.13)	8(.22)
VII	6(1.0)	15(.63)	3(.50)	24(.67)	6(1.0)	15(.63)	1(.17)	22(.61)
VIII	-	18(.75)	1(.08)	19(.53)	-	18(.75)	2(.17)	20(.56)
IX	12(1.0)	20(.83)	-	32(.89)	12(1.0)	17(.71)	-	29(.81)
X	-	6(.50)	2(.08)	8(.22)	-	7(.58)	5(.21)	12(.33)
Total.	42(1.0)	134(.70)	18(.14)	194(.54)	42(1.0)	127(.66)	20(.16)	189(.53)

	Panel C: TRADE (EQ Events)				Panel D: TRADE (Agreement)			
Round	b_0	b_1	b_2	Total.	b_0	b_1	b_2	Total.
I	12(1.0)	12(.50)	-	24(.67)	7(1.0)	11(.58)	-	18(.69)
II	12(1.0)	12(.50)	-	24(.67)	7(1.0)	9(.56)	-	16(.70)
III	-	8(.33)	2(.17)	10(.28)	-	6(.38)	2(.25)	8(.33)
IV	-	4(.33)	2(.08)	6(.17)	-	4(.50)	2(.13)	6(.29)
V	-	8(.67)	5(.21)	13(.36)	-	5(.71)	4(.29)	9(.43)
VI	-	6(.50)	8(.33)	14(.39)	-	4(.50)	4(.33)	8(.40)
VII	6(1.0)	14(.58)	0(.00)	20(.56)	3(1.0)	9(.60)	0(.00)	12(.52)
VIII	-	14(.58)	1(.08)	15(.42)	-	8(.67)	1(.20)	9(.53)
IX	12(1.0)	10(.42)	-	22(.61)	6(1.0)	8(.67)	-	14(.78)
X	-	10(.83)	2(.08)	12(.33)	-	5(.71)	2(.16)	7(.37)
Total.	42(1.0)	98(.51)	20(.16)	160(.44)	23(1.0)	69(.58)	15(.21)	107(.50)

Each cell in Panels A-C details the observed number of EQ events with the EQ frequency in parenthesis. Each cell in Panel D details the observed number of agreement subjects in TRADE with the agreement frequency in parenthesis. Both frequencies must be equivalent in BASE1 and BASE2.

Table 3: EQ and agreement frequencies (BASE1, BASE2 and TRADE)

threshold in reasoning abilities and explains the low EQ frequency. Finally, I observe little evidence for learning as aggregated EQ frequencies over rounds I-V (VI-X) of BASE1 and BASE2 are 0.55 and 0.54 (0.53 and 0.51), respectively.

Result 1 is convenient since it suggests that BASE1 and BASE2 can be pooled together to form the "BASE" treatment. Indeed, *agreement probabilities* - probability of being in agreement - for BASE1 and BASE2 subjects are not significantly different (10% level) for the b_1 and b_2 cases. This suggests that differences between BASE and TRADE should directly address the central crux of this study as to whether market competition for decision rights improves aggregate performances in the HPP game (Hypothesis 2). Furthermore, if the conventional wisdom holds, I should also expect improvements to be most evidential for the b_1 case, given that a sizeable proportion of BASE1 and BASE2 subjects demonstrated knowledge of the predicted behaviour.

Result 2 *Market competition for decision rights exacerbate aggregate performances in the HPP game.*

Support. Aggregated EQ frequencies in BASE and TRADE are 0.53 and 0.44, respectively (FE, $\rho < 0.01$). Pooled EQ frequencies in BASE (TRADE) for the b_0 and b_2 cases are 1.00 and 0.15 (1.00 and 0.16), respectively (FE, $\rho \geq 0.88$ for both cases). However, pooled frequencies for the $b = 1$ case are 0.68 and 0.51 (FE, $\rho < 0.01$) in BASE and TRADE, respectively.

There is also little evidence for learning as aggregated EQ frequencies over rounds I-V and VI-X of TRADE are 0.43 and 0.46, respectively. Taken together, Results 1 and 2 reflect negatively on the influence of markets and provide contradictory evidence to the conventional wisdom. Furthermore, the differences are primarily driven by the b_1 case. Some explanations as to the "failure" of markets are hinted by the pooled EQ and agreement frequencies over the ten rounds of TRADE, with the latter being significantly higher (Signrank, $\rho = 0.02$). This suggests that market competition had more often than not diverted tokens to non-agreement subjects. The following subsection explores this explanation in greater detail.

5.2 Do markets divert decision rights to individuals who are better able to utilise them?

To study the allocation property of markets, I present on Panel A of Table 4, the pooled agreement frequencies in TRADE apportioned by token ownership (x). For example, 70 subjects in TRADE had participated in the HPP game with $x = 1$ token for the b_1 case. Amongst these, 47 were in agreement. With the exception of the b_0 case, agreement frequencies are seemingly lower for subjects with more tokens. To see this more clearly, I partition TRADE subjects into the "Netbuyers" (NB) and "Non-Netbuyer" (nNB) groups, where $x > 1$ and $x = 1$, respectively. Here, agreement frequencies for nNB and NB subjects are 0.67 and 0.44 (0.32 and 0.09), respectively, for the b_1 (b_2) case. Amongst the non-agreement NB subjects, 75% and 55% for the b_1 and b_2 cases, respectively, also ended the HPP game in the first period.

Panel A: By tokens ownership (x)					
Tokens (x)	Group	b_0	b_1	b_2	Total.
$x = 1$	nNB	10(1.0)	47(.67)	12(.32)	69(.59)
$x = 2$	NB	9(1.0)	16(.47)	1(.05)	26(.41)
$x = 3$	NB	3(1.0)	5(.41)	2(.22)	10(.42)
$x = 4$	NB	-	1(.50)	0(.00)	1(.17)
$x = 5$	NB	1(1.0)	0(.00)	-	1(.33)
$x = 6$	NB	-	-	0(.00)	0(.00)
Total $x > 1$	NB	13 (1.0)	22(.44)	3(.09)	38(.39)
Total $x \geq 1$	nNB+NB	23(1.0)	69(.58)	15(.21)	107(.50)

Panel B: By average purchase price ($\ddot{p}$) - NB subjects only					
$\ddot{p}$	Group	b_0	b_1	b_2	Total.
$\ddot{p} \leq p^*$	NB-nB	3(1.0)	16(.57)	2(.25)	21(.54)
$\ddot{p} > p^*$	NB-B	10(1.0)	6(.27)	1(.04)	17(.29)
Total.		13(1.0)	22(.44)	3(.09)	38(.39)

Each cell in Panels A and B details the observed number of agreement subjects with the agreement frequency in parenthesis. Here, $p^* = 950 - 50b(s)$ denotes the equilibrium price.

Table 4: Agreement frequencies by x and $\ddot{p}$ (TRADE)

Clearly, the above observations suggest that markets did not divert decision rights to players who are better able to utilise them. To see formally, I use the GLLAMM logistic mixture model (Rabe-Hesketh et al. (2004, 2005)) to study the behavioural differences between NB and nNB subjects (Hypothesis 3).[27] The econometric estimates for the b_1 and b_2 cases, are reported on Panel A of Table 5, where I also include controls for subjects' CRT score, sequence of states administered and academic school - estimates for controls are not reported. Finally, to also control for dynamic behaviours across rounds, I include the dummy variable "Agree-Previous", which is only unity when a subject is in agreement during the last encounter of the same b_1 or b_2 case.

Result 3 *Agreement probabilities for the b_1 and b_2 cases are not higher but possibly lower for NB relative to nNB subjects in TRADE.*

Support. At the 10% level, agreement probabilities for the b_1 ($\rho = 0.08$) and b_2 ($\rho = 0.05$) cases are significantly lower for NB relative to nNB subjects.

Further to Result 3, the econometric estimates for the b_1 ($\rho = 0.33$) and b_2 ($\rho = 0.19$) cases suggest there to be no significant differences between agreement probabilities for the average BASE

[27]Because subjects remained in the same group for the duration of the experiments, the residual estimates are expected to be correlated amongst subjects of the same group but independent across groups. I therefore use the GLLAMM model to account for the correlations. The econometric model takes the following functional form

$$\text{Logit}[\text{Prob.}(y_{rlg} = 1|\mathbf{x}_{rlg}, \zeta^2_{lg}, \zeta^3_g) = \mathbf{x}'_{rlg}\beta + \zeta^2_{lg} + \zeta^3_g + \epsilon_{rlg}$$

where the dependent variable denotes an agreement in round r, by subject l belonging to group g and $\mathbf{x}_{rlg}$ are the covariates of interest. Here, ϵ_{rlg} denotes the within-subject variances. The model assumes that $\zeta^2_{lg}|\mathbf{x}_{rlg}, \zeta^3_g \sim \mathcal{N}(0, \psi^2)$, where ψ^2 denotes the between-subject, within-group variances. Furthermore, it assumes that $\zeta^3_g \sim \mathcal{N}(0, \psi^3)$, where ψ^3 denotes the between group variances. To derive the estimates, adaptive quadrature numerical methods were used to maximise the log-likelihood function (see Rabe-Hesketh et al. (2002)).

Dependent variable: Subjects in agreement (std. error in parenthesis)				
	Panel A		Panel B	
Covariates / Case	b_1	b_2	b_1	b_2
Reference: BASE subjects				
TRADE	-0.45 (0.50)	1.78 (1.31)	-0.45 (0.49)	1.81 (1.35)
Reference: nNB subjects in TRADE				
TRADE × NB	-0.88* (0.51)	-1.77* (0.91)		
TRADE × NB-B			-1.91*** (0.69)	-2.81** (1.34)
TRADE × NB-nB			-0.04 (0.63)	-0.50 (1.11)
Agree-Previous	1.24*** (0.29)	1.52** (0.70)	1.33*** (0.29)	1.52** (0.70)
Constant	-0.13 (0.76)	-4.04*** (1.49)	-0.18 (0.74)	-4.01*** (1.48)
Log-Likelihood	260.94	118.86	258.13	117.51
n	504	323	504	323
Wald Test: $NBnB = NBB$			$5.39^{\dagger}$	2.10

***, ** and * denote significance at 1%, 5% and 10% levels, respectively. TRADE, NB, NB-B and NB-nB are situation dummies of interest. I also control for sequence administered, subjects' academic schools and CRT score. Three and six subjects in TRADE never participated in the HPP game when observing b_1 and b_2, respectively.

Table 5: GLLAMM logistic mixture model estimates

and TRADE subjects.[28] This lends further support to the possibility that NB subjects behave differently from the average nNB and BASE subject.

In general, Result 3 provides contradictory evidence to the conventional wisdom that market competition will divert decision rights to individuals who are better able to utilise them. Finally, given that the EQ frequency assigns greater weights to NB relative to nNB subjects, the inferior aggregate performances in TRADE should not be unexpected.

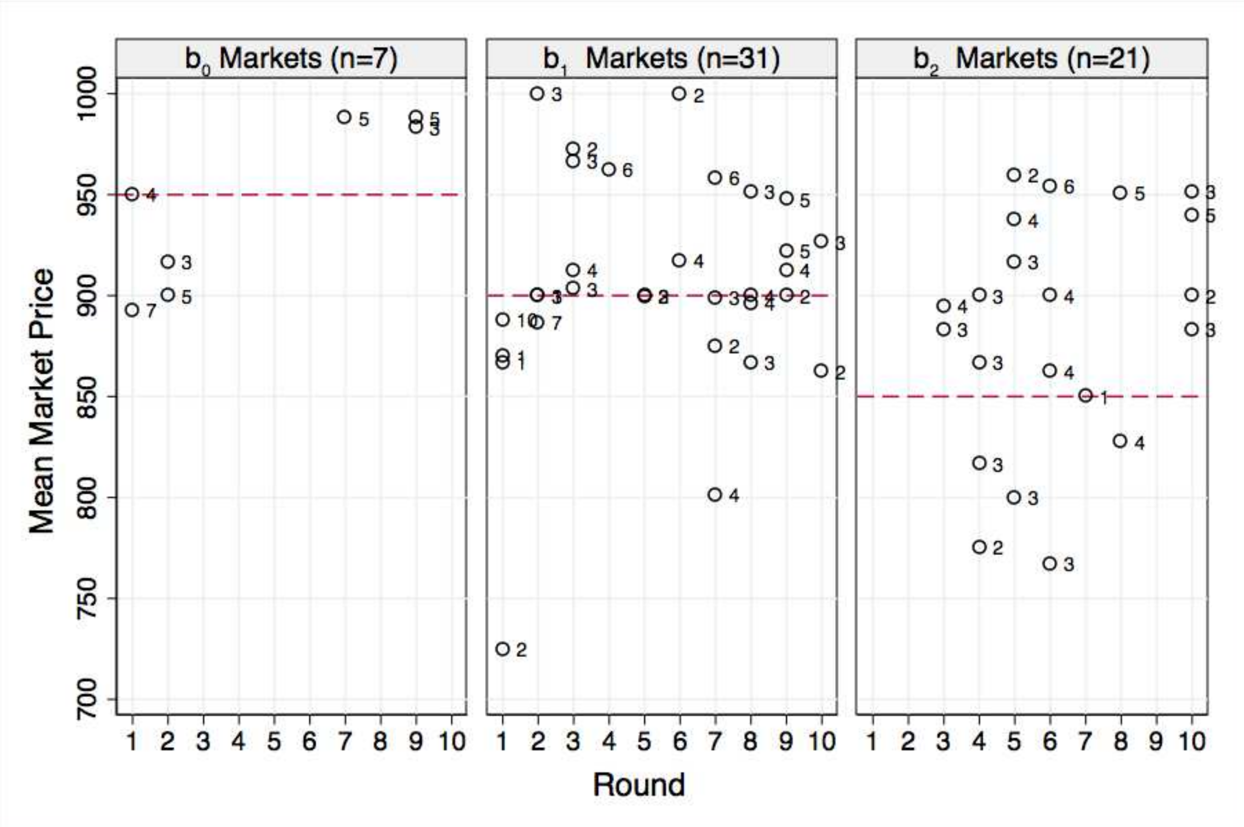
5.3 Explaining the failure of markets

To better understand why markets had seemingly failed to divert decision rights to individuals who are better able to utilise them as predicted by the behavioural model, I turn my attention to prices. Figure 1 details the mean prices and transaction volumes in b_0, b_1 and b_2 markets. Contradictory to the behavioural model's predictions, 69%, 48% and 74% of all transactions in b_0, b_1 and b_2 markets, respectively, occured above the equilibrium price $p^* = 950 - 50b$, a phenomenon known as price "Bubbles".

Bubbles are interesting given that Sophisticated types should strictly prefer to sell their tokens at prices above p^*.[29] This leads me to conjecture that the failure of markets were due to the behaviours

[28] I find no significant marginal influences due to sequence administered, subjects' CRT score or their academic school of study. Finally, agree probabilities at each round for the b_1 ($\rho < 0.01$) and b_2 ($\rho = 0.03$) cases are significantly higher when subjects were in agreement during the last encounter of the same case.

[29] Not surprisingly, end of round payoffs in TRADE are significantly higher ($\rho < 0.01$) for subjects who avoided the HPP game.



Mean transaction prices are denoted by the hollow circle with the accompanying numerical value detailing the transactional volume. The dashed horizontal line details the equilibrium price $p^* = 950 - 50b$. Only 59 mean prices are reported as no transaction occured in one of the b_2 markets.

Figure 1: Mean transaction prices and transaction volumes (TRADE)

of Unsophisticated types who bid up prices above p^*. Whilst it is difficult to formally investigate the above conjecture, support for it will naturally require some evidence of heterogeneity amongst the NB subjects, with agreement probabilities being lower for those purchasing tokens above p^*.

To study pricing behaviours, I compute for each NB subject, her *average purchase price* ($\ddot{p} = 6000 - L)/(x-1)$), defined as the average price paid for each additional unit of token - here L and x denote end of market inventories of capital and tokens, respectively.[30] Building on the rationale that Sophisticated types should not purchase tokens at prices above p^*, I further partition NB subjects into the "NetBuyer NoBubble" (NB-nB) and "NetBuyer Bubble" (NB-B) groups, referring to those whose $\ddot{p} \leq p^*$ and $\ddot{p} > p^*$, respectively. Panel B of Table 4 details the agreement frequencies for NB-nB and NB-B subjects. Here, agreement frequencies for the b_1 case are 0.57 and 0.27 for NB-nB and NB-B subjects, respectively - there are too few agreement NB subjects for the b_2 case to make meaningful statistical comparisons.

Building on the above observations I hypothesise that if the NB-B subjects are indeed Unso-

[30]Identifying subjects' pricing behaviours is tricky given the CDA mechanism that facilitates trade. Here, subjects could simultaneous buy and sell tokens within the same round, and do so at different prices. I therefore focus on behaviours across the entire market duration.

	Panel A: No. of Subjects			Panel B: Tokens Owned			Panel C: EQ Events		
	nNB	NB-nB	NB-B	nNB	NB-nB	NB-B	nNB	NB-nB	NB-B
b_0	10(.43)	3(.13)	10(.43)	10(.23)	7(.17)	25(.60)	10(.23)	7(.17)	25(.60)
b_1	70(.58)	28(.23)	22(.18)	70(.36)	64(.33)	58(.31)	47(.48)	36(.37)	15(.15)
b_2	37(.52)	8(.11)	26(.36)	37(.29)	18(.14)	71(.57)	12(.60)	6(.30)	2(.10)
Total.	117(.55)	39(.18)	58(.27)	117(.45)	89(.34)	154(.21)	69(.43)	49(.31)	42(.26)

Each cell in Panel A details the number of subjects from the specific group with the ratio (i.e. subjects as a proportion of all subjects) in parenthesis. Each cell in Panel B details the total number of tokens owned by the specific subject group with the ratio (i.e., token owned as a proportion of all tokens) in parenthesis. Each cell in Panel C details the total number of EQ events attributed to the specific subject group with the ratio (i.e., EQ events attributed to that group as a proportion of all EQ events in TRADE) in parenthesis.

Table 6: Tokens owned and EQ events by subject group (TRADE)

phisticated types, I should expect agreement probabilities to be: (i) Lower for NB-B relative to nNB subjects, (ii) Lower for NB-B relative to NB-nB subjects and (iii) No lower for NB-nB relative to nNB subjects. Whilst conditions (i) and (ii) are straightforward, condition (iii) is necessary to exclude the possibility that agreement probabilities are simply lower for NB subjects, independent of $\ddot{p}$. These three conditions are formally investigated with the GLLAMM logistic mixture model and the estimates are reported on Panel B of 5.

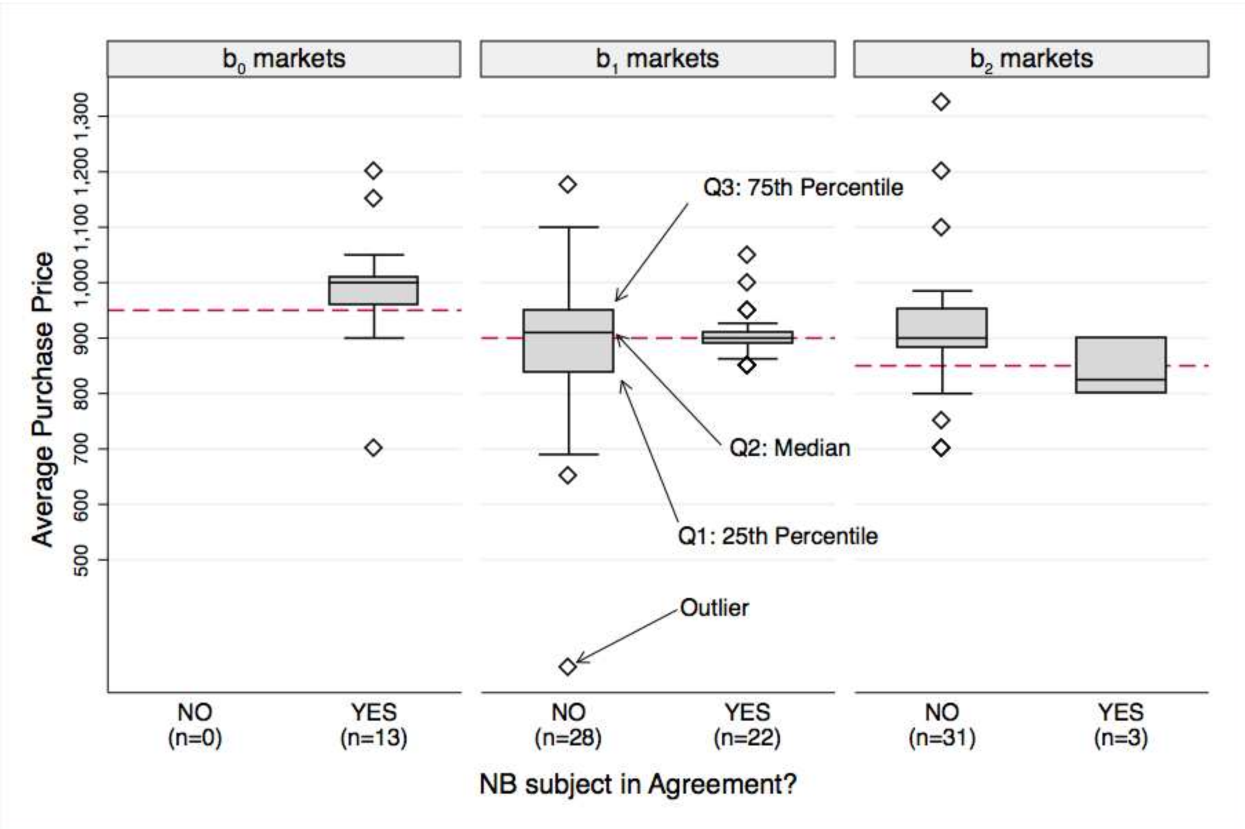
Result 4 *There is some evidence for the b_1 case that NB-B subjects are Unsophisticated types. The evidence for the b_2 case is less clear.*

Support. From Panel B of Table 5, agreement probabilities for the b_1 ($\rho < 0.01$) and b_2 ($\rho = 0.04$) cases are significantly lower for NB-B relative to nNB subjects. Agreement probabilities for the nNB and NB-nB subjects are not significantly different ($\rho \geq 0.65$ for both cases). The Wald test rejects the equality for the NB-B and NB-nB estimates for the b_1 ($\rho = 0.02$) case but not the b_2 ($\rho = 0.15$) case.

The above result lends weight to the possibility that the failure of markets were due to the behaviours of Unsophisticated types who bid up prices above p^*. Panels A-C of Table 6 provides further insights as to the influence of Unsophisticated types on the aggregate performances. Focusing on b_1 case, we note that NB-B subjects formed 18% of all subjects in the HPP game, owned 31% of all tokens but were only responsible for 15% of all EQ events. In contrast, nNB subjects whilst forming 58% of all HPP game subjects only owned 36% of all tokens - they were responsible for 48% of all EQ event. These observations suggest that market competition allowed Unsophisticated types to have an “outsized” influence on aggregate performances.

5.4 Explaining the behaviour of Unsophisticated types

Why were Unsophisticated types willing to purchase tokens at prices above p^*? To shed some light on this matter, I detail on Figure 2 the distribution of $\ddot{p}$ for NB subjects, apportioned by whether they were in agreement. Here, $\ddot{p}$ for agreement subjects cluster significantly closer to p^*



Each bar details the interquartile distribution of $\ddot{p}$ for NB subjects, apportioned by b and whether they were in agreement. The dashed horizontal line denotes the equilibrium price $p^* = 950 - 50b$.

Figure 2: Boxplot of average purchase prices (TRADE)

relative to non-agreement subjects.[31] These observations suggest that "focusing failures" (e.g., Tor and Bazerman (2003), Idson et al. (2004)) or the inability to link decisions in the Trading stage to behaviours in the HPP game, might be an explanation as to why Unsophisticated types were willing to purchase tokens above p^*.

The intuition here is that Unsophisticated types are more vulnerable to focusing failures than Sophisticated types. We see some evidence for this as $\ddot{p}$ for agreement subjects seem to be spot on at p^*, suggesting that they are incorporating their expected behaviours in the HPP game into their market pricing decisions. In contrast, the arbitrary nature of the non-agreement subjects' $\ddot{p}$ suggest that they might have been following some pricing strategy that is independent of their expected behaviours in the HPP game.

6 Conclusions

This paper seeks to test the conventional wisdom that market competition for decision rights improves aggregate performances in all relevant decision-making tasks by diverting such rights to individuals who are better able to utilise them. To do so, I use an experiment that embeds asset markets into the HPP game. Contradictory to the conventional wisdom, the experiment finds that market competition exacerbate aggregate performances in the HPP game and diverts decision rights to individuals who are less able to utilise them.

I remain sanguine as to the consequences of market competition. In part, this is due to the fact that the experiment finds that the the inferior performances in TRADE can be traced to the formation of price bubbles in the markets, which diverted decision rights to the Unsophisticated types. This potentially hints at role of price regulations or intervention in mitigating the adverse effects of market competition. This will be a direction for further research.

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[31] A simple panel linear regression finds absolute deviation of $\ddot{p}$ from p^* in b_1 markets to be significantly ($\rho = 0.02$) smaller for agreement relative to non-agreement subjects.

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Outcome	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Chance	1/7	1/7	1/7	1/7	1/7	1/7	1/7
Hat A	Black	Red	Black	Black	Black	Red	Red
Hat B	Black	Black	Red	Black	Red	Black	Red
Hat C	Black	Black	Black	Red	Red	Red	Black

Table A1: The 7 possible outcomes (BASE1)

A Appendix: Instructions for BASE1

There will be 10 experiment rounds, where you receive a payoff (denoted in ECU) at the end of each round. Upon completion of all 10 rounds, your earnings for the experiment will be computed as the average over ten rounds and converted to cash at the exchange rate of 67 ECU to £1. In addition, you will also receive a £5 show up fee. We shall now describe each experimental round.

A.1 Description of each round

Each round will involve three coloured hats - A, B and C. Each hat can be either Red or Black, and there is exactly one player under each hat. You will not be able to see your own hat colour. You will see the other two hat colours. There will always be one black hat. To determine the hat colours, the computer randomly picks from 1 of the 7 possible outcomes (see Table A1). Each player will see all other hat colours but his own. There is an equal chance for any one of these outcomes. Notice that at each outcome, there will always be at least one black hat.

For example, in outcome 2 Hat A is red, Hat B is black and Hat C is black.

- The player under Hat A will see that: Hat B is Black and Hat C is Black.
- The player under Hat B will see that: Hat A is Red and Hat C is Black.
- The player under Hat C will see that: Hat A is Red and Hat B is Black.

See Figure A1 for an example of what you might observe. Here you are under Hat A and you see that both Hat B and C are black.

Your task in each round is to determine the colour of your hat. You will do this in the decision stage that will consist of 4 periods. At each period the computer will present you with the following question, to which you must choose from 4 possible actions (a), (b), (c) or (d).

Computer's question: "Do You Know your hat colour?"

Your actions: (a) My Hat is RED, (b) My Hat is BLACK, (c) No! I will decide in a later period and (d) Toss a Coin, I would never know.

Here are some rules:

(Rule 1) At each period, you have a maximum of 4 minutes to choose an action.

(Rule 2) You will immediately end the decision stage if the action (a), (b) or (d) is chosen.

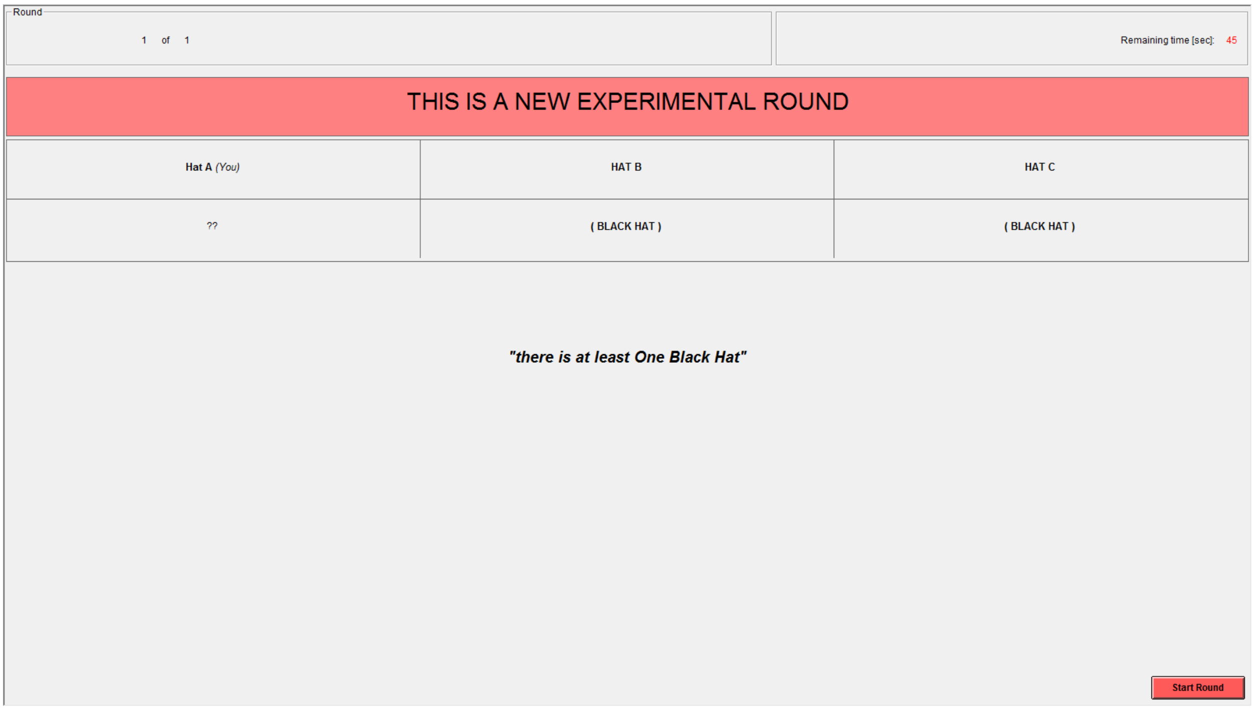

Figure A1: You see all other hat colours (BASE1)

(Rule 3) You will only go to the next period if you chose (c) in the previous period.

(Rule 4) If you arrive at period 4, you can only choose from the actions (a), (b) or (d).

(Rule 5) If you chose (d) the computer will simulate a coin toss and choose on your BEHALF either option (a) or (b) with equal chances

(Rule 6) Any action chosen will be known to all other players in the subsequent period.[32]

You are said to have "determined your hat colour" when you choose (a), (b) or (d). This is why you will only go to the next period if you have chosen (c). For example, if you had chosen (a) in period 1, the decision stage immediately ends for you. In period 2, all other players will observe that you had chosen (a) in period 1. However, if you had chosen (c) in period 1, you go on to period 2, when you must again choose your action. All players will also observe that you had chosen (c) in period 1. Here are some screenshots to help you understand the decision stage design (Figure A2 and Figure A3).

Figure A2 presents an illustration of the first period in the decision stage. You are under Hat B and you see the other hat colours. In addition the computer presents you with the question "Do you know your hat colour" to which you must reply with one of the 4 possible actions.

Figure A3 presents an illustration of the second period in the decision stage. You are under Hat B and you see the other hat colours. The computer again presents you with the question "Do

[32]Note that if you had chosen (d) and the computer chooses (b) on your behalf, the other players will only see that you had chosen (b).

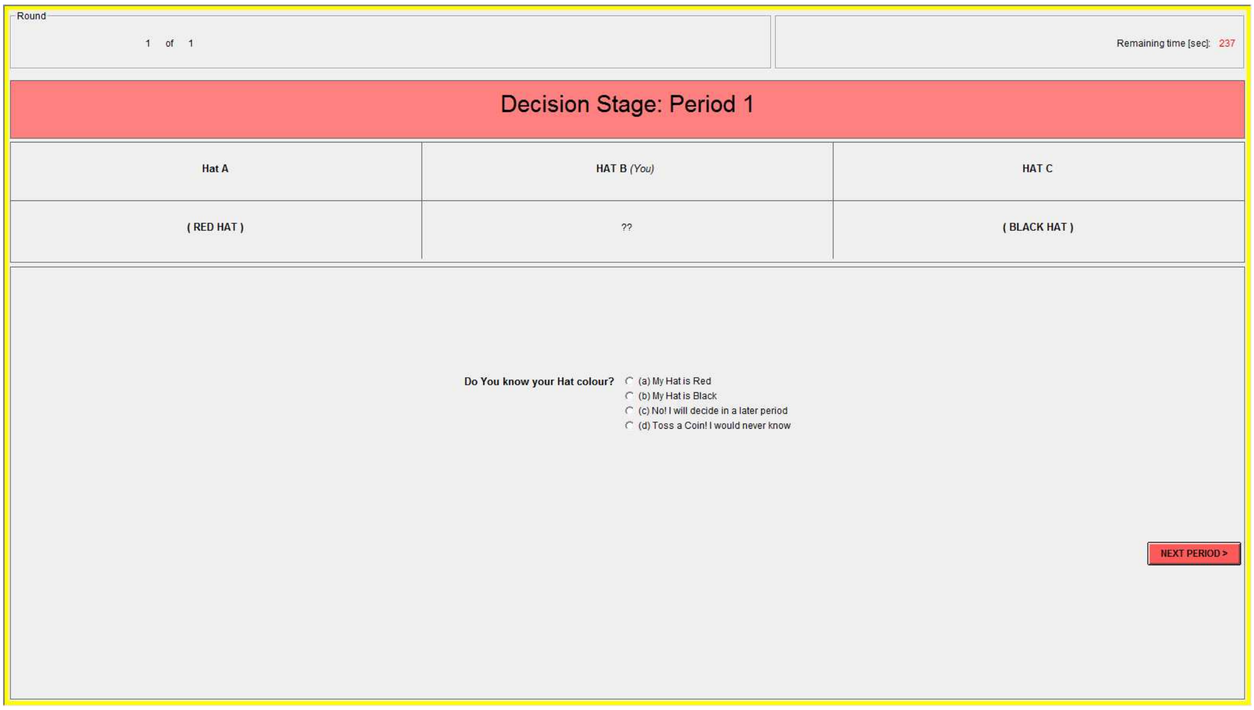

Figure A2: Decision stage period 1 (BASE1)

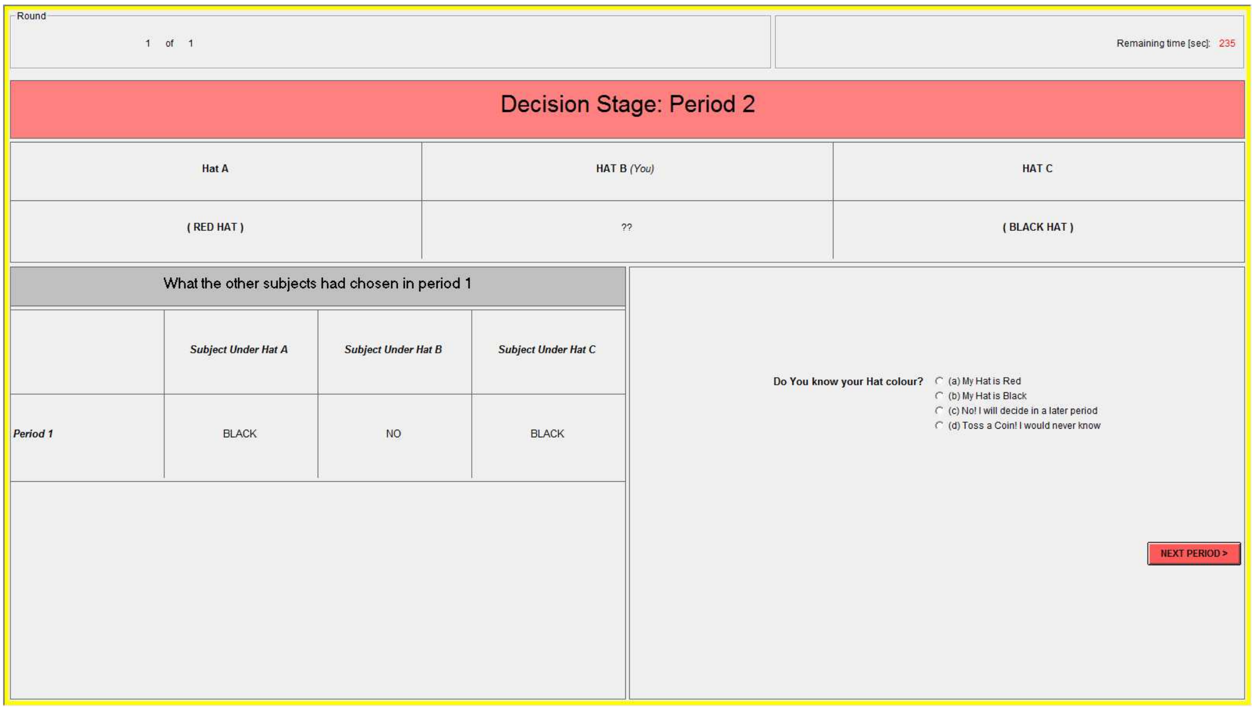

Figure A3: Decision stage period 2 (BASE1)

Description	Correct	Incorrect
“determined your hat colour” in Period 1	950 ECU	250 ECU
“determined your hat colour” in Period 2	900 ECU	200 ECU
“determined your hat colour” in Period 3	850 ECU	150 ECU
“determined your hat colour” in Period 4	800 ECU	100 ECU

Table A2: Payoffs with choosing (a) or (b)

Description	Payoff
“determined your hat colour” with (d) in Period 1	700ECU
“determined your hat colour” with (d) in Period 2	650ECU
“determined your hat colour” with (d) in Period 3	600ECU
“determined your hat colour” with (d) in Period 4	550ECU

Table A3: Payoffs with choosing (d)

you know your hat colour” to which you must reply with one of the 4 possible actions. In addition, you also see on your screen the actions chosen by the other players in the previous period (period 1). You see that the player under Hat A had chosen (b) in period 1. You also see that the player under Hat C had chosen (b) in period 1. Finally, in this illustration you had chosen (c) in period 1.

After all players had ended the decision stage, your hat colour with be made known and your payoffs for the round will be determined. Your payoff depends on whether you had correctly determined you hat colour and the period which you had “determined your hat colour”. If you had chosen (a) or (b), then your payoffs will depend on whether you are correct and the period which you had chosen them (see Table A2). If You had chosen (d), then your payoffs will only depend on the period which you had chosen (c) (see Table A3).

The payoffs can be easily summarised as follows. You start the round with 950 ECU. You get 50 ECU deducted for each time you had chosen (c). In addition, you get 700 ECU deducted if you had chosen (a) or (b) and was found to be incorrect, or no deduction if found to be correct. If you had chosen (d), you’ll get a fixed deduction of 250 ECU. Here are some examples to help you understand the payoff

1. Your hat is black. In period 1 you choose (c), in period 2 you choose (c) and in period 3 you choose (b). You have correctly determined your hat colour and your payoffs are therefore 850 ECU.

2. Your hat is black. In period 1 you choose (c), in period 2 you choose (c) and in period 3 you choose (a). You have incorrectly determined your hat colour and your payoffs are therefore 150 ECU.

3. Your hat is black. In period 1 you choose (c), in period 2 you choose (c) and in period 3 you choose (d). Your payoffs are therefore 600 ECU.

This completes the description of each experimental round.

Outcome	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Chance	1/7	1/7	1/7	1/7	1/7	1/7	1/7
Hat A	Black	Red	Black	Black	Black	Red	Red
Hat B	Black	Black	Red	Black	Red	Black	Red
Hat C	Black	Black	Black	Red	Red	Red	Black

Table B1: The 7 possible outcomes (BASE2)

A.2 Other information

Please note that you will be matched with the same other players over all 10 rounds of the experiment. After the completion of 10 experiment rounds, we require you to complete a survey before you receive your cash payments. Please feel free to clarify any question or doubts you might have with regards to the instructions.

B Appendix: Instructions for BASE2

There will be 10 experiment rounds, where you receive a payoff (denoted in ECU) at the end of each round. Upon completion of all 10 rounds, your earnings for the experiment will be computed as the average over ten rounds and converted to cash at the exchange rate of 67 ECU to £1. In addition, you will also receive a £5 show up fee. We shall now describe each experimental round.

B.1 Description of each round

Each round will involve three coloured hats - A, B and C. Each hat can be either Red or Black, and there is exactly six players under each hat. You will not be able to see your own hat colour. You will see the other two hat colours. There will always be one black hat. To determine the hat colours, the computer randomly picks from 1 of the 7 possible outcomes (see Table B1). Each player will see all other hat colours but his own. For example, in outcome 2, Hat A is red, Hat B is black and Hat C is black.

- The players under Hat A will see that: Hat B is Black and Hat C is Black.
- The players under Hat B will see that: Hat A is Red and Hat C is Black.
- The players under Hat C will see that: Hat A is Red and Hat B is Black.

See Figure B1 for an example of what you might observe. Here you are under Hat A and you see that both Hat B and C are black.

Your task in each round is to determine the colour of your hat. You will do this in the decision stage that will consist of 4 periods. At each period the computer will present you with the following question, to which you must choose from 4 possible actions (a), (b), (c) or (d).

Computer's question: "Do You Know your hat colour?"

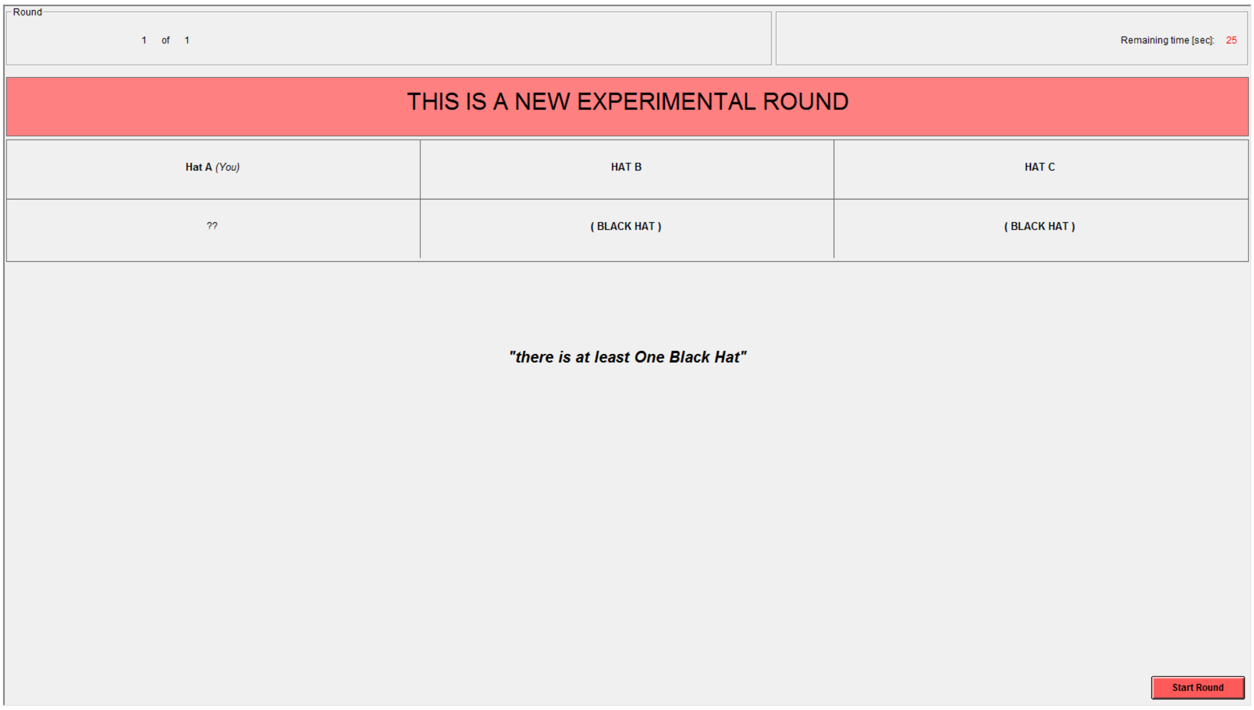

Figure B1: You see all other hat colours (BASE2)

Your actions: (a) My Hat is RED, (b) My Hat is BLACK, (c) No! I will decide in a later period and (d) Toss a Coin, I would never know.

Here are some rules:

(Rule 1) At each period, you have a maximum of 4 minutes to choose an action.

(Rule 2) You will immediately end the decision stage if the action (a), (b) or (d) is chosen.

(Rule 3) You will only go to the next period if you chose (c) in the previous period.

(Rule 4) If you arrive at period 4, you can only choose from the actions (a), (b) or (d).

(Rule 5) If you chose (d) the computer will simulate a coin toss and choose on your BEHALF either option (a) or (b) with equal chances

(Rule 6) Any action chosen will be known to all other players in the subsequent period.[33]

You are said to have "determined your hat colour" when you choose (a), (b) or (d). This is why you will only go to the next period if you have chosen (c). For example, if you had chosen (a) in period 1, the decision stage immediately ends for you. In period 2, all other players will observe that you had chosen (a) in period 1. However, if you had chosen (c) in period 1, you go on to period 2, when you must again choose your action. All players will also observe that you had chosen (c)

[33] Note that if you had chosen (d) and the computer chooses (b) on your behalf, the other players will only see that you had chosen (b).

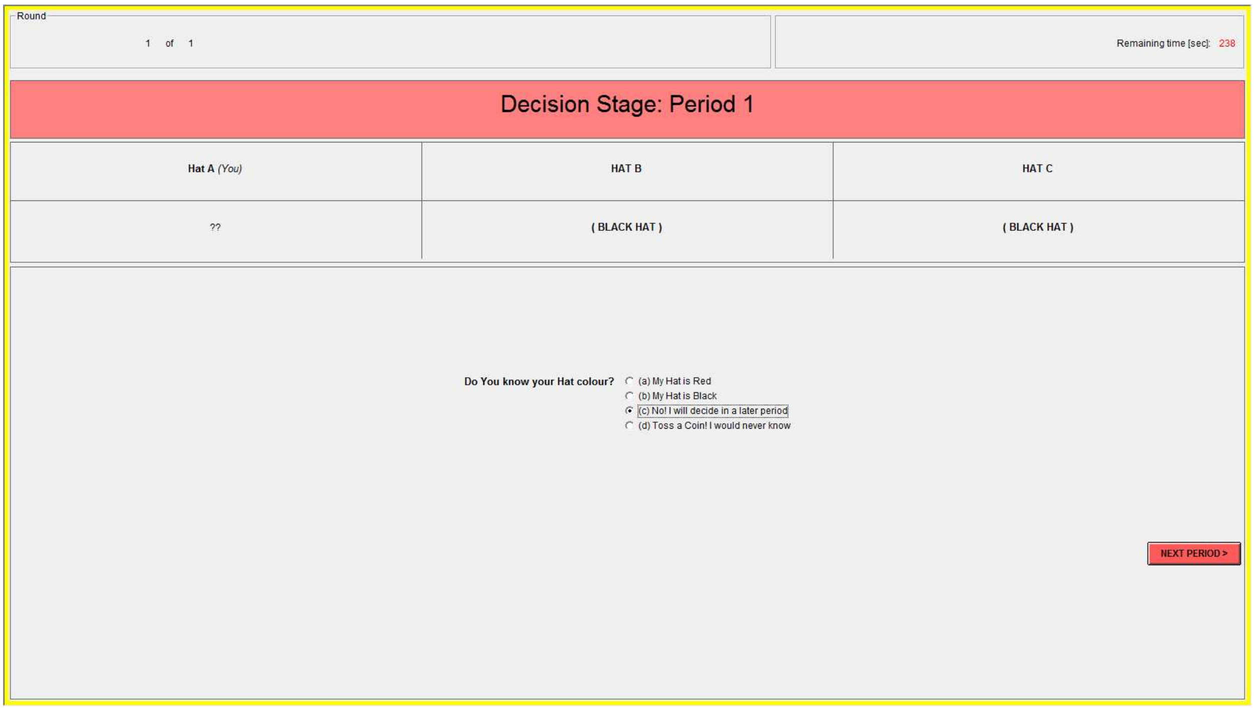

Figure B2: Decision stage period 1 (BASE2)

in period 1. Here are some screenshots to help you understand the decision stage design (Figure B2, Figure B3 and Figure B4).

Figure B2 presents an illustration of the first period in the decision stage. You are under Hat A and you see the other hat colours. In addition the computer presents you with the question "Do you know your hat colour" to which you must reply with one of the 4 possible actions.

Figure B3 presents an illustration of the second period in the decision stage. You are under Hat A and you see the other hat colours. The computer again presents you with the question "Do you know your hat colour" to which you must reply with one of the 4 possible actions. In addition, you also see on your screen the actions chosen by the other players in the previous period. For the six players under Hat A, all of them had chosen (c) in period 1. For the six players under Hat B, one of them had chosen (a), one of them had chosen (b) and four of them had chosen (c) in period 1. Finally for the six players under Hat C, two of them had chosen (a), one of them had chosen (b) and three of them had chosen (c) in period 1.

Figure B4 presents an illustration of the third period in the decision stage. You are under Hat A and you see the other hat colours. The computer again presents you with the question "Do you know you hat colour" to which you must reply with one of the 4 possible actions. For the six players under Hat A, all of them had chosen (c) in period 2. For the six players under Hat B, two of them had chosen (b) in period 2, two of them had chosen (c) in period 2 and two of them had not participated in period 2 since they had ended the round in period 1 and are awaiting results. For the six players under Hat C, three of them had chosen (c) in period 2 and three of them had not participated in period 2 as they had ended the round in an earlier period.

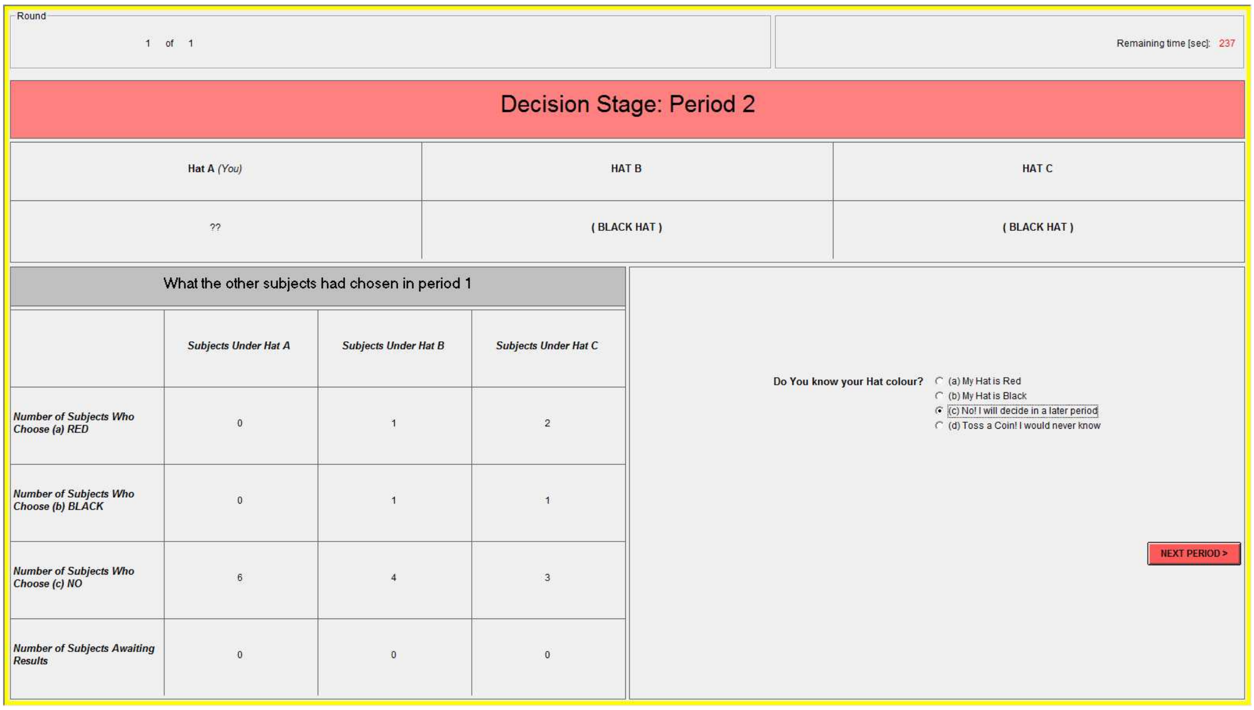

Figure B3: Decision stage period 2 (BASE2)

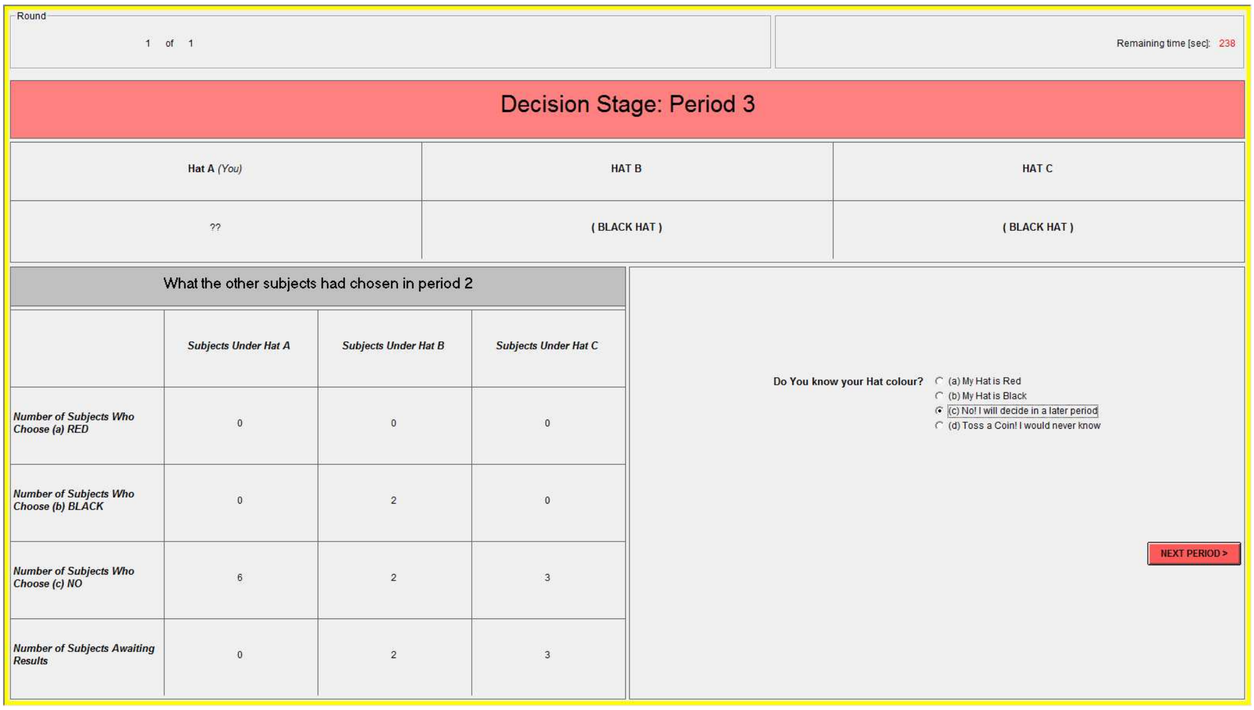

Figure B4: Decision stage period 3 (BASE2)

Description	Correct	Incorrect
“determined your hat colour” in Period 1	950 ECU	250 ECU
“determined your hat colour” in Period 2	900 ECU	200 ECU
“determined your hat colour” in Period 3	850 ECU	150 ECU
“determined your hat colour” in Period 4	800 ECU	100 ECU

Table B2: Payoffs with choosing (a) or (b)

Description	Payoff
“determined your hat colour” with (d) in Period 1	700ECU
“determined your hat colour” with (d) in Period 2	650ECU
“determined your hat colour” with (d) in Period 3	600ECU
“determined your hat colour” with (d) in Period 4	550ECU

Table B3: Payoffs with choosing (d)

After all players had ended the decision stage, your hat colour with be made known and your payoffs for the round will be determined. Your payoff depends on whether you had correctly determined your hat colour and the period which you had “determined your hat colour”. If you had chosen (a) or (b), then your payoffs will depend on whether you are correct and the period which you had chosen them (see Table B2). If You had chosen (d), then your payoffs will only depend on the period which you had chosen (c) (see Table B3).

The payoffs can be easily summarised as followed. You start the round with 950 ECU. You get 50 ECU deducted for each time you had chosen (c). In addition, you get 700 ECU deducted if you had chosen (a) or (b) and was found to be incorrect, or no deduction if found to be correct. If you had chosen (d), you'll get a fixed deduction of 250 ECU. Here are some examples to help you understand the payoff

1. Your hat is black. In period 1 you choose (c), in period 2 you choose (c) and in period 3 you choose (b). You have correctly determined your hat colour and your payoffs are therefore 850 ECU.

2. Your hat is black. In period 1 you choose (c), in period 2 you choose (c) and in period 3 you choose (a). You have incorrectly determined your hat colour and your payoffs are therefore 150 ECU.

3. Your hat is black. In period 1 you choose (c), in period 2 you choose (c) and in period 3 you choose (d). Your payoffs are therefore 600 ECU.

This completes the description of each experimental round.

B.2 Other information

Please note that you will be matched with the same other players over all 10 rounds of the experiment. After the completion of 10 experiment rounds, we require you to complete a survey before

Outcome	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Chance	1/7	1/7	1/7	1/7	1/7	1/7	1/7
Hat A	Black	Red	Black	Black	Black	Red	Red
Hat B	Black	Black	Red	Black	Red	Black	Red
Hat C	Black	Black	Black	Red	Red	Red	Black

Table C1: The 7 possible outcomes (TRADE)

you receive your cash payments. Please feel free to clarify any question or doubts you might have with regards to the instructions.

C Appendix: Instructions for TRADE

There will be 10 experiment rounds, where you receive a payoff (denoted in ECU) at the end of each round. Upon completion of all 10 rounds, your earnings for the experiment will be computed as the average over ten rounds and converted to cash at the exchange rate of 100 ECU to £1. In addition, you will also receive a £8 show up fee. We shall now describe each experimental round.

C.1 Description of each round

Each round will involve three coloured hats - A, B and C. Each hat can be either Red or Black, and there is exactly six players under each hat. You will not be able to see your own hat colour. You will see the other two hat colours. There will always be one black hat. To determine the hat colours, the computer randomly picks from 1 of the 7 possible outcomes (see Table C1). Each player will see all other hat colours but his own. There is an equal chance for any one of these outcomes. Notice that at each outcome, there will always be at least one black hat. For example, in outcome 2, Hat A is red, Hat B is black and Hat C is black.

- The players under Hat A will see that: Hat B is Black and Hat C is Black.
- The players under Hat B will see that: Hat A is Red and Hat C is Black.
- The players under Hat C will see that: Hat A is Red and Hat B is Black.

See Figure C1 for an example of what you might observe. Here you are under Hat A and you see that both Hat B and C are black.

After you have observed the hat colours, the round will proceed to the "trading stage" followed by the "decision stage". You begin the trading stage with 1 Token and a loan of 6000 ECU cash that must be returned at the end of the round. In the trading stage you have the opportunity to either buy more tokens or sell your token. You will only be trading with the other players under the same hat. After all transaction of tokens are completed, only players with at least one token will proceed to the decision stage - if you do not wish to participate in the decision stage, you should sell your token. In the decision stage, you will perform the task of determining your hat

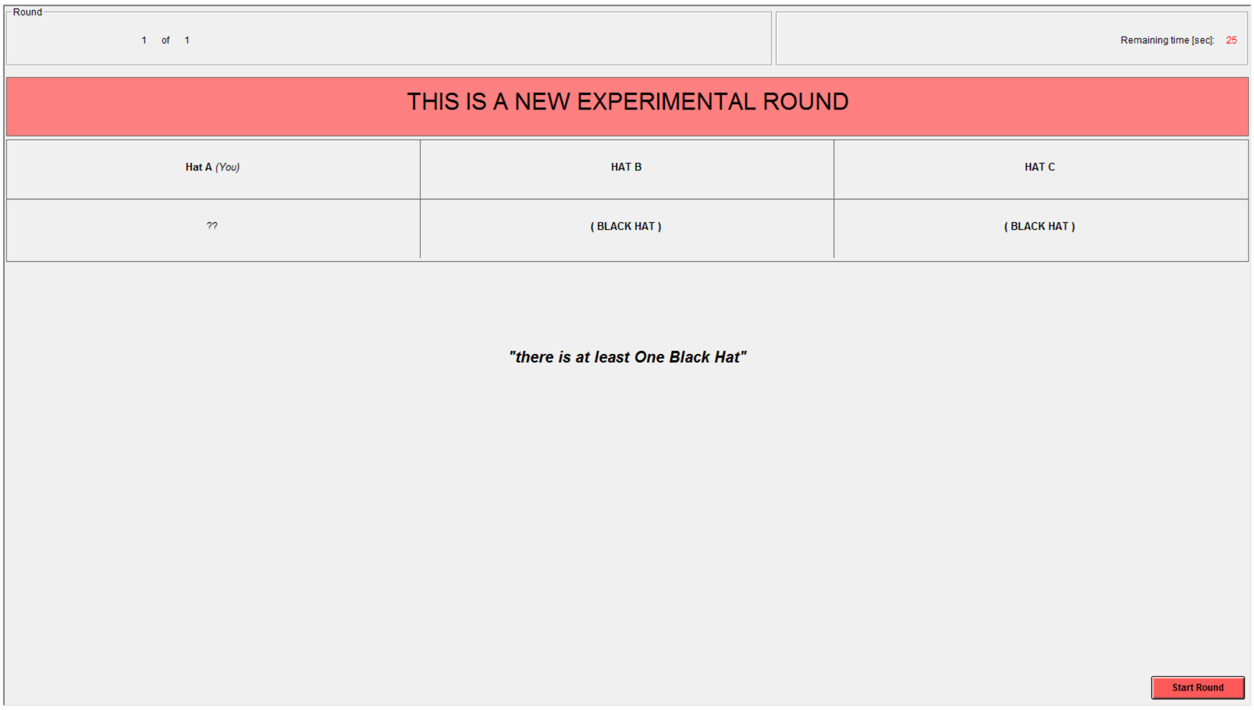

Figure C1: You see all other hat colours (TRADE)

colour. After you have completed the decision stage, you will return the loan of 6000 ECU, and your tokens owned will redeemed by the computer (bought by the computer) at a rate that will depend on your behaviours in the decision stage. In the following, we shall first describe the design of the trading and decision stages. Thereafter, we will describe how you token redemption rate will be determined and finally we will describe your payoffs in the round.

C.1.1 Trading Stage

All players begin the trading stage with One Token and a loan of 6000 ECU (Money). Here, you are permitted to buy or sell tokens, but only with the other players under the same hat. This implies that the market will consist of exactly 6 players and will last for 120 seconds. You will buy and sell tokens through a continuous double auction mechanism which we will now explain. See Figure C2 for a screenshot of the trading stage.

To buy or sell tokens, you will need to first announce your "Ask" and "Bid" prices to all other players. Your "Ask" price (between 0 and 1000ECU) tells all other players how much you are willing to sell a token for. Your "Bid" price (between 0 and 1000ECU) tells all other players how much you are willing to buy a token for. The column "Market Ask Prices" reflects the ask prices of all six players you interact with. The column "Market Bid Prices" reflects the bid prices of all six players you interact with. To buy a token, simply select the price on the "Market Ask Prices" column and click "Buy". Likewise to sell tokens simply select the price on the "Market Bid Prices" column and click "sell". The column "Market Price" provides the history of all transaction prices

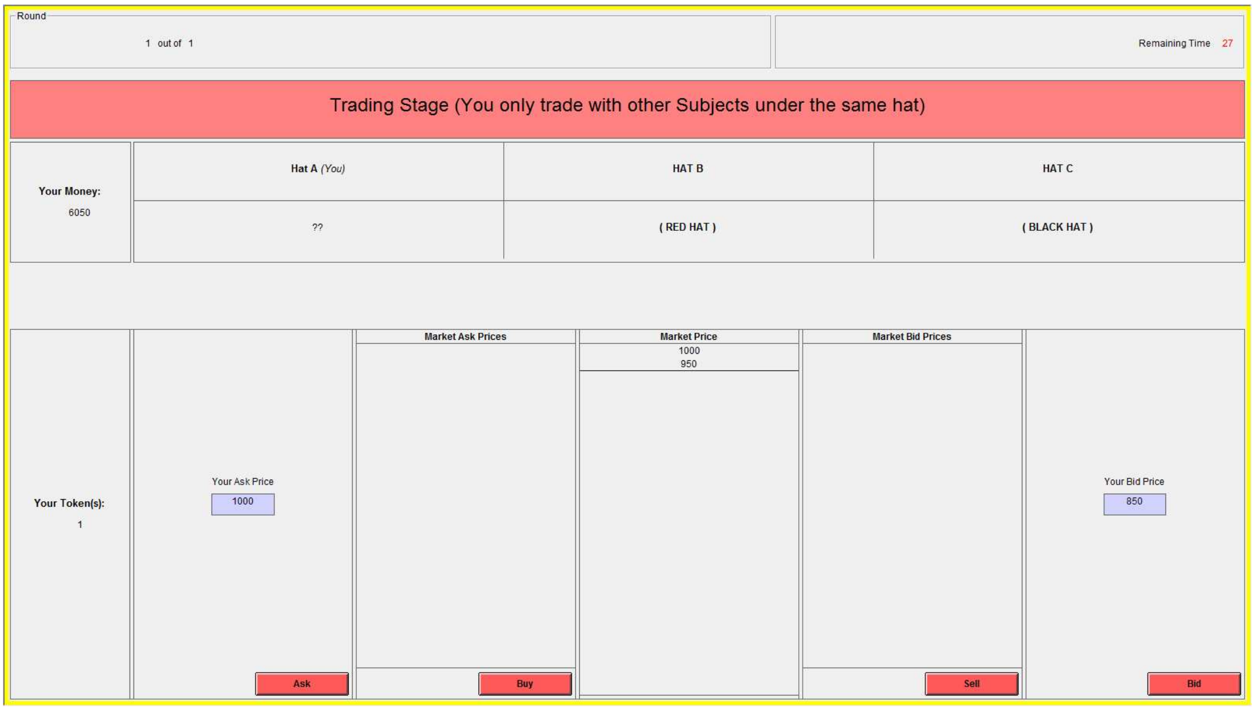

Figure C2: Trading stage activity (TRADE)

for tokens. After 120 seconds, the trading stage will end and you will see on your screens the amount of money you have and the number of tokens you own. See Figure C3 for a screenshot.

C.1.2 Decision stage

Only players with at least one token can participate in the Decision Stage. If you do not have any tokens, you can observe the decision of all other players participating in the Decision Stage through your computer screens but may not yourself participate. You task in the decision stage is to determine the colour of your hat. The decision stage will consist of 4 periods. At each period the computer will present you with the following question, to which you must choose from 3 possible actions (a), (b) or (c).

Computer's question: "Do You Know your hat colour?"

Your actions: (a) My Hat is RED, (b) My Hat is BLACK, and (c) No! I will decide in a later period.

Here are some rules:

(Rule 1) At each period, you have a maximum of 4 minutes to choose an action.

(Rule 2) You will immediately end the decision stage if the action (a) or (b) is chosen.

(Rule 3) You will only go to the next period if you chose (c) in the previous period.

(Rule 4) If you arrive at period 4, you can only choose from the actions (a) or (b).

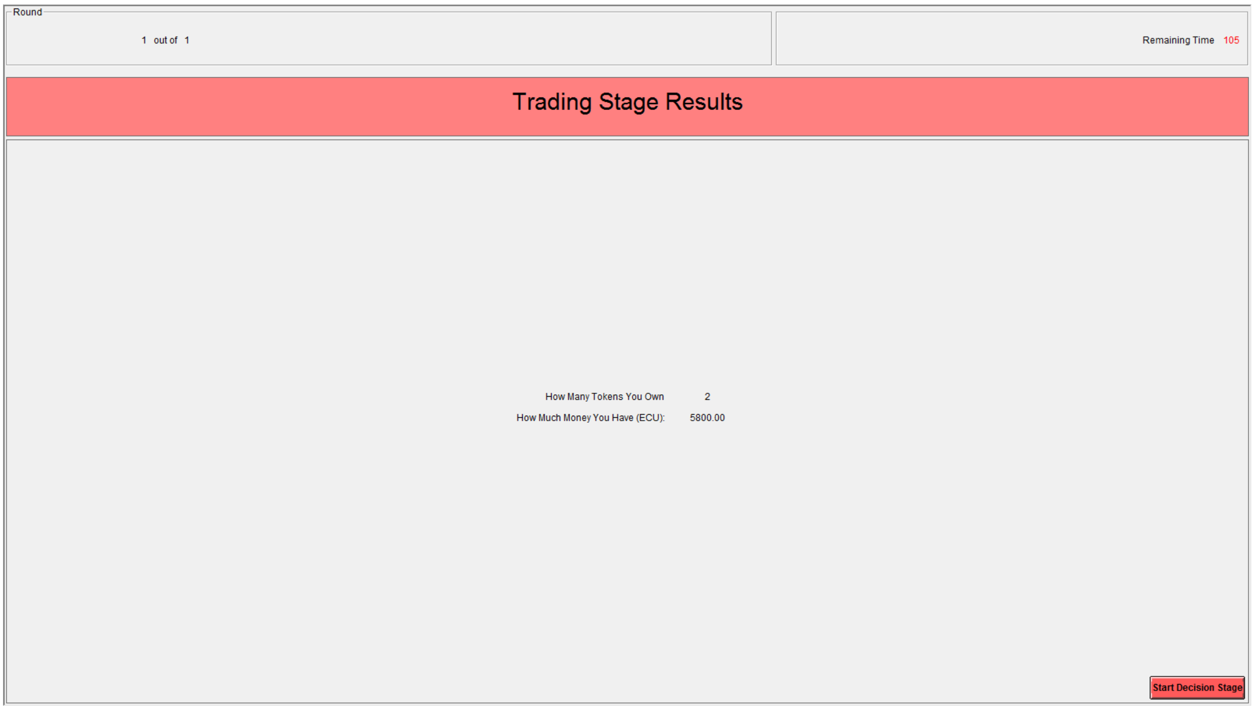

Figure C3: Trading stage results (TRADE)

(Rule 5) Any action chosen will be known to all other players in the subsequent period.

You are said to have "determined your hat colour" when you choose (a) or (b). This is why you will only go to the next period if you have chosen (c). For example, if you had chosen (a) in period 1, the decision stage immediately ends for you. In period 2, all other players will observe that you had chosen (a) in period 1. However, if you had chosen (c) in period 1, you go on to period 2, when you must again choose your action. All players will also observe that you had chosen (c) in period 1. Here, are some screenshots to help you understand the decision stage design (Figure C4, Figure C5 and Figure C6).

Figure C4 presents an illustration of the first period in the decision stage. You are under Hat A and you see the other hat colours. In addition the computer presents you with the question "Do you know your hat colour" to which you must reply with one of the 3 possible actions.

Figure C5 presents an illustration of the second period in the decision stage. You are under Hat A and you see the other hat colours. The computer again presents you with the question "Do you know your hat colour" to which you must reply with one of the 3 possible actions. In addition, you also see on your screen the actions chosen by the other players in the previous period. Here there are only two players under hat A who had participated in the decision stage. One player has 4 tokens and the other player has 2 tokens. You see that the player with 4 tokens had chosen (c) in period 1 and the player with 2 tokens had chosen (c) in period 1. Under hat B, there are three players who had participated in the decisions stage. All three player have 2 tokens and had chosen (c) in period 1. Finally, under Hat C, there are 4 players who had participate in the decision stage,

Figure C4: Decision stage period 1 (TRADE)

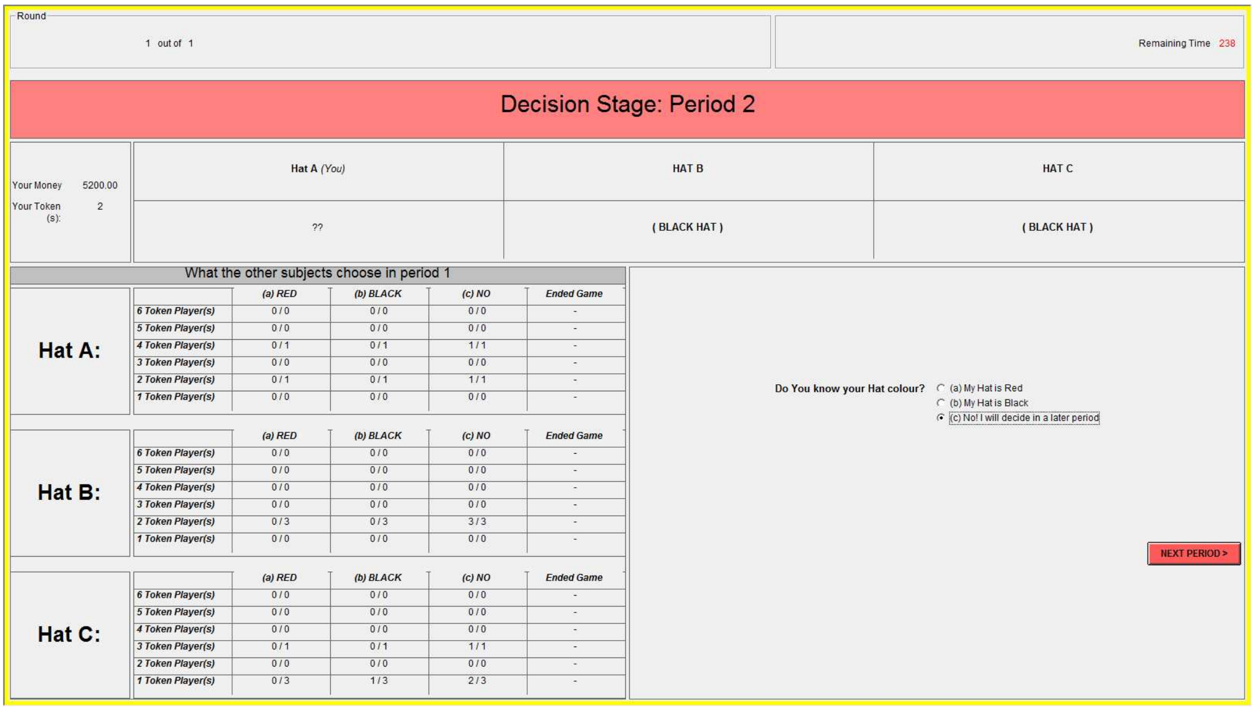

Figure C5: Decision stage period 2 (TRADE)

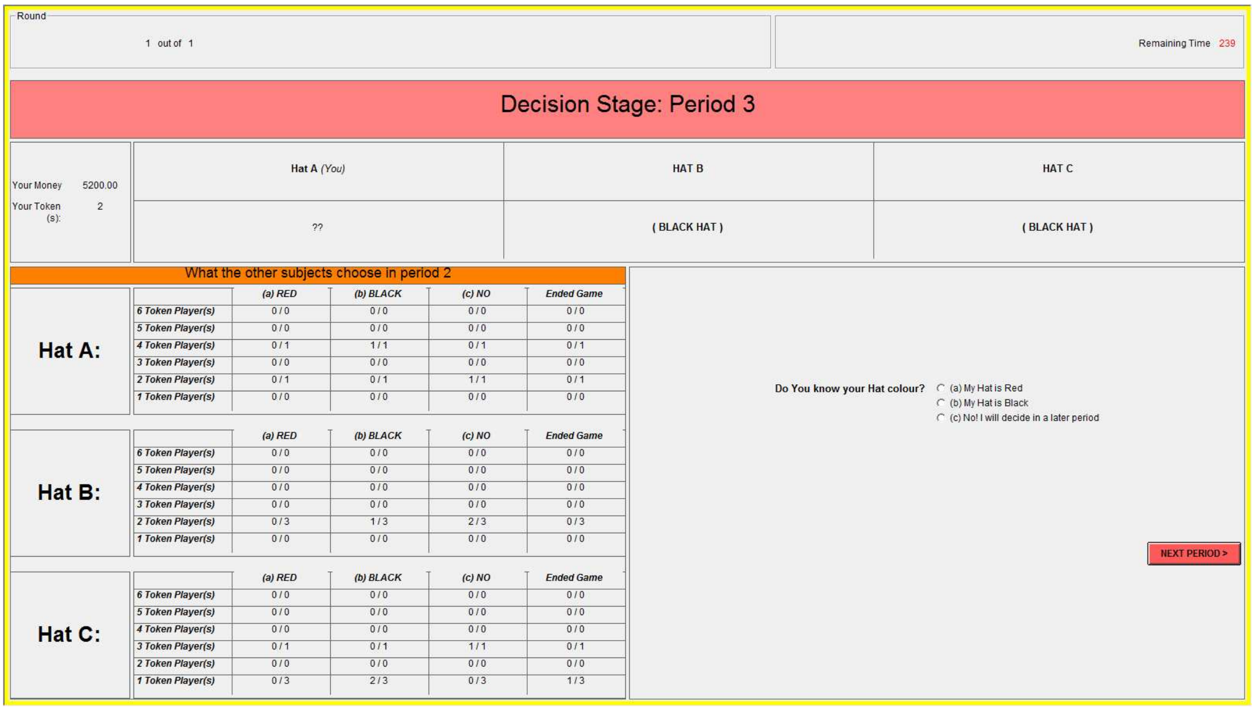

Figure C6: Decision stage period 3 (TRADE)

one of them has 3 tokens, whilst the other three have only one token. You see that the 3 token player had chosen (c) in period 1. Two of the players with one token had chosen (c) in period 1 whilst the last player, also with one token, had chosen (b) in period 1.

Figure C6 presents an illustration of the third period in the decision stage. You are under Hat A and you see the other hat colours. The computer again presents you with the question "Do you know your hat colour" to which you must reply with one of the 3 possible actions. There are two player under hat A. The two token player had chosen (c) in period 2. The four token player had chosen (b) in period 2. There are 3 players under hat B, each of them with two tokens. One of them had chosen (b) in period 2, whilst the other two had chosen (c) in period 2. There are four players under hat C. The three token player had chosen (c) in period 2. Amongst the one token players, one of them did not participate in period 2 as he had chosen either (a) or (b) in the period 1. Thus that player is said to have ended the game. However, the other two players with one tokens had chosen (b) in period 2.

C.1.3 Token Redemption Rate

After all players have completed the decision stage, your tokens will be redeemed by the computer. The redemption rate will depend on the period which he had "determined your hat colour" and whether you were correct. The payoffs can be easily summarised as followed. Each token is initially worth 950 ECU. The token's value decreases by 50 ECU each time you had chosen (c). In addition, the token's value decreases by 700 ECU if you had chosen (a) or (b) and was found to be incorrect,

Description	Correct	Incorrect
“determined your hat colour” in Period 1	950 ECU	250 ECU
“determined your hat colour” in Period 2	900 ECU	200 ECU
“determined your hat colour” in Period 3	850 ECU	150 ECU
“determined your hat colour” in Period 4	800 ECU	100 ECU

Table C2: Token redemption rate with choosing (a) or (b)

or 0 ECU if found to be correct. See Table C2 for an overview of the redemption rate. Here are some examples to help you understand the redemption rate:

1. Your hat is black. In period 1 you choose (c), in period 2 you choose (c) and in period 3 you choose (b). You have correctly determined your hat colour and your token redemption rate is therefore 850 ECU.

2. Your hat is black. In period 1 you choose (c), in period 2 you choose (c) and in period 3 you choose (a). You have incorrectly determined your hat colour and your token redemption rate is 150 ECU.

C.1.4 End of Round Payoff

Your payoffs at the end of each round will be determined as followed:

Payoffs = (Money After Trading Stage - 6000) + (Tokens) x (Redemption Rate)

If your payoffs are found to be negative, we will round it off to 0 ECU. This completes the description of each experimental round.

C.2 Other information

Please note that you will be matched with the same other players over all 10 rounds of the experiment. After the completion of 10 experiment rounds, we require you to complete a survey before you receive your cash payments. Please feel free to clarify any question or doubts you might have with regards to the instructions.