Social Learning with Partial and Aggregate Information: Experimental Evidence

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Abstract

In our information cascade experiments, we study social learning in decision-making situations in which decisions "not to do" are unobservable. Subjects, in sequence, choose whether to invest or not, without knowing their position. They observe a private signal and the number of investments made by their predecessors, but not how many predecessors have chosen not to invest. We find that down cascades, in which agents neglect the signal and do not invest, occur, in contrast with the equilibrium predictions. Up cascades, in which agents invest independently of the signal, occur, but less than in equilibrium.

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1 Introduction

Learning from observing the decisions of others is a pervasive phenomenon in societies. A large literature on social learning has shown that the process of learning, while, on average, beneficial, can have some pathological consequences, such as agents herding on a sub-optimal choice.

The phenomenon has been first illustrated in the seminal work by Banerjee (1992) and Bikhchandani et al. (1992). They study the extreme case in which agents move in sequence, one after the other, and observe the entire sequence of predecessors' actions. In most real-life situations, however, decision makers only have access to partial information about the choices of others. For instance, when an entrepreneur has to decide whether to make an investment (e.g., in a new technology), they can observe the investments already made, but not the entire sequence of choices; in particular, they do not typically observe the "non-investments", that is, all the entrepreneurs who thought about the new technology but then chose not to invest in it. Similarly, a doctor who is pondering whether to prescribe a new drug may have data on how many others have already done so, but not how many considered the option and chose to stick to the old one. In other words, in many situations, the choice "not to do" is not observable.[1]

Since the observability of one action only is a common feature of many situations, it is important to understand how people make decisions in such situations. This is the research question of this study. Guarino et al. (2011) have answered this question at a theoretical level. A result of that study is that, in equilibrium, informational cascades (i.e., situations in which agents make the same decision independently of their private information) only occur on the observable action. To go back to our examples, it is never the case that an entrepreneur with positive private information about a new technology would refrain from investing in it just because no one else has invested before. The intuition for this result is that, if everyone behaved this way, then the observable action would never be chosen; as a result, seeing no investment would be completely uninformative, and following the own private information would be the best response. In this paper, we show an even stronger result: following one's own signal when no investments are observed is not only an equilibrium strategy, it is actually a dominant strategy. While there are no cascades of non-investments (no "down cascades" in the terminology of Guarino et al., 2011), in

[1]Even the most celebrated, perhaps passé, example in this literature, the choice of a restaurant, does not really fit the canonical model: typically, one can observe the number of people already dining in a restaurant, not the sequence of choices.

equilibrium, cascades of investments ("up cascades") occur. The rationale is the same as in the seminal model of Bikhchandani et al. (1992): when agents observe a sufficiently high number of investments, their posterior belief on the good state of the world is so high that investing is the best response independently of the private signal.

After presenting the theoretical results, we move to the core of this work, a series of controlled experiments in which we implement the model by Guarino et al. (2011) in the laboratory, varying the group size from small ($n = 3$) to large ($n = 10$ and $n = 19$). Subjects have to choose between two actions (which here we refer to as investment and non-investment), on the basis of a private, binary signal and of the number of investments that have already been made. Subjects have no other information: they do not know their position in the sequence and, hence, they do not know how many other subjects have already had the opportunity to invest and have decided not to do so. Subjects' payoffs are such that they choose the action that more likely matches one of two states of the world. Since not knowing the position in the sequence is a crucial ingredient of the model and in the laboratory the mere passing of time may reveal it, at least to some extent, we introduce a methodological novelty in the experimental literature on informational cascades: rather than using the direct-response method, we use the strategy method. We can do so since, in contrast with experiments in which the sequence is observable, in our set up, the number of contingencies is sufficiently low.

The first experimental result that we are interested in is whether cascades occur on the unobservable action. As we said, the absence of down cascades (i.e., cascades on non-investment) is predicted, not only in equilibrium, but also in dominant strategies. Moreover, a very robust result presented in most of the previous cascade experiments (see, e.g., Çelen and Kariv, 2004a, Goeree et al., 2007, and Angrisani et al., 2021) is that human subjects tend to overweight their private information relative to the public information. Putting these results together, one could conjecture that down cascades do not occur or occur very rarely in the laboratory. In other words, a reasonable conjecture is that, when they see no previous investments, most of the time subjects just follow their signal. The results of our study only partially align with this conjecture for small groups of subjects ($n = 3$ in our laboratory), and do not align for large groups (i.e., 10 or 19). In these large groups, when observing no investments, subjects, more often than not, choose not to invest. This suggests that subjects *underweight* their private signal relative to public information. This result, confirmed when we look at the data through the lens of the Quantal Response Equilibrium (which takes into account the actual behavior of other subjects in the laboratory), is in stark contrast with previous results. This is not to say that previous results were incorrect, but that overweighting of private information is not a general property of how human subjects learn from others and from their private information. In our experiment, it seems as though subjects infer more negative information about the state of the world from a lack of investments than is theoretically justifiable.

The second result of interest is whether cascades occur on the observable action. It is important to note that, in most of the previous experiments, by design, the deviation from equilibrium can only consist in following the others too little. For instance, in the standard experimental test of Bikhchandani et al. (1992) (see, e.g., the seminal paper of Anderson and Holt, 1997), theoretically, a cascade occurs as soon as one action outnumbers the other by two, and even if it outnumbers it by one, neglecting the signal is not necessarily a deviation from equilibrium. Hence, there is no way in which a subject can engage in cascade behavior when they should not. In our experiment, instead, an up cascade starts when a threshold number of investments is reached. This threshold depends on the group size. In principle, one can therefore observe subjects following others *too little* (if they need a larger number of investment to neglect their signal) or *too much* (if they engage in cascade behavior even before the threshold is reached). In our data, we find that subjects engage in up cascade behavior too little: even after the threshold for an up cascade is reached, the frequency of up cascade behavior is substantially lower than predicted. This result shows that subjects do *overweight* their bad signal, in line with previous papers.

The third result relates to the aggregate number of investments and to welfare. In equilibrium, the asymmetry in observability implies that investments occur more than 50% of the time, and welfare is higher in the good state of the world than in the bad state. This is intuitive since the partial observability biases decisions in favor of investments, and this is beneficial in the good state of the world and detrimental in the bad state. These theoretical results are essentially reversed in the laboratory, due to subjects' reluctance to invest when they observe a low level of investments. For instance, for $n = 10$ and $n = 19$, while in the PBE, unconditionally, investments occur almost 60% of the time, in the laboratory, we observe investments no more than 40% of the time.

These results have implications for the way in which we think about social learning, not only in economic contexts, but also in contexts that are relevant to political science, sociology, etc.[2] It is also interesting to observe that, while, in many scenarios, one action

[2]For instance, in political science, social learning models are used to study voting, and are also referred to in the study of the diffusion of political ideas (see, e.g., Simmons et al., 2006). Yet another example in which agents only have partial and aggregate information is that of petitions, where agents only know the

arises naturally as the observable one, there are some important cases where third parties may have the power to decide what information is provided to agents (we discuss one example in Section 5). Our experimental results show that one should be cautious in recommending which action to make observable on the basis of the theoretical results.

In the next subsection, we will briefly survey the related literature. Here we note that there are various differences between our work and the standard experimental tests of the Bikhchandani et al. (1992) model that make observing subjects' behavior in our experiments interesting.

Firstly, as we noticed above, in the standard experiment, by design, the deviation from equilibrium can only consist in following the others too little. In our experiments, instead, we can observe subjects following others *too little* or *too much*.

Secondly, the standard experiment allows us to understand the extent to which human subjects imitate the crowd. In our experiments, we can also observe whether human subjects are influenced by the *lack* of observed investments by others.

Thirdly, in the standard experiment, there is a simple rule of thumb that a subject can apply: act according to the own signal unless there is a majority of at least two, in which case, follow the majority. In our experiment, one cannot use a simple rule; for instance, for $n = 10$, one should follow others' investment decisions when there are already four investments, which is a *minority* action relative to $n = 10$.

From a methodological viewpoint, we believe this is the first study of a cascade game using the strategy method. Moreover, with the exception of Goeree et al. (2007), who have groups of 20 and 40 participants, to the best of our knowledge, this is the only experimental study about informational cascades with a long sequence of subjects (i.e., 19 subjects).

The remainder of the paper is organized as follows. The next subsection reviews the literature. Section 2 presents the theoretical analysis and the equilibrium predictions. Section 3 describes the experiments. Section 4 illustrates the results. Section 5 concludes. The online Appendix contains the instructions and supplementary material.

1.1 Related literature

Our work builds on the theoretical contribution of Guarino et al. (2011). A closely related theoretical work is that by Herrera and Hörner (2013): in common with Guarino et al. (2011), only one action is observed; in contrast with Guarino et al. (2011), agents know the time at which they make their investment decision and observe past, individual in-

number of people who have already signed.

vestments, and the time at which these were made (rather than an aggregate statistics). Specifically, Herrera and Hörner (2013) study partial observability of predecessors' actions in a continuous time model with a Poisson arrival of investment opportunities. In this set up, an agent may not see previous investments not because they are unaware of some of them (not observing them, as in our framework), but because there were no investment opportunities in the past. Although cascades on both actions are possible in equilibrium, the asymmetry in observability generates an asymmetry in the frequency of the two actions, as is the case in our model: in equilibrium, the observable action is chosen more frequently than the other one.

Another work in which, similarly to Herrera and Hörner (2013), some agents randomly receive the opportunity to invest is the endogenous-timing model of Chamley and Gale (1994). Also, in that model, there is an asymmetry in the Bayesian inference from investments and absence of investments, specifically because agents who have the opportunity to invest may strategically decide to delay the investment.

The theme of partial observability of the predecessors' actions has also been investigated from other angles. In an early contribution, Çelen and Kariv (2004b) analyze social learning when agents only observe their immediate predecessor. Beliefs and actions are cyclical; eventually, longer and longer periods of uniform behavior are punctuated by rarer and rarer switches. Çelen and Kariv (2005) test this model experimentally, finding that herding is not very frequent, actually even less frequent than the theory predicts. Callander and Hörner (2009) study the case in which agents only observe the total number of predecessors who have chosen each of the two available options, but not the order in which the choices have been made. This feature, in addition to agents having signals of different precisions, implies that, for some parameter values, it is sometimes optimal to herd on the minority action. Monzon and Rapp (2014) consider the case in which agents are uncertain about their position in the sequence of decision makers and sample past decisions. They show that position uncertainty does not have a strong effect on the speed of social learning. In Larson (2015), instead, agents only have access to a summary statistic about predecessors' decisions (in a continuous action space). Since agents observing this statistic cannot correct for the fact that earlier actions influenced later ones, even a small presence of old actions in the aggregate statistic can imply persistent errors. Social learning can, therefore, be very slow. Guarino and Jehiel (2013) study social learning with coarse inference and show that when boundedly rational agents (in the sense of the Analogy Based Expectations Equilibrium – Jehiel, 2005) make inferences from predecessors in a continuous action space, there is a bias to overweight early signals in the sequence: this bias is non existent if agents only observe the immediate predecessor and increases with the number of observed predecessors. Angrisani et al. (2021) offer an experimental test of social learning in a continuous action space like that studied in Guarino and Jehiel (2013).[3]

2 Theoretical Framework

We consider the model introduced by Guarino et al. (2011) in which n agents choose in sequence between two options. For convenience, we will refer to this choice as whether to invest in a project or not. Time is discrete and indexed by $i = 1, 2, \ldots, n$. Each agent makes their choice only once in the sequence. Agents are numbered according to their positions: agent i chooses at time i only. The sequence in which agents make their choices is randomly determined, with all sequences equally likely. An agent's action space is $\{0, 1\}$, and their action is denoted by $a_i \in \{0, 1\}$, where 1 can be interpreted as the decision to invest and 0 as the decision not to invest. An agent's payoff, π_i, depends on their decision and on the true state of the world, ω: the project can be bad ($\omega = 0$) or good ($\omega = 1$), and the two states are equally likely. If $\omega = 1$, an agent receives a payoff of 1 if their action is 1 (i.e., investing in a good project), and a payoff of 0 otherwise; if $\omega = 0$, an agent receives a payoff of 1 if their action is 0 (i.e., not investing in a bad project). The payoff is thus

$$\pi_i = \omega a_i + (1 - \omega)(1 - a_i). \tag{1}$$

Each agent i receives a symmetric binary signal, s_i, about the project, distributed as follows:

$$\Pr(s_i = 1 \mid \omega = 1) = \Pr(s_i = 0 \mid \omega = 0) \equiv 0.7. \tag{2}$$

We assume that, conditional on the project being good or bad, the private signals are *i.i.d.*. We refer to $s_i = 1$ as a "good signal" and to $s_i = 0$ as a "bad signal."

In addition to private information, agents observe the choices of their predecessors, to some extent. Specifically, an agent does not know their position in the sequence. They know the *total number of agents* before them who have chosen the action $a_j = 1$ ($j < i$). While the aggregate number of previous investments is observable, each individual decision is not, nor is the total number of decisions not to invest. In this sense, we say that the action $a_j = 0$ is a non-observable action. We denote the total number of agents who

[3] A critical survey discussing several aspects of social learning theories is Gale (1996). In recent years, there has been much interest in another form of partial observability, due to agents being connected in networks. We refer the reader to Cabrales et al. (2016) for a survey.

have invested before agent i by T_i: agent i is then informed about $T_i = \sum_{j=1}^{i-1} a_j$. Their information set is, therefore, $\{T_i, s_i\}$. Note that the information set does not contain the position i in the sequence. With a slight abuse of notation, we denote the choice upon observing $\{T_i, s_i\}$ by $a_i(T_i, s_i)$.

2.1 Theoretical predictions

Each agent can infer whether the project is good or bad from their own signal and from their predecessors' choices. The question is how agents use private and public information in equilibrium. As we shall see, two possibilities can arise in the Perfect Bayesian Equilibrium (PBE): i) the agent follows their own signal; ii) the agent neglects their signal and invests. We refer to the second case as an "up cascade." An up cascade happens when the public information coming from the observation of others' choices provides sufficient evidence in favor of the good state of the world to offset even the contradicting, negative information coming from the private signal. Guarino et al. (2011) show that an up cascade (in which an agent chooses action 1, i.e., invests, independently of their private signal) occurs as soon as the aggregate number of observed investments, T_i, has reached a certain threshold (which depends on the size of the population, n). Instead, a "down cascade," in which an agent chooses action 0, that is, does not invest, independently of their private signal, never occurs in the PBE for any population size, n. We summarise these results in the next proposition, in which we focus on the cases of $n = 3$, $n = 10$, and $n = 19$, since these are the group sizes we will use in the experiment.[4] Tables 1, 2, and 3 illustrate the theoretical prediction.

Proposition 1. *In the PBE:* $a(T_i, 1) = 1$ *for any* T_i*, that is, an agent with a good signal chooses to invest for any* T_i*, independent of the group size,* n*;*
for $n = 3$, $a(T_i, 0) = 0$ *for* $T_i < 2$*, and* $a(T_i, 0) = 1$ *for* $T_i = 2$*, (i.e., an agent with a bad signal does not invest unless they observe that* 2 *predecessors have invested);*
for $n = 10$, $a(T_i, 0) = 0$ *for* $T_i < 4$*, and* $a(T_i, 0) = 1$ *for* $T_i \geq 4$*, (i.e., an agent with a bad signal does not invest unless they observe that at least* 4 *predecessors have invested);*
for $n = 19$ *,* $a(T_i, 0) = 0$ *for* $T_i < 7$*, and* $a(T_i, 0) = 1$ *for* $T_i \geq 7$*, (i.e., an agent with a bad signal does not invest unless they observe that at least* 7 *predecessors have invested).*

An up cascade occurs for the same reason that an informational cascade occurs in the

[4] We are interested in studying human behavior in small and large groups. We preferred to use $n = 19$ rather than $n = 20$ since, for $n = 19$, the PBE is unique (i.e., there is a unique threshold for the up cascade), whereas, for $n = 20$, there are multiple equilibria (see Guarino et al., 2011).

Table 1: PBE actions for $n = 3$

	$T_i = 0$	$T_i = 1$	$T_i = 2$
$s_i = 0$	0	0	1
$s_i = 1$	1	1	1

PBE actions for each contingency.

Table 2: PBE actions for $n = 10$

	$T_i = 0$	$T_i = 1$	$T_i = 2$	$T_i = 3$	$T_i = 4$	$T_i = 5$	$T_i = 6$	$T_i = 7$	$T_i = 8$	$T_i = 9$
$s_i = 0$	0	0	0	0	1	1	1	1	1	1
$s_i = 1$	1	1	1	1	1	1	1	1	1	1

PBE actions for each contingency.

Table 3: PBE actions for $n = 19$

	$T_i = 0$	$T_i = 1$	$T_i = 2$	$T_i = 3$	$T_i = 4$	$T_i = 5$	$T_i = 6$	$T_i = 7$	$T_i = 8$	$T_i = 9$
$s_i = 0$	0	0	0	0	0	0	0	1	1	1
$s_i = 1$	1	1	1	1	1	1	1	1	1	1
	$T_i = 10$	$T_i = 11$	$T_i = 12$	$T_i = 13$	$T_i = 14$	$T_i = 15$	$T_i = 16$	$T_i = 17$	$T_i = 18$	
$s_i = 0$	1	1	1	1	1	1	1	1	1	
$s_i = 1$	1	1	1	1	1	1	1	1	1	

PBE actions for each contingency.

canonical model of social learning of Bikhchandani et al. (1992). Consider, for instance, $n = 10$: when four or more investments are observed, the posterior probability that the project is good is higher than 0.5 even if the agent has a bad signal, therefore, the agent chooses to invest. From that time onwards, all following agents rationally choose to invest, whatever private signal they observe. Note that, in contrast with Bikhchandani et al. (1992), as more people invest in an up cascade, agents revise up the probability that the project is good. This is so since the agent does not know their position in the sequence and $T_i + 1$ is better news than T_i. The impossibility of a down cascade (a cascade on the unobservable action — the decision not to invest) is proven by relying on a subtle equilibrium argument. If a down cascade occurred when $T_i = 0$, then, in equilibrium, nobody would ever predict a good project. Hence, $T_i = 0$ would not reveal any information on the true state of the world, and agent i would be better off by following their informative signal, s_i. Since a monotonicity argument shows that a higher T_i cannot be worse news, Guarino et al.

(2011) can prove that a down cascade never occurs.[5] This equilibrium argument solves an inference problem that would seem quite complex. For example, consider an agent facing a "low" value of T_i. One could imagine that, in order to make their decision, agent i should consider all possible sequences compatible with T_i and attach a probability to each of them. A low number of investments may arise for two reasons: it may come from the fact that only a few agents had the opportunity to invest so far, in which case the low value of T_i should not be considered bad news (and, if on top of this, the agent receives a good signal, the overall information about the project could be good). Alternatively, a low number of investments could arise from many agents having had the opportunity to invest but only a few doing so, in which case the low T_i should be viewed as bad news. This inference process could be quite complicated. The problem is, instead, solved by just invoking the equilibrium argument explained above. As we said, while the threshold for the occurrence of an up cascade depends on the number of agents, n, in the economy, the impossibility of a down cascade holds for any n.

While Guarino et al. (2011) provide a proof of the PBE, we now prove an even stronger result: when observing $T_i = 0$, following the signal is not only a PBE strategy, it is also a dominant strategy.

Proposition 2. *For an agent observing $T_i = 0$, it is dominant strategy to follow their own signal, that is, to invest when $s_i = 1$ and not to invest when $s_i = 0$.*

We relegate the proof to the Appendix. Let us consider the intuition for $s_i = 1$. From Proposition 1, we know that, in the PBE, observing $T_i = 0$ is not sufficiently bad news that an agent with a good signal does not invest. *A fortiori*, this remains true in the case in which agents do not necessarily follow their signal, since the probability that the project is good, given $T_i = 0$, is higher in this scenario than in the PBE. Therefore, even if other agents deviate from the PBE, following $s_i = 1$ is still optimal. As for $s_i = 0$, it is intuitive that, as long as agents who observe $T_i = 0$ invest more frequently with a good signal than with a bad signal, $T_i = 0$ is bad news and not investing upon observing a bad signal is optimal. However, one could notice that, if agents invest more frequently with a bad signal than with a good signal, then observing $T_i = 0$ is, actually, good news. We prove that, even in the most extreme case in which other agents make decisions *against* their signal, although $T_i = 0$ is good news, the best response for an agent who receives $s_i = 0$ is not to invest.

[5] We refer the reader to that paper for the formal proofs. Similar arguments show that, in the PBE, an agent observing $T_i = 0$ cannot engage in an up cascade or go against their signal.

While following the signal when $T_i = 0$ is a dominant strategy for any size n of the population of agents, the profitability of this strategy varies with n. Intuitively, for a low n, the probability of observing $T_i = 0$ because the agent is early in the sequence (a case in which $T_i = 0$ is not so bad news) is high and the profitability of following the own signal is high too; for a high n, this probability is instead rather low, and so is the benefit of following the signal. Formally, note that the likelihood ratio (LR) upon observing $\{T_i = 0, s_i = 1\}$ is equal to:[6]

$$\frac{\Pr(\omega = 1 \mid T_i = 0, s_i = 1)}{\Pr(\omega = 0 \mid T_i = 0, s_i = 1)} = \frac{\Pr(T_i = 0 \mid \omega = 1)}{\Pr(T_i = 0 \mid \omega = 0)} \frac{\Pr(s_i = 1 \mid \omega = 1)}{\Pr(s_i = 1 \mid \omega = 0)} = \frac{1 - (1 - 0.7)^n}{1 - 0.7^n}. \quad (3)$$

For $n = 3$, the ratio is equal to 1.481, whereas it is equal to 1.029 for $n = 10$ and to 1.001 for $n = 19$. Essentially, when they are in a group of 10 or 19 people, an agent observing a good signal and $T_i = 0$ has odds close to $1 : 1$ on the two states of the world, that is, their incentives to follow the good signal are low.

To conclude this section, in Tables 4, 5, and 6, we show the likelihood ratios for all contingencies. Another noteworthy feature of the PBE is that, as n increases, the up cascade starts when the likelihood ratio is smaller. When $n = 3$, the cascade occurs for $T_i = 2$ and, conditional on a bad signal, the likelihood ratio is $\frac{0.7}{0.3} = 2.3$. Note that this coincides with the likelihood ratio in an informational cascade in the canonical model of Bikhchandani et al. (1992). Since, in that model, beliefs are not updated during a cascade, that means that 2.3 is the likelihood ratio in *any* cascade in Bikhchandani et al. (1992). For $n = 10$, the cascade starts at $T_i = 4$, and, conditional on a bad signal, the likelihood ratio is 1.55; for $n = 19$, it starts at $T_i = 7$, and, conditional on a bad signal, the likelihood ratio is 1.54.[7] Overall, the average likelihood ratio during an up cascade (and a bad signal) is 3.48 for $n = 10$, and 10.74 for $n = 19$ (recall that, in our model, in contrast with Bikhchandani et al. (1992), the likelihood ratio is increasing in the number of investments, even in an up cascade).

In summary, theoretically, cascades can occur on the observable action but not on the unobservable one. The impossibility of a down cascade is predicted not only in equilibrium but also in dominant strategies; nevertheless, the incentives to follow the good signal when

[6]The probabilities are computed as follows:

$$\frac{\Pr(T_i = 0|\omega = 1)}{\Pr(T_i = 0|\omega = 0)} = \frac{\sum_{i=1}^{n} \Pr(T_i = 0|\omega = 1, i) \Pr(i|\omega = 1)}{\sum_{i=1}^{n} \Pr(T_i = 0|\omega = 0, i) \Pr(i|\omega = 0)} = \frac{\sum_{i=1}^{n} \Pr(T_i = 0|\omega = 1, i)}{\sum_{i=1}^{n} \Pr(T_i = 0|\omega = 0, i)}.$$

[7]Asymptotically, for $n \to \infty$, the cascade starts when the likelihood ratio converges to 1 (see Guarino et al., 2011).

Table 4: PBE LRs, $\frac{\Pr(\omega=1|T_i,s_i)}{\Pr(\omega=0|T_i,s_i)}$, for $n = 3$

	$T_i = 0$	$T_i = 1$	$T_i = 2$
$s_i = 0$	0.272	0.667	**2.333**
$s_i = 1$	1.481	3.630	**12.704**

Likelihood ratios (LRs) in the PBE for each contingency. An up cascade occurs when LR> 1. Bold font indicates an up cascade.

Table 5: PBE LRs, $\frac{\Pr(\omega=1|T_i,s_i)}{\Pr(\omega=0|T_i,s_i)}$, for $n = 10$

	$T_i = 0$	$T_i = 1$	$T_i = 2$	$T_i = 3$	$T_i = 4$	$T_i = 5$	$T_i = 6$	$T_i = 7$	$T_i = 8$	$T_i = 9$
$s_i = 0$	0.189	0.216	0.297	0.519	**1.545**	**2.080**	**2.972**	**4.527**	**7.355**	**12.704**
$s_i = 1$	1.029	1.175	1.618	2.824	**8.413**	**11.324**	**16.180**	**24.645**	**40.043**	**69.165**

Likelihood ratios (LRs) in the PBE for each contingency. An up cascade occurs when LR> 1. Bold font indicates an up cascade.

$T_i = 0$ are high if the group size is small ($n = 3$) and low when the group size is large ($n = 10$ and $n = 19$). The likelihood ratios, and hence the incentives to choose an action at odds with the own signal, change during a cascade and are substantially different for different group sizes, n.

3 The Experiment

3.1 Experimental setup

We implemented the model in the laboratory. In the experimental instructions, we used the terminology of “predicting a good project” to indicate $a_i = 1$ or “predicting a bad project,” to indicate $a_i = 0$. We preferred to use a neutral terminology, as opposed to the expression “investing”, to avoid subjects associating one action to a risky action. For the reader’s convenience, in the next sections, we will stick to the terminology of investing or not.

The model poses an obvious implementation challenge. A subject should only be informed of their private signal and of T_i (the total number of predecessors choosing action $a_j = 1$) but not of their own position in the sequence. In the laboratory, a subject may infer their own position in the sequence by the mere passing of time since the start of a round of decision making. Even though positions may be randomly assigned, a subject being asked to make a decision early in the round would infer that presumably they are not the last subject; similarly, a subject waiting for some time would presumably infer that others have already made decisions. To circumvent these issues, we decided to use

Table 6: PBE LRs, $\frac{\Pr(\omega=1|T_i,s_i)}{\Pr(\omega=0|T_i,s_i)}$, for $n = 19$

	$T_i = 0$	$T_i = 1$	$T_i = 2$	$T_i = 3$	$T_i = 4$	$T_i = 5$	$T_i = 6$	$T_i = 7$	$T_i = 8$	$T_i = 9$
$s_i = 0$	0.184	0.186	0.193	0.212	0.256	0.349	0.549	**1.538**	**1.900**	**2.427**
$s_i = 1$	1.001	1.011	1.049	1.154	1.393	1.900	2.988	**8.372**	**10.347**	**13.215**
	$T_i = 10$	$T_i = 11$	$T_i = 12$	$T_i = 13$	$T_i = 14$	$T_i = 15$	$T_i = 16$	$T_i = 17$	$T_i = 18$	
$s_i = 0$	**3.218**	**4.450**	**6.442**	**9.794**	**15.655**	**26.284**	**46.227**	**84.795**	**161.384**	
$s_i = 1$	**17.521**	**24.227**	**35.075**	**53.324**	**85.231**	**143.103**	**251.682**	**461.662**	**878.647**	

Likelihood ratios (LRs) in the PBE for each contingency. An up cascade occurs when LR> 1.
Bold font indicates an up cascade.

the strategy method. We asked subjects to make decisions for each possible situation (i.e., each possible $\{T_i, s_i\}$) they may face, like in Tables 1, 2, and 3. The strategy method has other advantages. First, we collect many more data points for any given couple $\{T_i, s_i\}$: this increases the precision of the estimates. Second, we collect many more data points for the specific cases $\{T_i, s_i\}$ that are more relevant for our study, e.g., those in which there is an up cascade and the signal is bad. Third, we can observe an informational cascade without relying on assumptions about what the subject would have done with a different signal. With the direct-response method, used in previous experimental studies of social learning, one only observes the decision conditional on the signal that a subject receives. When the signal is in agreement with the past history of actions, one cannot infer whether the subject is following their signal or the past actions, since they agree. When the signal is at odds with the history of past actions and the subject follows past actions, this is interpreted as a cascade, based on the assumption that, *a fortiori*, the subject would choose the same action with the other signal. In our experiment, we observe the chosen action for each T_i and *both* signals. We can use the strategy method since, in our experiment, the number of possible contingencies is relatively small, whereas in experiments in which subjects observe an entire sequence, there are too many possible histories of actions to even consider the strategy method.[8]

3.2 Procedures

We ran the experiment in the Experimental Laboratory for Finance and Economics (ELFE) at the Department of Economics at University College London (UCL).[9] The subject pool mainly consisted of undergraduate students in all disciplines at UCL. They had no previous

[8]Cipriani and Guarino (2009) consider a hybrid method, in which subjects observe the sequence and make a decision conditional on each signal.

[9]This is the new name of the laboratory, formerly known as ELSE Laboratory.

experience with this experiment. In total, we ran six sessions per treatment for $n = 10$ and $n = 19$, and seven for $n = 3$, for a total of 195 subjects. Each subject participated in one session only.

The sessions started with written instructions (available in the online Appendix) given to all subjects. After reading the instructions, subjects watched a pre-recorded presentation, recapping the main aspects of the experiment. Subjects could ask clarifying questions, which we answered privately. Finally, subjects had to answer a series of multiple-choice questions about the procedures of the experiment.[10] The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007).

In each session, subjects played the game for 15 rounds.[11] We now describe the procedures for each round:

1. The computer randomly determined whether the state of the world (the "project") was good or bad with equal probability. Participants were not informed of the realization. They knew, however, that they would receive informative signals about whether the project was good or bad: if the project was good, a participant would receive a "green ball" with probability 0.7 and a "red ball" with probability 0.3 (a draw from a "virtual urn" containing 70 green and 30 red balls); if the project was bad, the probabilities were inverted. Clearly, a green ball was equivalent to $s_i = 1$ and a red ball to $s_i = 0$.

2. Before being informed about their ball color, subjects had to choose whether to invest or not (decisions coded as 1 and 0, respectively) for each possible couple T_i and s_i (for a total of $2n$ decisions). They submitted their strategies by clicking on radio buttons in a table similar to Tables 1, 2, and 3).[12]

3. Once all participants had submitted their strategy, the computer randomly determined each subject's position in the sequence and their private signal. Using subjects' stated strategies, the computer program determined the contingency (T_i, s_i) that was actually relevant for each subject in the realized sequence.

[10] The PowerPoint presentation with pre-recorded voice and the questionnaire are available upon request. When a subject answered the same question incorrectly twice, they were not allowed to proceed to the next question before an experimenter discussed the issue with them. This rarely happened.

[11] For $n = 3$, subjects played the game for a total of 30 rounds since completing each round took substantially less time. As we will see, there is almost no difference in the way that subjects played the first 15 rounds and the last 15 rounds.

[12] Recall that, as explained above, in the experimental instructions, we used the terminology of "predicting a good project" to indicate $a_i = 1$ or "predicting a bad project" to indicate $a_i = 0$.

4. Subjects received feedback on their actual position in the realized sequence, their values of s_i and T_i as well as whether the project was good or bad, and the resulting payoff. Furthermore, since subjects made many decisions but their payoff only depended on one of them, we gave them extra feedback by telling them the average payoff they would have earned for any of the other positions in the sequence, had they been selected for that position.

5. After subjects had observed the feedback screen, they could click on an arrow to move to the next round.

Subjects accrued £7 for each correct decision. The final payment was the amount accrued in three randomly selected rounds (one from the first 5 rounds, one from rounds $6-10$ and one from the last 5 rounds), plus a show up fee of £5. Subjects were paid in private immediately after the experiment. The average payment per subject was £18.

4 Results

4.1 Investments and cascade behavior

We start our presentation of the results with the investment rates observed in the laboratory. This is the most direct test of Proposition 1 and Proposition 2. As we said, an advantage of the strategy method is that we observe subjects' decisions conditional on both signals. A subject who chooses the same action conditional on either signal is said to be engaging in *cascade behavior*. In previous experiments, researchers have used the direct-response method rather than the strategy method, and, typically, have only looked at the decisions taken when the signal contradicts the majority action, since when the signal confirms the majority action, following it and being in agreement with the majority are equivalent. For comparability with previous experiments, when we discuss informational cascades, we also consider the actions taken in an up cascade, as classified according to the PBE, upon receiving a bad signal. When a subject invests with a bad signal in an up cascade, we say that they engage in *herd behavior*.

Definition 1. *A subject engages in up (down) cascade behavior when they choose to invest (not to invest) conditional on either signal. A subject engages in herd behavior when they invest conditional on $s_i = 0$ and, according to the PBE, they are in an up cascade.*

Tables 7, 8, and 9 show the average frequencies of investment for the different contingencies that subjects can find themselves in. For all three treatments, investment frequencies show some clear patterns. They are monotonically increasing in T_i; moreover, for a given T_i, they are always higher for a good signal than for a bad signal.[13]

When $n = 3$, behavior is relatively close to the PBE predictions (Table 7).[14] We observe investment in 71% of the cases when subjects observe no previous investment ($T_i = 0$) and the signal is good; this frequency becomes 94% for $T_i = 1$ and 95% for $T_i = 2$; that is, in a large majority of cases, subjects follow the signal, in agreement with the PBE. When $T_i = 2$, a situation of up cascade, we observe that in 82% of the cases subjects engage in cascade behavior (see Table 10). For comparison with previous experiments, note also that subjects engage in herd behavior (investing after observing $s_i = 0$ and $T_i = 2$) in 86% of the cases (see Table 7). In only 4% of the cases, they do not respect monotonicity and invest conditional on a bad signal but do not invest conditional on a good signal. Note that 86% is a significant jump from the frequency of 13% observed when $T_i = 1$ (and subjects are not in a cascade). The result is even more striking if one notices that in the same situation but with a good signal subjects invest in 95% (rather than in 100%) of the cases.

Table 7: Frequencies of investment for $n = 3$

	$T_i = 0$	$T_i = 1$	$T_i = 2$
$s_i = 0$	0.09	0.13	**0.86**
$s_i = 1$	0.71	0.94	**0.95**

Empirical frequencies of investment ($a_i = 1$). The bold font indicates that, theoretically, a subject is in an up cascade.

Table 8: Frequencies of investment for $n = 10$

	$T_i = 0$	$T_i = 1$	$T_i = 2$	$T_i = 3$	$T_i = 4$	$T_i = 5$	$T_i = 6$	$T_i = 7$	$T_i = 8$	$T_i = 9$
$s_i = 0$	0.15	0.15	0.18	0.33	**0.53**	**0.71**	**0.80**	**0.85**	**0.86**	**0.88**
$s_i = 1$	0.46	0.46	0.60	0.78	**0.89**	**0.92**	**0.95**	**0.95**	**0.95**	**0.97**

Empirical frequencies of investment ($a_i = 1$). The bold font indicates that, theoretically, a subject is in an up cascade.

When $n = 10$ and $n = 19$, the adherence to the PBE predictions is clearly less strong (Tables 8 and 9). The cases in which subjects have more difficulties in choosing the

[13]The monotonicity is only slightly violated for $n = 19$ when $T_i = 1$ and $s_i = 0$.

[14]In the Appendix, we also show the frequencies of investments for the first 15 rounds only (see Table 16). The results are almost unchanged.

Table 9: Frequencies of investment for $n = 19$

	$T_i = 0$	$T_i = 1$	$T_i = 2$	$T_i = 3$	$T_i = 4$	$T_i = 5$	$T_i = 6$	$T_i = 7$	$T_i = 8$	$T_i = 9$
$s_i = 0$	0.09	0.08	0.09	0.13	0.22	0.27	0.34	**0.44**	**0.50**	**0.58**
$s_i = 1$	0.41	0.41	0.49	0.61	0.67	0.74	0.77	**0.83**	**0.84**	**0.87**
	$T_i = 10$	$T_i = 11$	$T_i = 12$	$T_i = 13$	$T_i = 14$	$T_i = 15$	$T_i = 16$	$T_i = 17$	$T_i = 18$	
$s_i = 0$	**0.65**	**0.71**	**0.75**	**0.78**	**0.80**	**0.82**	**0.82**	**0.83**	**0.83**	
$s_i = 1$	**0.88**	**0.91**	**0.92**	**0.91**	**0.92**	**0.93**	**0.94**	**0.93**	**0.94**	

Empirical frequencies of investment ($a_i = 1$). The bold font indicates that, theoretically, a subject is in an up cascade.

PBE action are those in which they receive a good signal and observe a low number of investments. For $n = 10$, this is particularly pronounced for $T_i \leq 2$. In such cases, on average, subjects choose the PBE decision (to invest) in approximately 49% of the cases.[15] Note, in particular, that for $T_i = 0$ and a good signal, the investment rate, rather than being 100%, is 46%. The PBE predicts an absence of down cascades, but for $T_i = 0$, we do observe 51% of down cascade behavior (subjects choose not to invest conditional on either signals). As for up cascades, recall that, theoretically, they occur for $T_i \geq 4$ when $n = 10$. In the laboratory, when $T_i \geq 4$, cascade behavior occurs in 64% of the cases (see Table 10). Subjects, on average, engage in herd behavior in 66% of the cases.[16] Herd behaviour becomes more and more frequent when the evidence in favor of the good project becomes stronger, that is, for higher values of T_i. In particular, as illustrated in Table 8, for $T_i = 4$ (when, theoretically, subjects are in a cascade) and upon observing a bad signal, the frequency of investments is 53%, jumping from the 33% observed when $T_i = 3$ (and, theoretically, subjects are not in a cascade). When $T_i = 5$, the frequency goes up to 71%. The frequency is then monotonically increasing up to 88% for $T_i = 9$.

For $n = 19$, observe from Table 9 that, for $T_i = 0$ and a good signal, the investment rate, rather than being 100% (as in the PBE), is 41%, confirming that subjects in the laboratory are not that prone to invest. Indeed, when $T_i = 0$, subjects engage in down cascade behavior in 54% of the cases, whereas there are no down cascades in the PBE. The

[15]This and the other average numbers in this analysis are computed considering the probability of being in each contingency in the table, given the actual frequency of decisions.

[16]The difference between 64% and 66% is due to a small fraction of cases in which subjects did not respect monotonicity and did not invest with a good signal. For comparison, experiments aimed to test the Bikhchandani et al. (1992) model (in which there is symmetry between the two actions) with a similar number of subjects per session typically report a frequency of herd behavior in the order of 65% − 75% (see, e.g., Weizsäcker, 2010). Our results are thus in line with these experiments.

investment rate, conditional on a good signal, remains low (at 41%) for $T_i = 1$, approaches 50% for $T_i = 2$, and then increases monotonically to reach almost 95%.

As for up cascades, in the PBE, they start at $T_i = 7$. In the experiment, we observe cascade behavior in 51% of the cases (see Table 10). Subjects need to observe $T_i = 8$ to choose to invest at least 50% of the times upon receiving a bad signal (see Table 9). On average, herd behavior, monotonically increasing with T_i, occurs in 56% of the up-cascade cases.

We summarize our findings in the next result:

Result 1. *Decisions in the laboratory are relatively close to the PBE for $n = 3$, and deviate more from it for $n = 10$ and $n = 19$. In particular, in these larger groups, we observe less up cascade behavior than in the PBE; moreover, while in the PBE, there are no down cascades, we do observe that for low values of T_i, frequently subjects do engage in down cascade behavior.*

Table 10: Frequencies of up cascade behavior and herd behavior.

	$n = 3$	$n = 10$	$n = 19$
Herd behavior	0.86	0.66	0.55
Up cascade behavior	0.82	0.64	0.51

The table refers to situations of up cascade according to the PBE, that is, $T_i = 2$ for $n = 3$, $T_i \geq 4$ for $n = 10$, and $T_i \geq 7$ for $n = 19$. Subjects engage in herd behavior if, in such situations, they invest conditional on the bad signal. Up cascade behavior occurs if subjects invest conditional on both signals. The table shows the frequencies of herd behavior and up-cascade behavior in the three treatments.

4.2 Incentives and best responses

In Section 2.1, we have proven that following the signal is a dominant strategy (Proposition 2). Therefore, the down cascades that we have documented above cannot be rationalized by best responses to other subjects' behavior. Nevertheless, we have also shown that, in the PBE, the incentive to choose one action versus the other changes substantially with the number of participants, n. For instance, for $T_i = 0$ and $s_i = 1$, the likelihood ratio goes from 1.481 for $n = 3$ to 1.029 for $n = 10$ and to 1.001 for $n = 19$. In the experiment, the percentage of investment for $T_i = 0$ and $s_i = 1$ goes down as the group size, n, increases. We have also noticed that, theoretically, for any given n, the likelihood ratio increases as T_i increases, even in an up cascade. In the experiment, we do observe that, for any given n, as T_i increases, so does the investment rate.

These considerations already suggest that incentives may play a role. However, in the laboratory, subjects made decisions sometimes not in line with the PBE, which changes the incentives. It is, therefore, worth looking at the empirical likelihood ratios, that is, the likelihood ratios computed using the actual frequencies of T_i investments that occurred in the laboratory, $\mathrm{Fr}(T_i \mid \omega)$:[17]

$$LR(T_i, s_i) = \frac{\Pr(\omega = 1 \mid T_i, s_i)}{\Pr(\omega = 0 \mid T_i, s_i)} = \frac{\mathrm{Fr}(T_i \mid \omega = 1)}{\mathrm{Fr}(T_i \mid \omega = 0)} \frac{\Pr(s_i \mid \omega = 1)}{\Pr(s_i \mid \omega = 0)}. \tag{4}$$

The ultimate goal of this analysis is to understand subjects' behavior considering the actual incentives in the laboratory. Tables 11, 12, and 13 report the likelihood ratios for the three treatments. They are the empirical counterparts of Tables 4, 5, and 6. There are four interesting considerations to make.

First, for $T_i = 0$, the likelihood ratios are higher than in the PBE, for all n. For example, for $n = 19$ and $s_i = 1$, the likelihood ratio based on the empirical frequencies of investment is 1.41, instead of 1.001 for the PBE. This means that following the signal and investing upon observing $T_i = 0$ and $s_i = 1$ was more profitable in expectation in the laboratory than in the PBE. Intuitively, since subjects in the laboratory do not always invest after observing $T_i = 0$ and $s_i = 1$, the observation of no previous investments is not as bad news as in the PBE: observing no previous investment may simply be due to other subjects receiving the good signal and nevertheless deciding not to invest.

Second, for $n = 3$, the likelihood ratios for $T_i = 1$ and $T_i = 2$ are lower than in the PBE. Intuitively, since subjects make mistakes, by sometimes not investing after observing $T_i = 0$ and a good signal and by sometimes investing after observing $T_i = 0$ and a bad signal, a "high" number of observed investments ($T_i = 1$ or 2 for $n = 3$) is less indicative of a good state of the world. Note that, despite this difference between PBE and empirical likelihood ratios, subjects should still follow their signal except for $T_i = 2$, when it is still the case that they should engage in up-cascade behavior. The best responses remain the same as in the PBE since, whenever the PBE likelihood ratio is greater (less) than 1, so is the empirical likelihood ratio.

Third, for $n = 10$, similarly to $n = 3$, for "high" values of T_i (i.e., $T_i \geq 4$), the likelihood ratios are lower than in the PBE. A high number of observed investments is less indicative

[17] The frequencies are computed as follows:

$$\frac{\mathrm{Fr}(T_i|\omega = 1)}{\mathrm{Fr}(T_i|\omega = 0)} = \frac{\sum_{i=1}^{n} \mathrm{Fr}(T_i|\omega = 1, i) \Pr(i|\omega = 1)}{\sum_{i=1}^{n} \mathrm{Fr}(T_i|\omega = 0, i) \Pr(i|\omega = 0)} = \frac{\sum_{i=1}^{n} \mathrm{Fr}(T_i|\omega = 1, i)}{\sum_{i=1}^{n} \mathrm{Fr}(T_i|\omega = 0, i)}.$$

of the good state of the world, given that subjects make mistakes and do not always follow the signal when they face a low value of T_i. In other words, a high number of observed investments (relative to n) is not as good news as in the PBE. Note, in particular, that, conditional on a bad signal, the likelihood ratio becomes greater than 1 for $T_i = 5$, rather than for $T_i = 4$ as in the PBE. In other words, based on behavior in the laboratory, for a subject with a bad signal, it would be optimal to invest starting at $T_i = 5$ rather than at $T_i = 4$.

Fourth, for $n = 10$ and $n = 19$, for low values of T_i, the empirical likelihood ratios are *greater* than the PBE ones. As we have already mentioned in our first observation, subjects not investing in a large proportion of cases when T_i is low implies that a low value of T_i is not as bad news as in the PBE: it may simply be due to subjects not investing despite a good signal. Given that subjects have a low propensity to invest for low values of T_i, even a relatively low value of T_i may actually be quite strong evidence in favor of the good state of the world. Interestingly, for $n = 19$, the evidence in favor of the good state of the world is already sufficiently high for $T_i = 6$ that subjects should engage in up-cascade behavior, that is, invest despite a bad signal. In other words, given the behavior in the laboratory, for a subject, it would be optimal to engage in up-cascade behavior already for a *lower* value of T_i (in contrast to $n = 10$).

In sum, in the laboratory where subjects made decisions sometimes not in line with the PBE, low values of observed investments (relative to n) are not as bad news as in the PBE, and high values of observed investments are not as good news as in the PBE. Specifically, we have found the following result:

Result 2. *For $n = 3$, the best responses based on the empirical likelihood ratios coincide with the best responses in the PBE. For $n = 10$, given the empirical likelihood ratios, an up cascade should start later than in the PBE, and for $n = 19$, an up cascade should start earlier. For any n, not investing when $T_i = 0$ is more costly empirically than in the PBE.*

Table 11: Empirical LRs $\frac{\Pr(\omega=1|T_i,s_i)}{\Pr(\omega=0|T_i,s_i)}$ for $n = 3$

	$T_i = 0$	$T_i = 1$	$T_i = 2$
$s_i = 0$	0.324	0.619	**1.540**
$s_i = 1$	1.764	3.372	**8.387**

Empirical likelihood ratios (LRs) for each contingency.

Table 12: Empirical LRs $\frac{\Pr(\omega=1|T_i,s_i)}{\Pr(\omega=0|T_i,s_i)}$ for $n = 10$

	$T_i = 0$	$T_i = 1$	$T_i = 2$	$T_i = 3$	$T_i = 4$	$T_i = 5$	$T_i = 6$	$T_i = 7$	$T_i = 8$	$T_i = 9$
$s_i = 0$	0.299	0.357	0.454	0.639	**0.902**	**1.217**	**1.555**	**1.981**	**2.531**	**3.309**
$s_i = 1$	1.630	1.945	2.470	3.477	**4.911**	**6.628**	**8.467**	**10.784**	**13.782**	**18.015**

Empirical likelihood ratios (LRs) for each contingency.

Table 13: Empirical LRs $\frac{\Pr(\omega=1|T_i,s_i)}{\Pr(\omega=0|T_i,s_i)}$ for $n = 19$

	$T_i = 0$	$T_i = 1$	$T_i = 2$	$T_i = 3$	$T_i = 4$	$T_i = 5$	$T_i = 6$	$T_i = 7$	$T_i = 8$	$T_i = 9$
$s_i = 0$	0.259	0.273	0.325	0.413	0.578	0.762	1.045	**1.427**	**1.930**	**2.595**
$s_i = 1$	1.409	1.488	1.770	2.250	3.149	4.150	5.691	**7.771**	**10.509**	**14.131**
	$T_i = 10$	$T_i = 11$	$T_i = 12$	$T_i = 13$	$T_i = 14$	$T_i = 15$	$T_i = 16$	$T_i = 17$	$T_i = 18$	
$s_i = 0$	**3.493**	**4.623**	**6.132**	**8.188**	**10.846**	**14.510**	**19.536**	**26.704**	**36.637**	
$s_i = 1$	**19.019**	**25.169**	**33.383**	**44.578**	**59.050**	**78.997**	**106.362**	**145.386**	**199.468**	

Empirical likelihood ratios (LRs) for each contingency.

4.3 Quantal Response Equilibrium

To understand better the role of incentives in different contingencies and treatments, and whether there are other biases in the decision-making process, we now use the previous analysis to look at our data through the lens of the Quantal Response Equilibrium (QRE). As we noticed in the previous section, one characteristic common to all treatments is that the investment rate increases with the likelihood ratio. This is equivalent to saying that the higher the expected payoff from one action, the higher the frequency with which that action was chosen. This is also a characteristic of the QRE, in which the likelihood of a mistake is inversely related to its cost. Analyzing our data through the lens of the QRE seems, therefore, a natural way to shed more light on our results.

Compared to the estimation of a logit QRE for the basic informational cascade model of Bikhchandani et al. (1992), the estimation for our model presents some challenges. In a model in which agents know their position in the sequence, the likelihood function can be derived in a simple recursive way. Indeed, the probability of the first choice only depends on the logistic precision parameter and on the subject's signal. The probability of the second choice can be written as a function of this parameter, of the subject's signal, and of the first choice. All subsequent probabilities can be written as a function of the precision parameter, of the subject's own signal, and of the predecessors' choices. Under the assumption of rational expectations on the predecessors error rates, which is part of the equilibrium concept, it is therefore relatively straightforward to compute the likelihood function for an entire sequence of decisions. Assuming independence across sequences, one can then write and estimate the likelihood for all sequences observed in the laboratory. This is the standard "equilibrium correspondence approach to estimation" (Goeree et al., 2016). Note that, since each decision maker acts as in an individual decision-making set up (with informational externalities on the subsequent agents), the estimation of the precision parameter (and any other parameter of an enriched model) can be obtained without searching for a fixed point, which highly simplifies the analysis.

In our model, things are more complicated. To estimate the error rate of subjects observing, e.g., $T_i = 0$, one needs to know the subjects' belief for $T_i = 0$; this in turn depends on their error rate when they observe $T_i = 0$. Essentially, this means finding a fixed point. This is a complex problem when there are as many as 19 subjects who play the game. The problem becomes bigger for higher values of T_i, since the logit best response also depends on the belief about error rates for lower values of T_i. To tackle this issue, instead of using the equilibrium correspondence approach to estimation, we use the "empirical payoff approach" (Goeree et al., 2016). This consists of using the empirical expected payoffs, as implicitly described above by our likelihood ratios, and assuming that each subject's choice probability is a logit response to the empirical expected payoffs of different actions:[18]

$$\Pr(a_i = 1|T_i = j, s_i) = \frac{1}{1 + \exp(\lambda(1 - 2\pi_i^{s_i}(p_j))}, \tag{5}$$

where $p_j = \Pr(\omega = 1|T_i = j)$ is the belief after observing j investments and before receiving the signal, and $\pi_i^{s_i}(p_j)$ is the expected payoff from choosing $a_i = 1$ given the belief p_j and the signal s_i. In this expression, the belief of subjects observing $T_i = j$ is computed on the basis of the actual frequencies observed in the laboratory (as computed in expression (4)).

We refer the reader to the Appendix for a detailed illustration of the estimation method, and here we only report the results. In Panel A of Table 14, we show the precision parameter λ for the different group sizes. The precision parameter is decreasing in the group size n, indicating that, even after taking actual incentives into account, behavior differed across treatments. Subjects' behavior deviated more from rationality in larger groups. Note also that, for $n = 3$ and $n = 10$, λ, estimated separately for $s_i = 0$ and $s_i = 1$, is lower for $s_i = 1$, presumably reflecting the low frequency of investment, in particular, for low values of T_i.

[18] As observed by Goeree et al. (2016, p. 156), "In the limit, as the number of observations goes to infinity, and under the maintained hypothesis that all the data are generated by the same logit equilibrium, the empirical frequencies in the data will be exactly equal to the choice probabilities of the logit equilibrium, and the empirical expected payoff function will be exactly the expected payoffs in equilibrium."

For $n = 19$, the values of λ conditional on each signal (as well as the overall value) are the lowest among the three treatments, reflecting the frequent occurrence of down cascades for low values of T_i and the relatively low occurrence of up-cascade behavior for high values of T_i. For comparison, remember that Goeree et al. (2007, p. 753) obtain $\lambda = 4.4$ for their group of 20 participants and a precision of the signal similar to ours ($q = 0.66$ in their study versus $q = 0.7$ in ours).

Result 3. *The precision parameter in the logit QRE model is decreasing with n, indicating that, after taking actual incentives in the laboratory into account, subjects' deviations from full rationality are increasing in group size, n.*

Panel B of Table 14 presents the estimates for an enriched model, in which we also allow for the possibility that subjects underweight or overweight their private signal:

$$\Pr(\omega = 1 | T_i = j, s_i = 1) = \frac{q^{\alpha} p_j}{q^{\alpha} p_j + (1-q)^{\alpha}(1-p_j)}, \tag{6}$$

$$\Pr(\omega = 1 | T_i = j, s_i = 0) = \frac{(1-q)^{\alpha} p_j}{(1-q)^{\alpha} p_j + q^{\alpha}(1-p_j)}. \tag{7}$$

A value of the parameter α greater than 1 indicates overweighting of the private information *relative to* the information contained in the publicly observable number of investments T_i. Similarly, a value less than 1 indicates underweighting of private information relative to public information. A common result of the experimental literature on informational cascades is that subjects overweight their signal (see, e.g., Çelen and Kariv, 2004a, Goeree et al., 2007, and Angrisani et al., 2021).[19] Our results are quite different. For $n = 3$, overall $\alpha = 0.88$, while for $n = 10$, overall $\alpha = 0.61$. For both group sizes, α is lower for $s_i = 1$ than for $s_i = 0$. In other words, subjects underweight the signal, in particular, the good signal. For $n = 19$, subjects underweight the good signal ($\alpha = 0.28$) and overweight the bad signal. Overall, our results show that, in many cases, subjects in the laboratory underweight their signal relative to the public information, in sharp contrast with previous results. It seems, therefore, that overweighting private signal in social learning is not a universal characteristic of human behavior, rather it is context specific. In contexts in which all actions, and their timing, are observable (the typical set up studies in of previous experiments) subjects seem to attribute an error rate to predecessors' decisions, which

[19] In a recent paper, De Filippis et al. (2022) show, in the context of a continuous action space experiment, that the overweighting of private information occurs when it contradicts the public information, but not when it confirms it.

implies that the history of past decisions carries less information than in the PBE. In our experiment, instead, particularly when the group size is large, subjects consider a low number of investments as more informative of a bad state of the world than it actually is, with the result that they seem to put a very low weight on their signal (relative to public information).

Result 4. *According to our logit QRE model, subjects underweight their good signal, in contrast with previous experimental results in set ups in which both actions are observable. This shows that overweighting of private information is not a general characteristic of human behavior in social learning but depends on the information structure.*

Table 14: QRE parameter estimates

	Panel A			Panel B		
	λ			λ, α		
	Overall	$s_i = 0$	$s_i = 1$	Overall	$s_i = 0$	$s_i = 1$
$n = 3$	4.941	6.473	4.066	5.314, 0.880	6.610, 0.932	4.405, 0.882
$(s.e.)$	(0.214)	(0.282)	(0.190)	(0.237, 0.021)	(0.268, 0.024)	(0.319, 0.058)
$n = 10$	3.113	4.026	2.700	3.582, 0.611	4.074, 0.815	4.342, 0.220
$(s.e.)$	(0.078)	(0.139)	(0.074)	(0.105, 0.015)	(0.139, 0.021)	(0.172, 0.023)
$n = 19$	2.061	1.930	2.166	2.025, 1.412	2.275, 1.895	2.607, 0.283
$(s.e.)$	(0.046)	(0.064)	(0.047)	(0.045, 0.044)	(0.059, 0.045)	(0.062, 0.033)

Panel A shows the estimates for the precision parameter (λ) in the logit QRE model. Panel B shows the estimates for the precision parameter (λ) and the confidence parameter (α) in an enriched logit QRE model that allows for overconfidence in one's own private signal. Standard errors (s.e.) are estimated by bootstrapping with 200 replications.

4.4 Aggregate investments, welfare, and learning

To conclude, we now want to understand the implications of subjects' behavior in the laboratory in terms of aggregate investments, welfare, and learning.

An important prediction of the model is that, unconditionally, the overall fraction of investments (the observable action) is higher than 50%. Conditionally on each state of the world, there are more investments than in the standard informational cascade model (Bikhchandani et al., 1992) in which both actions are observable (and states and signals are symmetric). This is due to the absence of down cascades and the occurrence of up cascades. Table 15 reports the aggregate investment frequencies predicted by the PBE, as well as those observed in the laboratory. In stark contrast with the PBE prediction, the total frequency of investments is actually *less* than 50%, and decreasing in the group size, n. In other words, it is the unobservable action that is chosen more frequently.

Table 15: PBE and empirical frequencies of investment and welfare

PBE	$n = 3$	$n = 10$	$n = 19$
	Investment frequencies		
$\omega = 1$	0.75	0.83	0.84
$\omega = 0$	0.32	0.35	0.34
Overall	0.54	0.59	0.59
	Welfare		
Average Payoff	0.72	0.74	0.75

Data	$n = 3$	$n = 10$	$n = 19$
	Investment frequencies		
$\omega = 1$	0.63	0.51	0.49
$\omega = 0$	0.32	0.30	0.24
Overall	0.47	0.40	0.37
	Welfare		
Average Payoff	0.66	0.61	0.63

Theoretical and empirical frequencies of investment across treatments. The overall investment frequencies are computed using the theoretical probabilities (50%) of the states of the world. Welfare is measured as the payoff that, on average, subjects receive for each action in the experiment.

Since subjects receive a payoff of 1 if they choose an action matching the state of the world and 0 otherwise, a measure of welfare is given by the frequency with which the action matches the state. This coincides with the average payoff per action that subjects receive. Overall, in the PBE, welfare is increasing in the group size, since a higher frequency of up cascades in larger groups, on average, helps to make correct decisions. In the laboratory, instead, welfare is actually lower the larger the group, since deviations from equilibrium increase with the group size. Moreover, in the PBE, welfare is higher in the state $\omega = 1$ than in $\omega = 0$. This is intuitive since the occurrence of up cascades implies a higher probability of making the correct (wrong) choice in the good (bad) state of the world. In the laboratory, since subjects do not always engage in up cascade behavior and sometimes engage in down cascade behavior, the welfare loss compared to the PBE benchmark is much higher in the state $\omega = 1$ than in $\omega = 0$. As a result, welfare is actually higher in the bad than in the good state of the world.

Result 5. *In the PBE, unconditionally, investments (the observable action) occur in more than* 50% *of the cases. In contrast, in the data, overall, the unobservable action occurs more often than the observable one.*

Result 6. *In the PBE, welfare is higher in the good state of the world and increases with group size. In contrast, in the data, welfare is higher in the bad state of the world and decreases with group size.*

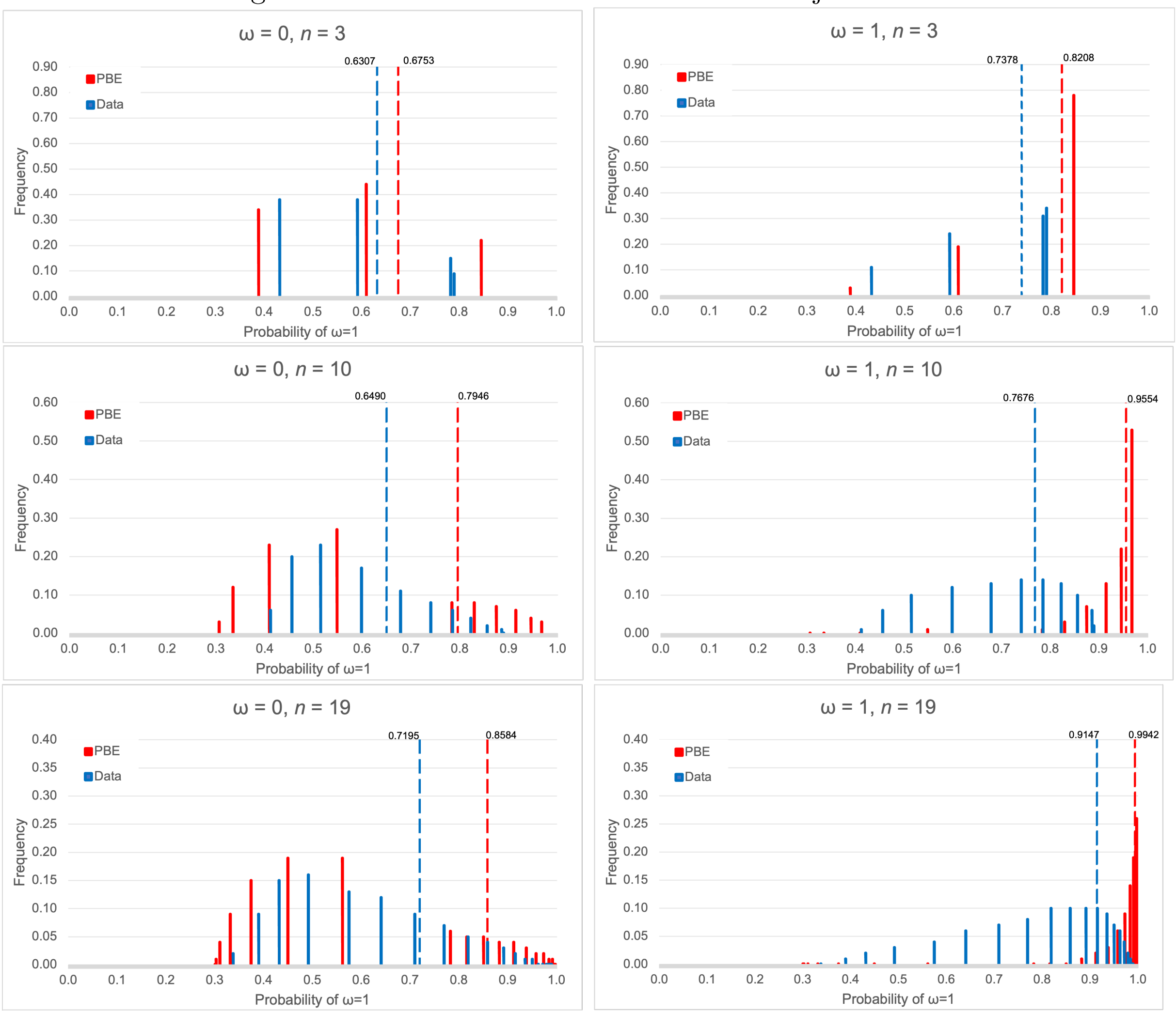
Finally, let us consider learning in the laboratory. Even if subjects had behaved as in the PBE, in our experiment, the state of the world would have not been revealed with probability one. The question is how much is learned in the experiment compared to the PBE benchmark. To this aim, we compute the distribution of beliefs after *all* n subjects have made their choices. Given the investment rates in Tables 4, 5, and 6, we compute the distribution of PBE likelihood ratios after time n, that is, after the n agents have made their decisions. Similarly, given the investment rates in Tables 11, 12, and 13, we compute the distribution of empirical likelihood ratios after time n. Figure 1 reports the results, expressed, for clarity of exposition, as the distribution of belief that the state is $\omega = 1$.[20]

In the experiment, the frequency of investments is different from the PBE and, as we discussed, due to noise, the informativeness of the number of investments is lower: this determines the difference between the PBE and the empirical distributions. As one can see, this difference becomes greater as n increases, which reflects both the closer adherence to the PBE in smaller groups and the fact that, over time, differences are cumulative. More importantly, the results are very different conditional on the state of the world. When the project is good, learning is much slower in the laboratory than in the PBE. For instance, for $n = 19$, the average likelihood ratio at the end of the experiment is 10.72, which is equivalent to saying that the probability that the project is good is 91%; in the PBE, instead, it is 171.3, equivalent to a probability that the project is good of 99%. In contrast, when the project is bad, the likelihood ratio is *lower* in the laboratory than in the PBE. This means that the belief is *closer* to the realized state of the world in the laboratory than in theory. For instance, for $n = 19$, the average likelihood ratio at the end of the experiment is 2.5647, which is equivalent to saying that the belief on the project being good is 72%; in the PBE, instead it is 6.0617 which is equivalent to saying that the belief on the project being good is 86%.

Result 7. *In the experiment, subjects learn the realized state of the world less accurately than in the PBE when it is good and more accurately than in the PBE when it is bad.*

[20] From $\frac{\Pr(\omega=1|T_i)}{\Pr(\omega=0|T_i)} = L$, one can immediately derive that $\Pr(\omega = 1|T_i) = \frac{L}{1+L}$.

Figure 1: Distribution of beliefs after all subjects acted



Each of the six panels in the figure refers to one treatment and one state of the world. In each panel, we show the distribution of beliefs ($\Pr(\omega = 1)$) after all subjects have made their decisions. The dashed line indicates the average of the distribution. The red histogram refers to the PBE while the blue histogram refers to the experimental data. For instance, consider the panel where $\omega = 1$ and $n = 3$; in the PBE, in 78% of the cases, there are either 2 or 3 investments by the three subjects, with the result that the belief is 0.85; in 19% of the cases, there is 1 investment with the result that the belief is 0.61, and in the remaining 3% of the cases, no investments occur with a resulting belief of 0.39.

5 Conclusion

We have studied how human subjects learn from others in social learning experiments in which, while the decision "to do" (e.g., to invest) is observable, the decision "not to do" (e.g., not to invest) is unobservable. In particular, in our experiments, subjects, in sequence, receive a private signal and only observe the aggregate number of previous investments.

Taken as a test of existing theories, our results are not very supportive of the equilibrium predictions, in particular when subjects choose in large groups (e.g., $n = 10$ and $n = 19$).

Under the conditions studied by Guarino et al. (2011), subjects in the laboratory are often unwilling to invest even with a good signal when they observe no or few previous investments, in clear contrast with the theory; at the same time, they engage in up-cascade behavior (i.e., investing with a bad signal after observing a sufficiently high number of previous investments) less than theoretically predicted. It is important to remark that subjects' reluctance to invest despite a good signal means they are actually underweighting their good private information relative to the public information conveyed by the lack (or the paucity) of previous investments. At the same time, the lower frequency of up cascades indicates that subjects overweight their bad signal relative to the information conveyed by a large number of investments. While overweighting private information is a standard result in social learning experiments, our work shows that, in more complex situations (in our case, arising from the asymmetry in the observability of actions), subjects can be mistaken, compared to the Bayesian benchmark, in both directions of overweighting and underweighting private information. Since these more complex situations are likely to arise in many real economic and social decision-making contexts, our experiment indicates that one should be careful in expecting human subjects to put always too much weight on their private information. This also means that one should not necessarily expect a lower tendency to imitate others than predicted by theories of rational social learning.

These deviations from equilibrium have important implications for aggregate investments and welfare. While according to the theory, the non observability of one action means that investments occur in more than 50% of the cases, in the laboratory, the result is actually reversed. In theory, welfare is higher than in a standard situation in which both decisions are observable (like in Bikhchandani et al., 1992) when the state of the world is good (i.e., the investment is good). In the laboratory, welfare is higher in the bad state of the world.

While these results are relevant in evaluating the theory in a positive perspective, they also have some interesting normative implications. While in many scenarios one action arises naturally as the observable one, there are some important cases where third parties may have the power to decide what kind of information is provided to agents. An example is the disclosure policy of a health agency. Consider a health agency that must decide how to disclose information on the adoption of a new treatment: one possibility is to reveal information on how many doctors have already decided to adopt the new treatment; another is to inform on how many have judged that it is preferable to stick to the old treatment; a third is to reveal both the number of doctors in favor of the new treatment and the number of doctors in favor of the old one. Following the theoretical predictions, one could conclude that, if the health agency is particularly concerned about the adoption of a particular treatment (e.g., in case it then proves to be ineffective, or because it is particularly expensive), the agency should not reveal information about the adoption rate of this treatment.[21] Theoretically, that would avoid a cascade of adoptions on the new treatment, which is relevant in the case the treatment is not good. Our works shows that one should be cautious in using this logic, since the theoretical results on aggregate investments and welfare for large groups of agents are actually reversed in the laboratory.

[21] Note that these extra considerations are unmodelled, hence they were not part of our welfare analysis. An example of adoption of a new treatment in which imitation seemed to play a big role is that of tonsillectomy in the sixties and seventies (see Bikhchandani et al., 1992).

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6 Online Appendix

Proof of Proposition 1

Let us first consider the optimal decision of an agent who observes $(T_i = 0, s_i = 1)$. The agent's likelihood ratio is

$$\frac{\Pr(\omega = 1 \mid T_i = 0, s_i = 1)}{\Pr(\omega = 0 \mid T_i = 0, s_i = 1)} = \frac{\Pr(T_i = 0 \mid \omega = 1)}{\Pr(T_i = 0 \mid \omega = 0)} \frac{q}{1-q}, \tag{8}$$

where q is the signal precision (in the text, we set $q = 0.7$ since this is the precision used in the experiment – the proposition holds more generally).

Hence, the agent predicts that the project is more likely to be good if

$$\frac{\Pr(T_i = 0 \mid \omega = 1)}{\Pr(T_i = 0 \mid \omega = 0)} > \frac{1-q}{q}. \tag{9}$$

Observe that

$$\begin{aligned}
\Pr(T_i = 0 \mid \omega = 1) &= \sum_{i=1}^{n} \Pr(T_i = 0 \mid \omega = 1, i) \Pr(i \mid \omega = 1) \\
&= \sum_{i=1}^{n} \Pr(T_i = 0 \mid \omega = 1, i) \frac{1}{10}.
\end{aligned} \tag{10}$$

Moreover,

$$\Pr(T_i = 0 \mid \omega = 1, i = 1) = 1, \tag{11}$$

and

$$\begin{aligned}
\Pr(T_i = 0 \mid \omega = 1, i = 2) &= \Pr(T_2 = 0 \mid \omega = 1) \\
&= \Pr(a_1 = 0 \mid \omega = 1, T_1 = 0) \\
&= \Big(q\big(1 - \Pr(a_1 = 1 \mid s_1 = 1, T_1 = 0)\big) \\
&\quad + (1-q)\big(1 - \Pr(a_1 = 1 \mid s_1 = 0, T_1 = 0)\big)\Big).
\end{aligned} \tag{12}$$

Let $x_0 \equiv \Pr(a_i = 1 \mid s_i = 1, T_i = 0)$ and $y_0 \equiv \Pr(a_i = 1 \mid s_i = 0, T_i = 0)$ denote the probabilities of investing after observing no investments and a good or bad signal, respectively. Then, we have that

$$\Pr(T_i = 0 \mid \omega = 1, i = 2) = (q(1 - x_0) + (1-q)(1 - y_0)). \tag{13}$$

Similar computations show that

$$\Pr(T_i = 0 \mid \omega = 1, i) = ((q(1 - x_0) + (1-q)(1 - y_0)))^{i-1}. \tag{14}$$

Therefore,

$$\Pr(T_i = 0 \mid \omega = 1) = \sum_{i=1}^{n} (q(1-x_0) + (1-q)(1-y_0))^{i-1}, \tag{15}$$

and, similarly,

$$\Pr(T_i = 0 \mid \omega = 0) = \sum_{i=1}^{n} ((1-q)(1-x_0) + q(1-y_0))^{i-1}. \tag{16}$$

Therefore, it is optimal for the agent to predict a good project if

$$\frac{\sum_{i=1}^{n}(q(1-x_0) + (1-q)(1-y_0))^{i-1}}{\sum_{i=1}^{n}((1-q)(1-x_0) + q(1-y_0))^{i-1}} > \frac{1-q}{q}. \tag{17}$$

Now note that the left hand side of the inequality is decreasing in x_0 and increasing in y_0, hence it reaches its minimum at $(x_0 = 1,\ y_0 = 0)$. At the minimum, solving for the sums and rearranging terms, the inequality becomes

$$\frac{\frac{1-(1-q)^n}{1-(1-q)}}{\frac{1-q^n}{1-q}} > \frac{1-q}{q}, \tag{18}$$

which is satisfied for any $q > 0.5$. (Note that the minimum coincides with the expression for the PBE; see also the proof in Guarino et al. (2011, p. 171).

We now consider the optimal decision of an agent who observes $(T_i = 0, s_i = 1)$. The agent's likelihood ratio is

$$\frac{\Pr(\omega = 1 \mid T_i = 0, s_i = 1)}{\Pr(\omega = 0 \mid T_i = 0, s_i = 1)} = \frac{\Pr(T_i = 0 \mid \omega = 1)}{\Pr(T_i = 0 \mid \omega = 0)} \frac{q}{1-q}. \tag{19}$$

Hence, the agent predicts that the project is more likely to be bad if

$$\frac{\Pr(\omega = 1 \mid T_i = 0)}{\Pr(\omega = 0 \mid T_i = 0)} < \frac{q}{1-q}, \tag{20}$$

that is, if

$$\frac{\Pr(T_i = 0 \mid \omega = 1)}{\Pr(T_i = 0 \mid \omega = 0)} < \frac{q}{1-q}. \tag{21}$$

Similar steps to those above prove that the inequality is respected if and only if

$$\frac{\sum_{i=1}^{n}(q(1-x_0) + (1-q)(1-y_0))^{i-1}}{\sum_{i=1}^{n}((1-q)(1-x_0) + q(1-y_0))^{i-1}} < \frac{q}{1-q}. \tag{22}$$

Now observe that the maximum of the left hand side of the inequality is obtained when $(x_0 = 0,\ y_0 = 1)$. In this case, the inequality becomes

$$\frac{\frac{1-q^n}{1-q}}{\frac{1-(1-q)^n}{1-(1-q)}} < \frac{q}{1-q}, \tag{23}$$

or

$$\frac{1 - q^n}{1 - (1 - q)^n} < 1, \tag{24}$$

which is true for any $q > 0.5$.

Frequencies of Investment for n = 3 (First 15 Rounds)

For the $n = 3$ treatment, we ran the experiment with 30 rounds. Table 16 shows the average investment rates across the first 15 rounds for each contingency.

Table 16: Frequencies of investment for $n = 3$ (first 15 rounds)

	$T_i = 0$	$T_i = 1$	$T_i = 2$
$s_i = 0$	0.08	0.10	**0.84**
$s_i = 1$	0.68	0.94	**0.93**

Empirical frequencies of investment ($a_i = 1$) for the first 15 rounds. The bold font indicates that, theoretically, a subject is in an up cascade.

QRE Estimation Method

In this section, we describe the QRE estimation method. We use the empirical frequency approach. Each subject's choice probability is a logit response to the empirical expected payoffs of different actions and is computed according to

$$Pr(a_i = 1|s_i, T_i = j) = \frac{1}{1 + \exp(\lambda(1 - 2\pi_i^{s_i}(p_j))}, \tag{25}$$

where $p_j = \Pr(\omega = 1|T_i = j)$ is the belief after observing j investments and before receiving the signal, and $\pi_i^{s_i}(p_j)$ is the expected payoff from choosing $a_i = 1$ given the belief p_j and the signal s_i.

In the empirical frequency approach, we compute the values of p_j from the actual frequencies of investment. Let us denote these frequencies by k_{sT}, where s refers to the signal and T to the number of prior investments. Consider the case of $n = 3$; the frequencies are as follows:

	$T_i = 0$	$T_i = 1$	$T_i = 2$
$s_i = 0$	k_{00}	k_{01}	k_{02}
$s_i = 1$	k_{10}	k_{11}	k_{12}

From these frequencies, we can compute the value of p_j as:

$$\begin{aligned} p_j &= \frac{\Pr(T_i = j|\omega = 1)\Pr(\omega = 1)}{\Pr(T_i = j|\omega = 1)\Pr(\omega = 1) + \Pr(T_i = j|\omega = 0)\Pr(\omega = 0)} \\ &= \frac{\Pr(T_i = j|\omega = 1)\frac{1}{2}}{\Pr(T_i = j|\omega = 1)\frac{1}{2} + \Pr(T_i = j|\omega = 0)\frac{1}{2}}. \end{aligned} \tag{26}$$

As an example, let us consider, for $n = 3$, the case for p_0. Let us consider the good state of the world, that is, $\omega = 1$.

$$\begin{aligned} \Pr(T_i = 0|\omega = 1) = & \Pr(T_i = 0|\omega = 1, i = 1)\frac{1}{3} + \Pr(T_i = 0|\omega = 1, i = 2)\frac{1}{3} \\ & + \Pr(T_i = 0|\omega = 1, i = 3)\frac{1}{3} \\ = & \frac{1}{3}\Bigg(1 + \Big(q(1 - k_{10}) + (1 - q)(1 - k_{00})\Big) \\ & + \Big(q^2(1 - k_{10}) + (1 - q)^2(1 - k_{00}) \\ & + 2q(1 - q)(1 - k_{00})(1 - k_{10})\Big)\Bigg). \end{aligned} \tag{27}$$

Similarly, for $\omega = 0$, we find that

$$\begin{aligned}
\Pr(T_i = 0|\omega = 0) = &\Pr(T_i = 0|\omega = 0, i = 1)\frac{1}{3} + \Pr(T_i = 0|\omega = 0, i = 2)\frac{1}{3} \\
&+ \Pr(T_i = 0|\omega = 0, i = 3)\frac{1}{3} \\
= &\frac{1}{3}\Bigg(1 + \Big((1-q)(1-k_{10}) + q(1-k_{00})\Big) \\
&+\Big((1-q)^2(1-k_{10}) + q^2(1-k_{00}) \\
&+2q(1-q)(1-k_{00})(1-k_{10})\Big)\Bigg)
\end{aligned} \tag{28}$$

.

After computing p_j, we apply Bayes's rule to find the expected payoffs from choosing action $a_{isT} = 1$, defined as the action of agent i, conditional on signal s and observed investments T. If $s_i = 1$ and $T_i = j$, then

$$\pi_i^1 \equiv \Pr(\omega = 1|s_i = 1, T_i = j) = \frac{qp_j}{qp_j + (1-q)(1-p_j)}. \tag{29}$$

If $s_i = 0$ and $T_i = j$, then

$$\pi_i^0 \equiv \Pr(\omega = 1|s_i = 0, T_i = j) = \frac{(1-q)p_j}{(1-q)p_j + q(1-p_j)}. \tag{30}$$

The expected payoff loss if the agent chooses $a_i = 1$ is the expected payoff of choosing $a_i = 0$ minus the expected payoff of choosing $a_i = 1$:

$$(1 - \pi_i^{s_i}(p_j)) - \pi_i^{s_i}(p_j) = (1 - 2\pi_i^{s_i}(p_j)). \tag{31}$$

From the expected payoff functions, we use the logit specification in Expression 25 to compute the probabilities of a_i. The likelihood function for a single round of the experiment is given by

$$l(\lambda) = \prod_{i=1}^{n}\prod_{s=0}^{1}\prod_{T=0}^{n-1} \Pr\left(a_{isT}|\lambda\right). \tag{32}$$

To compute the likelihood function for all M rounds, we define a_{isT}^m as the action of agent i in round m, conditional on signal s and observed investments T. The likelihood function is given by

$$L(\lambda) = \prod_{m=1}^{M}\prod_{i=1}^{n}\prod_{s=0}^{1}\prod_{T=0}^{n-1} \Pr\left(a_{isT}^m|\lambda\right). \tag{33}$$

For the enriched model, we use the same steps. However, beliefs after receiving the private signals are updated as in Expressions 6 and 7.

Experimental Instructions

INSTRUCTIONS [n=3]

Welcome to our experiment!

You are participating in an experiment in which you interact with two other participants. There may be more people in the room, but you will be interacting with only two participants, and this group will be the same throughout the entire experiment. Your earnings will depend on your decisions and some luck. If you are careful and make good decisions, you may earn a considerable amount of money. You will receive the money, in private, immediately after the experiment. All participants have the same instructions.

Please be quiet during the entire experiment. Do not talk to your neighbours and do not try to look at their screens. Simply concentrate on the experiment. If you have a question during the experiment, please raise your hand. We will be happy to come to you and answer it privately.

The experiment

What do I have to do?

There will be several rounds in this experiment. In each round, **you will be asked to predict if a project is good or bad.** At the beginning of each round**,** the computer will randomly select whether the project is good or bad. It is equally likely that either a good project or a bad project is selected. In other words, the project is good with 50% probability and bad with 50% probability.

Note that the project is the same for all participants. If the project is good, it is good for all three participants in the group. Similarly, if it is bad, it is bad for all the three of you.

If your prediction is correct, that is, the computer selects the good project and you predict that the project is good, or the computer selects the bad project and you predict that the project is bad, **then you earn £7. If your prediction is incorrect, you earn nothing.**

What information do I have in order to make my decision?

As we said, **the computer will select whether the project is good or bad randomly**. You will not know the computer's selection, but we will give you some information about it to help you to make your prediction. You will be shown a ball, either green or red, drawn from an urn. **If the project is good, the ball is drawn from an urn containing 70 GREEN and 30 RED balls. In other words, if the project is good, there is 70% probability that a green ball is drawn. If the project is bad, the ball is drawn from an urn containing 70 RED and 30 GREEN balls.** In other words, if the project is bad, there is 70% probability that the ball is red. You (and only you) will be told the colour of this ball.

Note, while the project is the same for all participants (and thus the urn from which the ball is drawn is the same for everybody), **the computer will draw a ball afresh for each participant**. It will draw a ball for you and then replace it into the urn. Then, it will draw a ball for another participant and then replace it. And so on, so that the composition of the urn is always the same. Of course, it is well possible that you receive a green ball and another participant a red one, and vice versa.

This is not the only information that you will receive. You will also observe something about the other participants' decisions.

Information about other participants' decisions

You and the other two participants will make your predictions about the project in sequence. Therefore, you may be the first in the sequence and make your decision before everybody else; or you may be the second in the sequence, or the third in the sequence. Your position in the sequence is assigned to you randomly by the computer. Any position in the sequence is equally likely.

We will not tell you your position in the sequence. However, **we will tell you how many people before your turn in the sequence have predicted that the project is good. Note that you will only know how many people before your**

turn predicted the project to be good. We will not tell you how many people predicted the project to be bad. Let us briefly look at the different possibilities that can arise:

(i) You might see that two participants predicted the project to be good, in which case, obviously, you know for sure that you must be the last in the sequence, which is the third position. In this case, you know that nobody predicted the project to be bad.

(ii) You might observe that none of the other participants before your turn predicted the project to be good. In that case you might be the first in the sequence; or you might be the second in the sequence and the first participant predicted the project to be bad (something you cannot observe); or you might be the third in the sequence and both the first and the second participants predicted the project to be bad. In general, you may be in any position in the sequence and the reason you are observing no prediction of "good project" is because the participants who made their predictions before you predicted that the project is bad.

(iii) You might see some predictions of "good project". If you see, for instance, two predictions of "good project", it means that the first and second participants in the sequence have both predicted "the project is good" and you are, obviously, the third (and last) in the sequence. If you see, for instance, one prediction of "good project", you might be the second in the sequence and the first participant predicted that the "project is good", or you might also be the third in the sequence and either one of your predecessors in the sequence (the first or the second) predicted "the project is good", whereas the other predicted "the project is bad".

It is important that this set up is clear to you. Please raise your hand if you have any question at this point.

Procedures for each round

There will be 33 rounds in this experiment. The first 3 are practice rounds: they are for you to become familiar with the experiment and will not count towards your payment. The last 30 will count towards your final payment.

Note that every round is completely independent of other rounds. In other words, whether the project is good or bad in a round is independent of whether it was good or bad in previous rounds.

First, the computer decisions – At the beginning of each round the computer selects whether the project is good or bad, randomly. It then draws a ball for you and one for each other participants in sequence either from the urn with 70 GREEN balls and 30 RED balls if the project is good, or from the run with 70 RED balls and 30 GREEN balls if the project is bad. Moreover, it decides the position of each participant in the sequence: it selects one of you as the first in the sequence, one as the second, one as the third.

Second, your decision – You have to predict whether the project is good or bad. You have two pieces of information: (i) the colour of the ball you receive and (ii) how many people you observe having predicted "the project is good" before your turn.

But note: we will not tell you your position in the sequence and the colour of your ball straight away. We will reveal this to you later. Instead, at this stage, we will ask you to make your prediction for each possible situation you may find yourself in. We will ask you to make the prediction about whether the project is good or bad for each possible combination of "number of people predicting that the project is good you observe" and "colour of your ball".

You will see a table like this:

Row	Number of people predicting "the project is good" you observe	You receive a GREEN ball	You receive a RED ball
0	You observe no one predicting "the project is good"	???	???
1	You observe 1 person predicting "the project is good"	???	???
2	You observe 2 persons predicting "the project is good"	???	???

The table indicates all possible situations in which you can be. For each possible situation, you have to predict whether the project is good or bad. Each row number indicates how many people predicting "the project is good" you observe. These are the number of predictions "the project is good" made by other participants who preceded you in the sequence. Remember that they are not necessarily the number of participants who preceded you, because you can only observe predictions of the type "the project is good", you cannot observe predictions of the type "the project is bad". The last two columns indicate the colour of the ball you receive.

Therefore, the way to read the table is the following:

Look at row numbered 0:

Row	Number of people predicting "the project is good" you observe	You receive a GREEN ball	You receive a RED ball
0	You observe no one predicting "the project is good"	???	???

In the row numbered 0, we are asking you: suppose you observe NO ONE PREDICTING "THE PROJECT IS GOOD"; and suppose you receive a green ball from the urn; do you think the project is good or bad? And if, instead, you receive a red ball from the urn, do you think the project is good or bad? We will ask you to record your answers in the cells marked by symbol "???" in row 0, by clicking on it: clicking once changes the answer to "PREDICT GOOD PROJECT"; clicking twice changes the answer to "PREDICT BAD PROJECT". You can click and change the answer as many times as you like.

Look now at row numbered 1:

Row	Number of people predicting "the project is good" you observe	You receive a GREEN ball	You receive a RED ball
1	You observe 1 person predicting "the project is good"	???	???

In the row numbered 1, you observe that somebody else predicted the project to be good. In this situation, we are asking you: suppose you observe ONE PERSON PREDICTING "THE PROJECT IS GOOD" and you receive a green ball from the urn; do you think the project is good or bad? And if instead you receive a red ball from the urn, do you think the project is good or bad? We will ask you to record your answers in the cells marked with symbol "???" in row 1.

The last row reads in a similar way. In row numbered 2 you observe TWO PEOPLE PREDICTING "THE PROJECT IS GOOD".

Row	Number of people predicting "the project is good" you observe	You receive a GREEN ball	You receive a RED ball
2	You observe 2 persons predicting "the project is good"	???	???

In row 2 we are asking you: suppose you observe TWO PEOPLE PREDICTING "THE PROJECT IS GOOD" and you receive the green ball; do you think the project is good or bad? And if, instead, you receive the red ball, do you think the project is good or bad?".

We will ask you to record your answers for each possible situation. So, you have to make 6 decisions in total.

Your Per-round earnings

After all participants have made their predictions, the computer will reveal your position in the sequence, whether the project was good or bad, and the colour of your ball.

Out of the 6 situations you were presented, only one situation will be relevant for your earnings and this depends on three things:

1. the colour of the ball you actually received;
2. the position in the sequence the computer assigned to you;
3. the decisions of the other participants who preceded you in the sequence.

Your earnings will depend on whether your prediction was correct in that selected situation.

Let us see some examples. Suppose, for instance, that your decisions in rows 0 to 2 are as follows:

Row	Number of people predicting "the project is good" you observe	You receive a GREEN ball	You receive a RED ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe 1 person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT
2	You observe 2 persons predicting "the project is good"	PREDICT BAD PROJECT	.

For the purpose of the examples we show you only 5 imaginary decisions out of the 6 decisions you will have to make. These decisions are just for the examples; do not attach any value to them.

Example 1.

Suppose the computer selects you as the **first in the sequence** and **you receive the green ball from either urn**. Clearly, being in the first position in the sequence, you observe no one predicting before your turn. Therefore, the relevant situation for your earnings is the one in row 0 (because you observe no one predicting "the project is good") and in the column "you receive a green ball", which is highlighted in yellow below:

Row	Number of people predicting "the project is good" you observe	You receive a GREEN ball	You receive a RED ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since in this situation your prediction was "THE PROJECT IS BAD", your earnings will be

£0 if the project is good
£7 if the project is bad

Example 2.

Suppose the computer selects you as the **second in the sequence** and **you receive a green ball**. **The relevant situation for you depends on what the participant who was selected as first in the sequence decided to do.** Suppose he received a red ball and predicted that the "project is bad" when he receives a red ball and observes no one predicting the project to be good (as he does since he is the first in the sequence). In this case, being the second in the sequence, you observe no one predicting the "project is good". Therefore, your relevant situation for your earnings is again the one in row 0 (because you observe no one predicting "the project is good") and in the column "you receive a green ball", which is highlighted in yellow below:

Row	Number of people predicting "the project is good" you observe	You receive a GREEN ball	You receive a RED ball
0	You observe no one predicting “the project is good”	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since in this situation you predicted that the “PROJECT IS BAD”, your earnings will be

£0 if the project is good
£7 if the project is bad

Consider now the same example but a different scenario: suppose you are second in the sequence and the participant selected as the first in the sequence and who received a red ball predicted that “the project is good”. In this case, being the second in the sequence, you observe one person predicting “the project is good”. Therefore, the relevant situation for your earnings is the one in row 1 (because you observe one person predicting “the project is good”) and in the column “you receive a green ball” (because you received a green ball), which is highlighted in yellow below:

Row	Number of people predicting "the project is good" you observe	You receive a GREEN ball	You receive a RED ball
0	You observe no one predicting “the project is good”	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe 1 person predicting “the project is good”	PREDICT GOOD PROJECT	PREDICT BAD PROJECT

Since in this situation you predicted that the “PROJECT IS GOOD”, your earnings will be

£7 if the project is good
£0 if the project is bad

Example 3.

Suppose the computer selects you as the **third in the sequence** and **you receive a green ball**. **The relevant situation for you depends on what the participants who were selected as first and second in the sequence decided to do.** Suppose that the one selected as first received a red ball and predicted that “the project is bad”. Furthermore, suppose that the one selected as second received a green ball and predicted that “the project is bad” when he observes a green ball and no one predicting the project to be good (as he does because the first participant predicted that “the project is bad”). In this case, being the third in the sequence, you observe no one predicting that “the project is good”. Therefore, your relevant situation for your earnings is again the one in row 0 and in the column “you receive a green ball”, which is highlighted in yellow below:

Row	Number of people predicting "the project is good" you observe	You receive a GREEN ball	You receive a RED ball
0	You observe no one predicting “the project is good”	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since in this situation you predicted that the "PROJECT IS BAD", your earnings will be

£0 if the project is good,
£7 if the project is bad.

Consider now the same example but a different scenario: suppose that the participant selected as second in the sequence and who received a green ball predicted the project to be good. In this case, being the third in the sequence, you observe one person predicting that "the project is good". Therefore, the relevant situation for your earnings is the one in row 1 and in the column "you receive a green ball", which is highlighted in yellow below:

Row	Number of people predicting "the project is good" you observe	You receive a GREEN ball	You receive a RED ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe one person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT

Since in this situation you predicted that the "PROJECT IS GOOD", your earnings will be

£7 if the project is good,
£0 if the project is bad.

Consider now a different scenario. Suppose that the participant selected as first in the sequence and who received a red ball predicted that "the project is good". Furthermore, suppose that the one selected as second in the sequence and who received a green ball predicted that "the project is good" when he observes a green ball and one person predicting that "the project is good" (as he does because the first participant made that prediction too). In this case, being the third in the sequence, you observe two people predicting that "the project is good". Therefore, the relevant situation for your earnings is the one in row 2 and in the column "you receive a green ball", which is highlighted in yellow below:

Row	Number of people predicting "the project is good" you observe	You receive a GREEN ball	You receive a RED ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe one person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT
2	You observe two people predicting "the project is good"	PREDICT BAD PROJECT	.

Since in this situation you predicted that the "PROJECT IS BAD", your earnings will be

£0 if the project is good,
£7 if the project is bad.

Since the computer chooses the sequence randomly, you may end up in any position. Hence, **think carefully about what is in your interest to do in each situation**.

You earnings will be summarised on a screen. For example, take the last scenario in example 3: you will see your earnings on a screen similar to the one below:

You earnings for round # 1

The project was **good.**

You received a **green ball**.

You were the **third** in the sequence.

Based on your predictions and the other participants' predictions, the sequence of predictions in this round is:

Your and other participants' position in the sequence	1st in sequence	2nd in sequence	**3rd in sequence: YOU**
Participant's prediction	"GOOD PROJECT"	"GOOD PROJECT"	**"BAD PROJECT"**

The **project was good** and your prediction was that the **project is BAD**, so your earnings are **£0**

How much would my payoff be if I were in a different position in the sequence?

Your accrued earnings for each round are based on one selected sequence. For instance, in the example above you were selected as the third in the sequence. What would your payoff be had you been in a different position in the sequence? For example, how much would you have gotten if you had been first in the sequence? And, what if you had been selected as the second in the sequence?

At the end of each round, the computer will tell you the payoff you would have ***gained on average for each possible position in the sequence in which you could be***, based on your predictions and on the predictions of the other participants in this round. These will be *average* earnings because there is more than one potential sequence. For instance, if you are second in the sequence, each of the remaining 2 participants can be selected as the first. So there are two different potential sequences. Your average earnings are calculated based on *your predictions* and on *the predictions of others* in ***all possible sequences.***

These average payoffs will not accrue to your final earnings. But they will give you an idea about the quality of your predictions.

Your average payoffs for each position in the sequence will be shown on the last screen of each round. You will see your average payoff for each position in the sequence on a screen similar to the one below:

What would your payoffs be on average if you had been selected in any other position in the sequence?

Each column below tells you the average payoff for each possible position in the sequence. Note that these average payoffs are calculated based on the predictions of all participants in this round.

Based on your predictions and the predictions of the other participants in this round, if you had been selected in the:

1st position in the sequence, your average payoff would have been: **£7.00**	**2nd position** in the sequence, your average payoff would have been: **£7.00**	**3rd position** in the sequence, your average payoff would have been: **£3.50**

Final payment

For showing up in time for the experiment you earn £5. In addition, you will earn an amount that depends on your answers during the experiment. We will pay you according to your accrued earnings in 3 randomly selected rounds.

Remember, this experiment has 30 rounds and you accrue some earnings in each round. After the last round, three rounds among the 30 rounds will be selected randomly (one among the rounds 1-10, one among rounds 11-20 and one among rounds 21-30). **We will sum up your earnings in these 3 rounds and add £5 for showing up**. Since each round has an equal chance to be selected for payment, think carefully about what is in your interest to do in each round.

Do you have any question? If so, please raise your hand. The experiment will start shortly.

INSTRUCTIONS [n=10]

Welcome to our experiment!

You are participating in an experiment in which you interact with nine other participants. Your earnings will depend on your decisions and some luck. If you care careful and make good decisions, you may earn a considerable amount of money. You will receive the money, in private, immediately after the experiment. All participants have the same instructions.

Please be quiet during the entire experiment. Do not talk to your neighbours and do not try to look at their screens. Simply concentrate on the experiment. If you have a question during the experiment, please raise your hand. We will be happy to come to you and answer it privately.

The experiment

What do I have to do?

There will be several rounds in this experiment. In each round, **you will be asked to predict if a project is good or bad.** At the beginning of each round**,** the computer will randomly select whether the project is good or bad. It is equally likely that either a good project or a bad project is selected. In other words, the project is good with 50% probability and bad with 50% probability.

Note that the project is the same for all participants. If the project is good, it is good for all ten participants. Similarly, if it is bad, it is bad for all the ten of you.

If your prediction is correct, that is, the computer selects the good project and you predict that the project is good, or the computer selects the bad project and you predict that the project is bad, **then you earn £7. If your prediction is incorrect, you earn nothing.**

What information do I have in order to make my decision?

As we said, **the computer will select whether the project is good or bad randomly**. You will not know the computer's selection, but we will give you some information about it to help you to make your prediction. You will be shown a ball, either green or red, drawn from an urn. **If the project is good, the ball is drawn from an urn containing 70 GREEN and 30 RED balls. In other words, if the project is good, there is 70% probability that a green ball is drawn. If the project is bad, the ball is drawn from an urn containing 70 RED and 30 GREEN balls.** In other words, if the project is bad, there is 70% probability that the ball is red. You (and only you) will be told the colour of this ball.

Note, while the project is the same for all participants and thus, the urn from which the ball is drawn is also the same for everybody, **the computer will draw a ball afresh for each participant**. It will draw a ball for you and then replace it into the urn. Then, it will draw a ball for another participant and then replace it. And so on, so that the composition of the urn is always the same. Of course, it is well possible that you receive a green ball and another participant a red one, and vice versa.

This is not the only information that you will receive. You will also observe something about the other participants' decisions.

Information about other participants' decisions

You and the other nine participants will make your predictions about the project in sequence. Therefore, you may be the first in the sequence and make your decision before everybody else; or you may be the second in the sequence or the third and so on. The last position in the sequence is, obviously, the tenth. Your position in the sequence is assigned to you randomly by the computer. Any position in the sequence is equally likely.

We will not tell you your position in the sequence. However, **we will tell you how many people before your turn in the sequence have predicted that the project is good. Note, you will only know how many people before your turn predicted the project to be good. We will not tell you how many people predicted the project to be bad.** Let us briefly look at the different possibilities that can arise:

(i) You might see that nine participants predicted the project to be good, in which case, obviously, you know for sure that you must be the last in the sequence. In this case, you know that nobody predicted the project to be bad.

(ii) You might observe that none of the other participants before your turn predicted the project to be good. In that case you might be the first in the sequence; or you might be the second in the sequence and the first participant predicted the project to be bad (something you cannot observe); or you might be the third in the sequence and both the first and the second participants predicted the project to be bad; or you might be fourth in the sequence, and the three preceding participants all predicted the project to be bad. In general, you may be in any position in the sequence and the reason you are observing no prediction of "good project" is because the participants who made their predictions before you predicted that the project is bad.

(iii) You might see some predictions of "good project". If you see, for instance, two people predicting "the project is good", it may be that you are the third in the sequence and the first two in the sequence have both predicted "the project is good". But you might also be the fourth in the sequence and only two of the three participants who preceded you have predicted "the project is good". You might even be the last one in the sequence and only two of your predecessors have predicted "the project is good", whereas all the others have predicted "the project is bad".

It is important that this set up is clear to you. Please raise your hand if you have any question at this point.

Procedures for each round

There will be 18 rounds in this experiment. The first 3 are practice rounds: they are for you to become familiar with the experiment and will not count for your payment. The last 15 will count for your final payment.

Note that every round is completely independent of other rounds. Specifically, whether the project is good or bad in a round is independent of whether it was good or bad in previous rounds.

First, the computer decisions – At the beginning of each round the computer selects whether the project is good or bad, randomly. It then draws a ball for you and one for each other participants in sequence (every time with replacement in the urn) either from the urn with 70 GREEN balls and 30 RED balls if the project is good, or from the run with 70 RED balls and 30 GREEN balls if the project is bad. Moreover, it decides the position of each participant in the sequence: it selects one of you as the first in the sequence, one as the second, one as the third, and so on.

Second, your decision – You have to predict whether the project is good or bad. You have two pieces of information: (i) the colour of the ball you receive and (ii) how many people you observe having predicted "the project is good" before your turn.

But note: we will not tell you your position in the sequence and the colour of your ball straight away. We will reveal this to you later. Instead, at this stage, we will ask you to make your prediction for each possible situation you may find yourself in. We will ask you to make the prediction about whether the project is good or bad for each possible combination of "number of people predicting that the project is good you observe" and "colour of your ball".

You will see a table like this:

Row number	Number of people predicting "the project is good" you observe:	You receive a Green ball	You receive a Red ball
0	You observe no one predicting "the project is good"	?	?
1	You observe 1 person predicting "the project is good"	?	?
2	You observe 2 people predicting "the project is good"	?	?
3	You observe 3 people predicting "the project is good"	?	?
4	You observe 4 people predicting "the project is good"	?	?
5	You observe 5 people predicting "the project is good"	?	?
6	You observe 6 people predicting "the project is good"	?	?
7	You observe 7 people predicting "the project is good"	?	?
8	You observe 8 people predicting "the project is good"	?	?
9	You observe 9 people predicting "the project is good"	?	?

The table indicates all possible situations in which you can be. For each possible situation, you have to predict whether the project is good or bad. Each row number indicates how many people predicting "the project is good" you observe. These are the number of predictions "the project is good" made by other participants who preceded you in the sequence. Recall that they are not necessarily the number of participants who preceded you, because you can only observe predictions of the type "the project is good", you cannot observe predictions of the type "the project is bad". The last two columns indicate the colour of the ball you receive.

Therefore, the way to read the table is the following:

Look at row numbered 0:

		Green ball	Red ball
0	You observe no one predicting "the project is good"	?	?

In the row numbered 0, we are asking you: suppose you observe NO ONE PREDICTING "THE PROJECT IS GOOD"; and suppose you receive a green ball from the urn; do you think the project is good or bad? And if, instead, you receive a red ball from the urn, do you think the project is good or bad? We will ask you to record your answers in the cells marked by symbol "?" in row 0.

Look now at row numbered 1:

		Green ball	Red ball
1	You observe 1 person predicting "the project is good"	?	?

In the row numbered 1, you observe that somebody else predicted the project to be good. In this situation, we are asking you: suppose you observe ONE PERSON PREDICTING "THE PROJECT IS GOOD" and you receive a green ball from the urn; do you think the project is good or bad? ? And if instead you receive a red ball from the urn, do you think the project is good or bad? We will ask you to record your answers in the cells marked with symbol "?" in row 1.

All other rows read in a similar way, but as you go down the table, the number of people you observe predicting "the project is good" increases in each row. In row numbered 2 you observe TWO PEOPLE PREDICTING "THE PROJECT IS GOOD". In row numbered 3 you observe THREE PEOPLE PREDICTING "THE PROJECT IS GOOD", and so on. For instance, look at row 6:

		Green ball	Red ball
6	You observe 6 people predicting the "project is good"	?	?

In row 6 we are asking you: suppose you observe SIX PEOPLE PREDICTING "THE PROJECT IS GOOD" and you receive the green ball; do you think the project is good or bad? And if, instead, you receive the red ball, do you think the project is good or bad?

We will ask you to record your answers for each possible situation. So, you have to make 20 decisions in total.

Your Per-round earnings

After all participants have made their predictions, the computer will reveal your position in the sequence, whether the project was good or bad, and the colour of your ball.

Out of the 20 situations you were presented, only one situation will be relevant for your earnings and this depends on three things:

1. the colour of the ball you received;
2. the position in the sequence the computer assigned to you;
3. the decisions of the other participants who preceded you in the sequence.

Your earnings will depend on whether your prediction was correct in that selected situation.

Let us see some examples. Suppose, for instance, that your decisions in rows 0 to 3 are as follows:

		Green ball	Red ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe 1 person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT

2	You observe 2 people predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
3	You observe 3 people predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT
4	You observe 4 people predicting "the project is good"	.	.
5	You observe 5 people predicting "the project is good"	.	.
6	You observe 6 people predicting "the project is good"	.	.
7	You observe 7 people predicting "the project is good"	.	.
8	You observe 8 people predicting "the project is good"	.	.
9	You observe 9 people predicting "the project is good"	.	.

For the purpose of the examples we show you only 8 imaginary decisions out of the 20 decisions you will have to make. These decisions are just for the examples; do not attach any value to them.

Example 1.

Suppose the computer selects you as the **first in the sequence** and **you receive the green ball from either urn**. Clearly, being in the first position in the sequence, you observe no one predicting before your turn. Therefore, the relevant situation for your earnings is the one in row 0 (because you observe no one predicting "the project is good") and in the column "you receive a green ball", which is highlighted in yellow below:

		You receive a Green ball	You receive a Red ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since in this situation your prediction was "THE PROJECT IS BAD", your earnings will be

£0 if the project is good
£7 if the project is bad

Example 2.

Suppose the computer selects you as the **second in the sequence** and **you receive a green ball**. **The relevant situation for you depends on what the participant who was selected as first in the sequence decided to do.** Suppose he received a red ball and predicted that the "project is bad" when he receives a red ball and observes no one predicting (as he does since he is the first in the sequence). In this case, being the second in the sequence, you observe no one predicting the "project is good". Therefore, your relevant situation for your earnings is again the one in row 0 (because you observe no one predicting "the project is good") and in the column "you receive a green ball", which is highlighted in yellow below:

		You receive a Green ball	You receive a Red ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since in this situation you predicted that the "PROJECT IS BAD", your earnings will be

£0 if the project is good
£7 if the project is bad

Consider now the same example but a different scenario: suppose that the participant selected as the first in the sequence and who received a red ball predicted that "the project is good". In this case, being the second in the sequence, you observe one person predicting "the project is good". Therefore, the relevant situation for your earnings is the one in row 1 (because you observe one person predicting "the project is good") and in the column "you receive a green ball", which is highlighted in yellow below:

		You receive a Green ball	You receive a Red ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe 1 person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT

Since in this situation you predicted that the "PROJECT IS GOOD", your earnings will be

£7 if the project is good
£0 if the project is bad

Example 3.

Suppose the computer selects you as the **third in the sequence** and **you receive a green ball**. **The relevant situation for you depends on what the participants who were selected as first and second in the sequence decided to do.** Suppose that the one selected as first received a red ball and predicted that the project is bad when he observes no one predicting that the project is good and a red ball. Furthermore, suppose that the one selected as second received a green ball and predicted that the project is bad when he observes a green ball and no one predicting that the project is good (as he does because the first predicted that the project is bad). In this case, being the third in the sequence, you observe no one predicting that the project is good. Therefore, your relevant situation for your earnings is again the one in row 0 and in the column "you receive a green ball", which is highlighted in yellow below:

		You receive a Green ball	You receive a Red ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since in this situation you predicted that the "PROJECT IS BAD", your earnings will be

£0 if the project is good,
£7 if the project is bad.

Consider now the same example but a different scenario: suppose that the participant selected as second and who received a green ball decided that he would predict that the project is good. In that case, being the third in the sequence, you observe one person predicting that the project is good. Therefore, the relevant situation for your earnings is the one in row 1 and in the column "you receive a green ball", which is highlighted in yellow below:

		You receive a Green ball	You receive a Red ball
0	You observe no one predicting "the project is good"	NO	INVEST
1	You observe one person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT

Since in this situation you predicted that the "PROJECT IS GOOD", your earnings will be

£7 if the project is good,
£0 if the project is bad.

Consider now a different scenario. Suppose that the participant selected as first in the sequence and who received a red ball decided that he would predict that the project is good. Furthermore, suppose that the one selected as second and who received a green ball decided that he would predict that the project is good when he observes a green ball and one person predicting that the project is good (as he does because the first participant made this prediction). In this case, being the third in the sequence, you observe two people predicting that the project is good. Therefore, the relevant situation for your earnings is the one in row 2 and in the column "you receive a green ball", which is highlighted in yellow below:

		Green ball	Red ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe one person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT
2	You observe two people predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since in this situation you predicted that the "PROJECT IS BAD", your earnings will be

£0 if the project is good,
£7 if the project is bad.

The same logic applies to any other position in the sequence in which you may be selected. **Since the computer chooses the sequence randomly, you may end up in any position**. Hence, **think carefully about what is in your interest to do in each situation**.

You earnings will be summarised on a screen. For example, take the last scenario in example 3: you will see your earnings on a screen similar to the one below:

*****

You earnings for round # 1

The project was **good.**

You received a **green ball**.

You were the **third** in the sequence.

Based on your predictions and the other participants' predictions, the sequence of predictions in this round is:

Your and other participants' position in the sequence	1st in sequence	2nd in sequence	**3rd in sequence: YOU**	4th in sequence	5th in sequence	6th in sequence	7th in sequence	8th in sequence	9th in sequence	10th in sequence
Participant's prediction	"GOOD PROJECT"	"GOOD PROJECT"	**"BAD PROJECT"**	"BAD PROJECT"	"GOOD PROJECT"	"GOOD PROJECT"	"GOOD PROJECT"	"GOOD PROJECT"	"GOOD PROJECT"	"GOOD PROJECT"

Hence, among the 20 possible situations, the relevant one for your earnings is the one recorded in row 2, i.e. you observe TWO PEOPLE PREDICTING "THE PROJECT IS GOOD".

		Green ball	Red ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe one person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT
2	You observe two people predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since you predicted that the **project is bad** and the **project was GOOD**, your earnings for this round are **£0.**

*****

How much would my payoff be if I were in a different position in the sequence?

Your accrued earnings for each round are based on one selected sequence. For instance, in the example above you were selected as the third in the sequence. What would your payoff be had you been in a different position in the sequence? For example, how much would you have gotten if you had been first in the sequence? And, what if you had been selected as the second in the sequence?

At the end of each round, the computer will tell you the payoff you would have ***gained on average for each possible position in the sequence in which you could be***, based on your predictions and on the predictions of the other participants in this round. These will be *average* earnings because there are many potential sequences. For instance, if you are second in the sequence, each of the remaining 9 participants can be selected as the first. Your average earnings are calculated based on *your predictions* and on *the predictions of others* in ***all possible sequences.***

These average payoffs will not accrue to your final earnings. But they will give you an idea about the quality of your predictions.

Your average payoffs for each position in the sequence will be shown on the last screen of each round. Take again the last scenario in example 3: you will see your average payoff for each position in the sequence on a screen similar to the one below:

*****

In this round #1, based on the selected sequence and based on your predictions and those of other participants,
you accrued £0 in earnings.

What would your payoffs be *on average* if you had been selected in any other position in the sequence?

Each column below tells you the average payoff for each possible position in the sequence. Note that these average payoffs are calculated based on the predictions of all participants in this round.

Based on your predictions and the predictions of other participants in this round, if you had been selected in the									
1st **position** in the sequence, your average payoff would have been **£x**	2nd **position** in the sequence, your average payoff would have been **£x**	3rd **position** in the sequence, your average payoff would have been **£x**	4th **position** in the sequence, your average payoff would have been **£x**	5th **position** in the sequence, your average payoff would have been **£x**	6th **position** in the sequence, your average payoff would have been **£x**	7th **position** in the sequence, your average payoff would have been **£x**	8th **position** in the sequence, your average payoff would have been **£x**	9th **position** in the sequence, your average payoff would have been **£x**	10th **position** in the sequence, your average payoff would have been **£x**

*****

Final payment

For showing up in time for the experiment you earn £5. In addition, you will earn an amount which depends on your answers during the experiment. We will pay you according to your accrued earnings in 3 randomly selected rounds.

Remember, this experiment has 15 rounds and you accrue some earnings in each round. After the last round, three rounds among the 15 rounds will be selected randomly (one among the rounds 1-5, one among rounds 6-10 and one among rounds 11-15). **We will sum up your earnings in these 3 rounds and add £5 for showing up**. Since each round has an equal chance to be selected for payment, think carefully about what is in your interest to do in each round.

Do you have any question? If so, please raise your hand. The experiment will start shortly.

***

Your final payment

You have finished the experiment. Three rounds have been randomly selected and you will paid according to you predictions in these rounds. The three selected rounds are:

Round 3	Round 7	Round 13
Your earnings in round **#3** was	Your earnings in round **#7** was	Your earnings in round **#13** was
£ 7	£ 0	£ 7

Your final payment including £5 for showing up is **£19.**

INSTRUCTIONS [n=19]

Welcome to our experiment!

You are participating in an experiment in which you interact with eighteen other participants. Your earnings will depend on your decisions and some luck. If you are careful and make good decisions, you may earn a considerable amount of money. You will receive the money, in private, immediately after the experiment. All participants have the same instructions.

Please be quiet during the entire experiment. Do not talk to your neighbours and do not try to look at their screens. Simply concentrate on the experiment. If you have a question during the experiment, please raise your hand. We will be happy to come to you and answer it privately.

The experiment

What do I have to do?

There will be several rounds in this experiment. In each round, **you will be asked to predict if a project is good or bad.** At the beginning of each round**,** the computer will randomly select whether the project is good or bad. It is equally likely that either a good project or a bad project is selected. In other words, the project is good with 50% probability and bad with 50% probability.

Note that the project is the same for all participants. If the project is good, it is good for all nineteen participants. Similarly, if it is bad, it is bad for all the nineteen of you.

If your prediction is correct, that is, the computer selects the good project and you predict that the project is good, or the computer selects the bad project and you predict that the project is bad, **then you earn £7. If your prediction is incorrect, you earn nothing.**

What information do I have in order to make my decision?

As we said, **the computer will select whether the project is good or bad randomly**. You will not know the computer's selection, but we will give you some information about it to help you to make your prediction. You will be shown a ball, either green or red, drawn from an urn. **If the project is good, the ball is drawn from an urn containing 70 GREEN and 30 RED balls. In other words, if the project is good, there is 70% probability that a green ball is drawn. If the project is bad, the ball is drawn from an urn containing 70 RED and 30 GREEN balls.** In other words, if the project is bad, there is 70% probability that the ball is red. You (and only you) will be told the colour of this ball.

Note, while the project is the same for all participants and thus, the urn from which the ball is drawn is also the same for everybody, **the computer will draw a ball afresh for each participant**. It will draw a ball for you and then replace it into the urn. Then, it will draw a ball for another participant and then replace it. And so on, so that the composition of the urn is always the same. Of course, it is possible that you receive a green ball and another participant a red one, and vice versa.

This is not the only information that you will receive. You will also observe something about the other participants' decisions.

Information about other participants' decisions

You and the other eighteen participants will make your predictions about the project in sequence. Therefore, you may be the first in the sequence and make your decision before everybody else; or you may be the second in the sequence or the third and so on. The last position in the sequence is the

19th. Your position in the sequence is assigned to you randomly by the computer. Any position in the sequence is equally likely.

We will not tell you your position in the sequence. However, **we will tell you how many people before your turn in the sequence have predicted that the project is good. Note, you will only know how many people before your turn predicted the project to be good. We will not tell you how many people predicted the project to be bad.** Let us briefly look at the different possibilities that can arise:

(i) You might see that 18 participants predicted the project to be good, in which case, obviously, you know for sure that you must be the last in the sequence. In this case, you know that nobody predicted the project to be bad.

(ii) You might observe that none of the other participants before your turn predicted the project to be good. In that case you might be the first in the sequence; or you might be the second in the sequence and the first participant predicted the project to be bad (something you cannot observe); or you might be the third in the sequence and both the first and the second participants predicted the project to be bad; or you might be fourth in the sequence, and the three preceding participants all predicted the project to be bad. In general, you may be in any position in the sequence and the reason you are observing no prediction of "good project" is because the participants who made their predictions before you predicted that the project is bad.

(iii) You might see some predictions of "good project". If you see, for instance, two people predicting "the project is good", it may be that you are the third in the sequence and the first two in the sequence have both predicted "the project is good". But you might also be the fourth in the sequence and only two of the three participants who preceded you have predicted "the project is good". You might even be the last one in the sequence and only two of your predecessors have predicted "the project is good", whereas all the others have predicted "the project is bad".

It is important that this set up is clear to you. Please raise your hand if you have any question at this point.

Procedures for each round

There will be 18 rounds in this experiment. The first 3 are practice rounds: they are for you to become familiar with the experiment and will not count for your payment. The last 15 will count for your final payment.

Note that every round is completely independent of other rounds. Specifically, whether the project is good or bad in a round is independent of whether it was good or bad in previous rounds.

First, the computer decisions – At the beginning of each round the computer selects whether the project is good or bad, randomly. It then draws a ball for you and one for each other participants in sequence (every time with replacement in the urn) either from the urn with 70 GREEN balls and 30 RED balls if the project is good, or from the urn with 70 RED balls and 30 GREEN balls if the project is bad. Moreover, it decides the position of each participant in the sequence: it selects one of you as the first in the sequence, one as the second, one as the third, and so on.

Second, your decision – You have to predict whether the project is good or bad. You have two pieces of information: (i) the colour of the ball you receive and (ii) how many people you observe having predicted "the project is good" before your turn.

But note: we will not tell you your position in the sequence and the colour of your ball straight away. We will reveal this to you later. Instead, at this stage, we will ask you to make your prediction for each possible situation you may find yourself in. We will ask you to make the prediction about whether the project is good or bad for each possible combination of "number of people predicting that the project is good you observe" and "colour of your ball".

You will see a table like this with rows from 0 to 18:

Row	**Number of people predicting "the project is good" you observe:**	**You receive a GREEN ball**	**You receive a RED ball**
0	You observe no one predicting "the project is good"	?	?
1	You observe 1 person predicting "the project is good"	?	?
2	You observe 2 people predicting "the project is good"	?	?
3	You observe 3 people predicting "the project is good"	?	?
4	You observe 4 people predicting "the project is good"	?	?
5	You observe 5 people predicting "the project is good"	?	?
6	You observe 6 people predicting "the project is good"	?	?
7	You observe 7 people predicting "the project is good"	?	?
8	You observe 8 people predicting "the project is good"	?	?
9	You observe 9 people predicting "the project is good"	?	?
…	…	?	?
18	You observe 18 people predicting "the project is good"	?	?

The table indicates all possible situations in which you can be. For each possible situation, you have to predict whether the project is good or bad. Each row number indicates how many people predicting "the project is good" you observe. These are the number of predictions that "the project is good" made by other participants who preceded you in the sequence. Recall that they are not necessarily the number of participants who preceded you, because you can only observe predictions of the type "the project is good", you cannot observe predictions of the type "the project is bad". The last two columns indicate the colour of the ball you receive.

Therefore, the way to read the table is the following:

Look at row numbered 0:

Row	**Number of people predicting "the project is good" you observe:**	**You receive a GREEN ball**	**You receive a RED ball**
0	You observe no one predicting "the project is good"	?	?

In the row numbered 0, we are asking you: suppose you observe NO ONE PREDICTING "THE PROJECT IS GOOD"; and suppose you receive a green ball from the urn; do you think the project is good or bad? And if, instead, you receive a red ball from the urn, do you think the project is good or bad? We will ask you to record your answers in the cells marked by symbol "?" in row 0, by clicking on it: clicking once changes the answer to "PREDICT GOOD PROJECT"; clicking twice changes the answer to "PREDICT BAD PROJECT". You can click and change the answer as many times as you like.

Look now at row numbered 1:

Row	**Number of people predicting "the project is good" you observe:**	**You receive a GREEN ball**	**You receive a RED ball**
1	You observe 1 person predicting "the project is good"	?	?

In the row numbered 1, you observe that somebody else predicted the project to be good. In this situation, we are asking you: suppose you observe ONE PERSON PREDICTING "THE PROJECT IS GOOD" and you receive a green ball from the urn; do you think the project is good or bad? And if instead you receive a red ball from the urn, do you think the project is good or bad? We will ask you to record your answers in the cells marked with symbol "?" in row 1.

All other rows read in a similar way, but as you go down the table, the number of people you observe predicting "the project is good" increases in each row. In row numbered 2, you observe TWO PEOPLE PREDICTING "THE PROJECT IS GOOD". In row numbered 3, you observe THREE PEOPLE PREDICTING "THE PROJECT IS GOOD", and so on.

For instance, look at row 6:

Row	**Number of people predicting "the project is good" you observe:**	**You receive a GREEN ball**	**You receive a RED ball**
6	You observe 6 people predicting the "project is good"	?	?

In row 6, we are asking you: suppose you observe SIX PEOPLE PREDICTING "THE PROJECT IS GOOD" and you receive the green ball; do you think the project is good or bad? And if, instead, you receive the red ball, do you think the project is good or bad?

We will ask you to record your answers for each possible situation. So, you have to make 38 decisions in total.

Your Per-round earnings

After all participants have made their predictions, the computer will reveal your position in the sequence, whether the project was good or bad, and the colour of your ball.

Out of the 38 situations you were presented, only one situation will be relevant for your earnings, and this depends on three things:

1. the colour of the ball you received;
2. the position in the sequence the computer assigned to you;
3. the decisions of the other participants who preceded you in the sequence.

Your earnings will depend on whether your prediction was correct in that selected situation.

Let us see some examples. Suppose, for instance, that your decisions in rows 0 to 3 are as follows:

Row	**Number of people predicting "the project is good" you observe:**	**You receive a GREEN ball**	**You receive a RED ball**
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe 1 person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT
2	You observe 2 people predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
3	You observe 3 people predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT
4	You observe 4 people predicting "the project is good"	.	.
5	You observe 5 people predicting "the project is good"	.	.
6	You observe 6 people predicting "the project is good"	.	.
7	You observe 7 people predicting "the project is good"	.	.
8	You observe 8 people predicting "the project is good"	.	.
9	You observe 9 people predicting "the project is good"	.	.
…	…	.	.
18	You observe 18 people predicting "the project is good"	.	.

For the purpose of the examples, we show you only 8 imaginary decisions out of the 38 decisions you will have to make. These decisions are just for the examples; do not attach any value to them.

Example 1.

Suppose the computer selects you as the **first in the sequence** and **you receive the green ball from either urn**. Clearly, being in the first position in the sequence, you observe no one predicting before your turn. Therefore, the relevant situation for your earnings is the one in row 0 (because you observe no one predicting "the project is good") and in the column "you receive a green ball", which is highlighted in yellow below:

Row	**Number of people predicting "the project is good" you observe:**	**You receive a GREEN ball**	**You receive a RED ball**
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since in this situation your prediction was "THE PROJECT IS BAD", your earnings will be

£0 if the project is good
£7 if the project is bad

<u>Example 2.</u>

Suppose the computer selects you as the **second in the sequence** and **you receive a green ball**. **The relevant situation for you depends on what the participant who was selected as first in the sequence decided to do.** Suppose he received a red ball and predicted that the "project is bad" when he receives a red ball and observes no one predicting (as he does since he is the first in the sequence). In this case, being the second in the sequence, you observe no one predicting the "project is good". Therefore, your relevant situation for your earnings is again the one in row 0 (because you observe no one predicting "the project is good") and in the column "you receive a green ball", which is highlighted in yellow below:

Row	**Number of people predicting "the project is good" you observe:**	**You receive a GREEN ball**	**You receive a RED ball**
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since in this situation you predicted that the "PROJECT IS BAD", your earnings will be

£0 if the project is good
£7 if the project is bad

Consider now the same example but a different scenario: suppose that the participant selected as the first in the sequence and who received a red ball predicted that "the project is good". In this case, being the second in the sequence, you observe one person predicting "the project is good". Therefore, the relevant situation for your earnings is the one in row 1 (because you observe one person predicting "the project is good") and in the column "you receive a green ball", which is highlighted in yellow below:

Row	**Number of people predicting "the project is good" you observe:**	**You receive a GREEN ball**	**You receive a RED ball**
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe 1 person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT

Since in this situation you predicted that the "PROJECT IS GOOD", your earnings will be

£7 if the project is good
£0 if the project is bad

Example 3.

Suppose the computer selects you as the **third in the sequence** and **you receive a green ball**. **The relevant situation for you depends on what the participants who were selected as first and second in the sequence decided to do.** Suppose that the one selected as first received a red ball and predicted that the project is bad when he observes no one predicting that the project is good and a red ball. Furthermore, suppose that the one selected as second received a green ball and predicted that the project is bad when he observes a green ball and no one predicting that the project is good (as he does because the first predicted that the project is bad). In this case, being the third in the sequence, you observe no one predicting that the project is good. Therefore, your relevant situation for your earnings is again the one in row 0 and in the column "you receive a green ball", which is highlighted in yellow below:

Row	**Number of people predicting "the project is good" you observe:**	**You receive a GREEN ball**	**You receive a RED ball**
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since in this situation you predicted that the "PROJECT IS BAD", your earnings will be

£0 if the project is good,
£7 if the project is bad.

Consider now the same example but a different scenario: suppose that the participant selected as second and who received a green ball decided that he would predict that the project is good. In that case, being the third in the sequence, you observe one person predicting that the project is good. Therefore, the relevant situation for your earnings is the one in row 1 and in the column "you receive a green ball", which is highlighted in yellow below:

Row	**Number of people predicting "the project is good" you observe:**	**You receive a GREEN ball**	**You receive a RED ball**
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe one person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT

Since in this situation you predicted that the "PROJECT IS GOOD", your earnings will be

£7 if the project is good,
£0 if the project is bad.

Consider now a different scenario. Suppose that the participant selected as first in the sequence and who received a red ball decided that he would predict that the project is good. Furthermore, suppose that the one selected as second and who received a green ball decided that he would predict that the project is good when he observes a green ball and one person predicting that the project is good (as he does because the first participant made this prediction). In this case, being the third in the sequence, you observe two people predicting that the project is good. Therefore, the relevant situation for your earnings is the one in row 2 and in the column "you receive a green ball", which is highlighted in yellow below:

Row	Number of people predicting "the project is good" you observe:	You receive a GREEN ball	You receive a RED ball
0	You observe no one predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT
1	You observe one person predicting "the project is good"	PREDICT GOOD PROJECT	PREDICT BAD PROJECT
2	You observe two people predicting "the project is good"	PREDICT BAD PROJECT	PREDICT GOOD PROJECT

Since in this situation you predicted that the "PROJECT IS BAD", your earnings will be

£0 if the project is good,
£7 if the project is bad.

The same logic applies to any other position in the sequence in which you may be selected. **Since the computer chooses the sequence randomly, you may end up in any position**. Hence, **think carefully about what is in your interest to do in each situation**.

Your earnings will be summarised on a screen. For example, take the last scenario in example 3: you will see your earnings on a screen similar to the one below:

Your earnings for round # 1

The project was **good.**

You received a **green ball**.

You were the **third** in the sequence.

Based on your predictions and the other participants' predictions, the sequence of predictions in this round is:

Your and other participants' position in the sequence	1st in sequence	2nd in sequence	**3rd in sequence: YOU**	4th in sequence	5th in sequence	6th in sequence	7th in sequence	8th in sequence	…	19th in sequence
Participant's prediction	"GOOD PROJECT"	"GOOD PROJECT"	**"BAD PROJECT"**	"BAD PROJECT"	"GOOD PROJECT"	"GOOD PROJECT"	"GOOD PROJECT"	"GOOD PROJECT"	…	"GOOD PROJECT"

Since you predicted that the **project is bad** and the **project was GOOD**, your earnings for this round are **£0.**

How much would my payoff be if I were in a different position in the sequence?

Your accrued earnings for each round are based on one selected sequence. For instance, in the example above you were selected as the third in the sequence. What would your payoff be had you been in a different position in the sequence? For example, how much would you have gotten if you had been first in the sequence? And, what if you had been selected as the second in the sequence?

At the end of each round, the computer will tell you the payoff you would have ***gained on average for each possible position in the sequence in which you could be***, based on your predictions and on the predictions of the other participants in this round. These will be *average* earnings because there are many potential sequences. For instance, if you are second in the sequence, each of the remaining 18 participants can be selected as the first. Your average earnings are calculated based on *your predictions* and on *the predictions of others* in a random set of potential sequences.

These average payoffs will not accrue to your final earnings. But they will give you an idea about the quality of your predictions.

Your average payoffs for each position in the sequence will be shown on the last screen of each round. You will see your average payoff for each position in the sequence on a screen similar to the one below:

What would your payoffs be *on average* if you had been selected in any other position in the sequence?

Each column below tells you the average payoff for each possible position in the sequence. Note that these average payoffs are calculated based on the predictions of all participants in this round.

Based on your predictions and the predictions of other participants in this round, if you had been selected in the									
1st position in the sequence, your average payoff would have been **£7.00**	**2nd position** in the sequence, your average payoff would have been **£7.00**	**3rd position** in the sequence, your average payoff would have been **£5.45**	**4th position** in the sequence, your average payoff would have been **£3.50**	**5th position** in the sequence, your average payoff would have been **£1.83**	**6th position** in the sequence, your average payoff would have been **£0.72**	**7th position** in the sequence, your average payoff would have been **£0.17**	**8th position** in the sequence, your average payoff would have been **£0.00**	**… position** in the sequence, your average payoff would have been **£…**	**19th position** in the sequence, your average payoff would have been **£0.00**

Final payment

For showing up in time for the experiment, you earn £10. In addition, you will earn an amount which depends on your answers during the experiment. We will pay you according to your accrued earnings in 3 randomly selected rounds.

Remember, this experiment has 15 rounds, and you accrue some earnings in each round. After the last round, three rounds among the 15 rounds will be selected randomly (one among the rounds 1-5, one among rounds 6-10 and one among rounds 11-15). **We will sum up your earnings in these 3 rounds and add £10 for showing up**. Since each round has an equal chance to be selected for payment, think carefully about what is in your interest to do in each round.

Do you have any question? If so, please raise your hand. The experiment will start shortly.