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Disclosure of information under competition: An experimental study

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Abstract: The theory of voluntary disclosure of information posits that market forces lead senders to disclose information through a process of unravelling. This prediction requires that receivers hold correct beliefs and, in equilibrium, make adverse inferences about non-disclosed information. Previous research finds that receivers do not sufficiently infer non-disclosure as bad news, leading to the failure of complete unravelling. This paper experimentally examines whether competition between senders when receivers strongly prefer disclosed over non-disclosed information increases unravelling. We further examine whether receivers' naivety about non-disclosed information decreases with competition between senders. We find that complete unravelling fails to occur without competition. However, with competition, there is significantly higher unravelling such that it increases receivers' overall welfare. Interestingly, receivers' welfare increases despite no significant difference in their guesses or beliefs about non-disclosed information relative to the treatment without competition. We conclude that competition between senders positively affects disclosure of information and receivers' welfare.

Keywords: Competition, experiment, disclosure, verifiable information, conflict of interest

JEL classification: C92, D82, D83, L15

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1. Introduction

The unravelling prediction of the voluntary disclosure theory posits that firms (information senders) completely disclose information about the quality of their products provided the information disclosed is verifiable, and the costs of disclosure are negligible (Viscusi, 1978; Grossman & Hart, 1980; Grossman, 1981; Milgrom, 1981; for a review see Milgrom, 2008). This prediction requires that consumers (information receivers) hold correct beliefs through an iterative process of reasoning leading to the equilibrium where all non-disclosed information is viewed with extreme scepticism.[2] The logic behind unravelling rests on receiver's ability to make adverse inferences about non-disclosed information. Jin et al., (2017), Penczynski & Zhang, (2017), Brown et al., (2012), Sah & Read (2017), Deversi et al., (2018) show that one of the reasons unravelling can fail to occur is when receivers are too optimistic about non-disclosed information, given the sender's actual quality level. Recent papers have documented evidence in support of incomplete unravelling of information under voluntary disclosure settings (Jin & Leslie, 2003; Jin, 2005; Mathios, 2000; Benndorf et al., 2015; Luca & Smith, 2015).

This paper experimentally examines whether introducing competition between senders increases disclosure of information. We examine the effect of competition on information disclosure because we conjecture that if receivers prefer senders that disclose information over those that do not, then competition between senders may generate unravelling of information as senders may start competing in disclosing information to receivers in order to attract them. We conceptualise competition in this way as we believe it is intuitive and natural to observe competition between senders in field settings in a way where firms compete with each other to be able to trade with a consumer.[3] We further examine whether naivety about hidden information among receivers decreases with competition between senders. We believe that a second mechanism, i.e. comparative evaluation of information, will help attenuate strategic naivety in a setting with competing firms. Our conjecture is that comparing information that is revealed with information that is not revealed will affect consumer's inferences about non-disclosed information. This conjecture finds support in the social psychology and marketing literature which provides extensive evidence suggesting that human judgements are comparative in nature.

The comparative modes of evaluation may be deeply rooted in an individual's psyche such that individuals evaluate a given piece of information in relation to other pieces of information available to them which act as a standard for comparison (Dehaene et al., 1998, Mussweiler, 2003). For example, while deciding which firms' product to buy, consumers judge whether the product of firm A is better than the product of firm B on a given dimension and evaluate the products of the two firms in a comparative manner. The underlying mechanism

[2] See Dranove and Jin (2010) for a review on quality disclosure and certification.

[3] Milgrom and Roberts (1986) propose a form of competition between firms which generates unravelling of information in the presence of strategically naïve consumers. Their theoretical result postulates that if each piece of information in the marketplace favours at least one firm, then all relevant information unravels in the presence of competition between firms. That is, even a naïve consumer can elicit all relevant information from firms by promoting information competition, thus, motivating each firm to explain why its product is better than the competitor's product. See Milgrom (2008) for an overview of the theoretical arguments about how firms disclose information to influence buyers.

for comparison to affect decision-making is that the presence of a standard influences judgements by making a particular knowledge unit accessible to the consumer (Higgins, 1996). The more accessible a given piece of information is, the more likely it will be used in the decision-making process and the more likely it is to influence the decision (Bollinger et al., 2011).

Since comparative evaluation forms a core mechanism in decision-making, we conjecture that comparing information that is disclosed with information that is not disclosed might help consumers make sceptical inferences about information that is not disclosed to them. In other words, the absence of a particular piece of information may be compared with a salient piece of information which might generate scepticism about the absent information and attenuate strategic naivety that is documented in the literature.

This paper closely relates to the papers by Forsythe et al. (1989) and Penczynski & Zhang (2017) who study unravelling of information in an auction setting. Forsythe et al. (1989) find that the sequential equilibrium, where buyers "assume the worst", is reached through an unravelling process over the course of their experiment. Penczynski & Zhang (2017) also examine in an auction setting how the market structure and the information structure affect disclosure of information. They find that introducing competition between sellers increases disclosure of information, however, buyers do not compensate for sellers' selective disclosure of evidence in their bids and their welfare does not improve under competition. In this paper, we examine the role of competition in the amount of information that is disclosed by senders, and in addition, explore the effect of comparative evaluation of information on receivers' sophistication, which may also help increase disclosure of information in natural settings.

To examine how competition affects information unravelling and explore its effects on receiver sophistication, we design an experiment with two treatments, the 'Baseline' and the 'Competition' treatment, which builds on the design proposed by Jin et al. (2017). There is one sender and one receiver in the Baseline, and two senders and one receiver in the Competition treatment. The basic setup of the experiment is as follows: the sender obtains a private number and decides whether to revel this number to the receiver or stay silent. If the sender has revealed the number, he cannot lie or misreport it which makes it a verifiable disclosure game. The receiver observes the sender's decision and the true number if it is revealed, or a blank message if it is not revealed by the sender. She then reports or guesses the number based on the sender's decision and on the probability distribution of the numbers, which is common knowledge. In the Competition treatment, the senders separately obtain a private number from the set {1, 2, 3, 4, 5}. Senders simultaneously and individually decide whether to reveal their private number to the receiver. The receiver observes both senders' decision (alongside each other) and reports or guesses the value of the private number (of each sender).

The differences in the Competition treatment compared to the Baseline are that: a) there are two senders in the Competition treatment and, b) the receiver chooses her preferred sender after reporting the numbers of both senders. This choice of the receiver determines the probability with which a sender is selected by the computer to earn a payoff (specifically, the preferred sender is more likely to be selected). The sender selected by the computer earns a payoff based on the receiver's report, and the other sender earns zero. The receiver earns a payoff based on the accuracy of her report of the selected sender. The receiver's choice of the preferred sender introduces competition between senders.

We find that competition between senders significantly increases the amount of information that is disclosed to receivers. In particular, the intermediate numbers are more likely to be revealed in the presence of competition between senders. Our conjecture about the effect of comparative evaluation on receivers' sophistication fails to hold as competition does not attenuate receiver's naivety about non-disclosed information. We do not find significant differences in guesses of non-disclosed numbers by receivers across the Baseline and the Competition treatment. Interestingly, we find that the average payoff of receivers in the Competition treatment is higher than the average payoff of receivers in the Baseline despite no marked improvement in inferences about non-disclosed information. This effect is largely driven by a higher rate of information disclosure by senders in the Competition treatment which led receivers to report accurately when the senders revealed the number. We further find that naivety in receivers is driven by miscalibrated beliefs about the actions of senders with intermediate and high numbers rather than miscalibrated beliefs about the actions of senders with low numbers. That is, receivers underestimate how often intermediate and high numbers are revealed by senders but correctly estimate how often low numbers are revealed by senders.

Our findings suggest that even in the presence of strategically naïve consumers, competition in the marketplace can increase disclosure of information by firms. Therefore, tools that aim to increase competition between firms, which are at the disposal of regulators like the Competition and Markets Authority in the United Kingdom, can be used to generate increased disclosure of information.

The rest of this paper is organised as follows. Section 2 provides the details of the design of the experiment. Section 3 presents the results. This section also outlines the welfare effects of competition on receivers and the role of beliefs in driving the decisions of senders and receivers. Section 4 discusses the results and offers some concluding remarks.

2. Experimental design

We design a sender-receiver game to examine whether competition between senders increases information disclosure and affects receivers' scepticism about non-disclosed information. The basic setup of our game is as follows: There are two player roles – senders and receivers. The sender observes a private number which is drawn from the set {1, 2, 3, 4, 5}. Each of these numbers is equally likely to be generated and this probability distribution over the set of numbers is common knowledge. The sender then decides whether to reveal this number to the receiver or stay silent. If he decides to reveal the number, he cannot lie or misreport the true number and the receiver is sent this message from the sender: "The number I received is:" followed by the actual private number.

The receiver knows the number with certainty following this message from the sender. Otherwise, the receiver observes: "The number I received is:" followed by a blank. The receiver observes the sender's decision to reveal or not and must report or guess the true number of the sender from the set {1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5}. The incentives of the game are such that receivers earn a higher payoff if they report the true number accurately, and the senders earn a higher payoff when the receiver makes a higher report. The specific payoffs in the experiment are derived using the payoff functions as in Jin et al. (2017). Subjects did not see these functional forms as the payoffs were shown in a table.[4] The payoff functions for the sender (U_S) and the receiver (U_R) respectively are:

$$U_s = 110 - 20\,|5 - \text{receiver's report}|^{1.4}$$

$$U_R = 110 - 20\,|\text{actual private number} - \text{receiver's report}|^{1.4}$$

When the receiver's action space is sufficiently rich, as in our experiment, the sequential equilibrium of the disclosure game, as shown by Milgrom (1981), is such that the sender always reveals the true private number, unless it is the lowest number, i.e. private number 1 - in which case he is indifferent between revealing and not, and the receiver guesses the lowest number upon observing non-disclosure.[5]

Based on the game described above, our experiment consists of two treatments - the Baseline and the Competition treatment. The treatments primarily vary based on the number of senders that are matched with the receiver: one in Baseline, and two in Competition. In addition, the receiver in the Competition treatment must choose her preferred sender. In the Competition treatment, the two senders are paired together, and the senders remain in their fixed pairs for the entire duration of the experiment which mimics competition between sellers in natural environments. We randomly rematch a receiver with a different sender [sender pair] in each round of the Baseline [Competition treatment] to minimise reputational effects that might drive disclosure decisions.

At the beginning of the experiment, subjects are assigned to one of the two roles, i.e. sender or receiver. They remain in these roles for the whole experiment. The subjects play 30 rounds of this game in both treatments and we do not provide feedback to subjects between rounds. The Baseline is akin to the "No feedback" treatment in Jin et al. (2017) where senders receive no feedback and receivers observe the draw if the sender decides to reveal, or no message if the sender does not reveal the draw.[6]

In each round of the Competition treatment, the two senders receive numbers that are independently and uniformly drawn from the set of private numbers. The senders then individually and simultaneously decide whether to reveal their own number to the receiver or stay silent. After observing both senders' decision to reveal or not, the receiver must make reports about the true numbers of both senders. If no number is revealed, the receiver must

[4] The specific payoffs are shown in Table A 1 in Appendix A.

[5] We ensure richness in receiver's action space by allowing them to guess in increments of 0.5, i.e. 1.5, 2.5, 3.5, and 4.5.

[6] The Baseline is a conceptual replication of the 'No feedback' treatment in Jin et al. (2017) who borrow elements from Cai and Wang (2006) and Wang et al. (2010). We depart from Jin et al. (2017) by eliminating role reversal and eliciting beliefs every 5 rounds in an incentivised manner instead of eliciting them only once at the end of the 30 rounds.

make a guess about the true numbers based on the sender's decision not to reveal. The receiver also chooses her preferred sender.

This choice of the preferred sender determines the probability with which the sender is selected by the computer to be matched with the receiver to earn a payoff for that round. The preferred sender is selected by the computer with a 75% probability and the non-preferred sender is selected by the computer with a 25% probability to be matched with the receiver to earn a payoff. This incentive mechanism ensures that the receiver is incentivised to choose her preferred sender as well as to report the number of the sender that she does not prefer. This helps us gain meaningful insights about the receiver's report even when the number is not disclosed, and when the receiver does not choose that sender. The receiver's choice of the preferred sender ensures that there is a conflict of interest between senders which is what we refer to as competition.

In both treatments, we also elicit subjects' beliefs about the actions of the other player after every 5 rounds (5 rounds = 1 block).[7] We incentivised each question in the belief elicitation stage using the scoring rule as in Kugler et al. (2007): 70 - |Correct answer –Subject's answer|. Using responses to these questions and applying Bayes' rule, we infer what the receivers should have guessed based on the beliefs they held about the sender's strategy. Similarly, using the sender's responses to these questions, we infer what senders believed the receivers would guess upon observing non-disclosure. This gave us insights into the relationship between the senders' and receivers' actions and their beliefs.

After the final round of the experiment, subjects are paid for two different blocks at random - once for the decision-making stage, and once for the accuracy of the answers to the belief questions. We paid two different blocks to avoid subjects hedging their actions with their responses to the belief questions in the same block. This ensured incentive compatibility of both the beliefs and the actions of subjects. Subjects also answered a questionnaire where we obtained information on their gender, field of study, risk preference, social preferences using the questions in Falk et al. (2016), cognitive ability using the three Cognitive Reflection Task questions (Frederick, 2005), and scepticism level using the Hurtt's scepticism scale (Hurtt, 2010).

The experiment was programmed on z-Tree (Fischbacher, 2007) and was run at the Centre for Decision Research and Experimental Economics Laboratory at the University of Nottingham in April 2018. We used ORSEE (Greiner, 2015) to recruit 173 subjects from a diverse, mostly undergraduate, subject pool.[8] In total, we conducted 9 sessions, i.e. 3 sessions with two matching groups in each session for the Baseline, and 6 sessions for the Competition treatment with each session as one matching group. Each matching group in the Baseline comprised of 10 to 12 subjects, and each matching group in the Competition treatment comprised of 15 to 18 subjects. Subjects were paid in cash privately at the end of the

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[7] We ask senders what percentage of receivers they thought guessed 1 or 1.5, 2 or 2.5, 3 or 3.5, 4 or 4.5, and 5 when they observed non-disclosure in that block. We ask receivers what percentage of senders they thought revealed in that block when the true private number was 1, 2, 3, 4, and 5. The specific belief questions are relegated to Appendix B: Experimental Instructions.

[8] Table A 2 in Appendix A provides summary statistics of the subjects in the experiment.

experiment. Sessions lasted, on average, 70 minutes, and the average payment per subject was £12 which included a show-up fee of £4.

3. Results

3.1. Analysis of senders' behaviour

Panel A in Table 1 provides a summary of the senders' actions in the Baseline and the Competition treatment. In both treatments, on average, senders reveal higher draws more often than the lower draws. When the draw is 4 or 5, the revealing rate is above 90% in both the Baseline and the Competition treatment but not 100% as per the equilibrium prediction. The revealing rate drops below 75% in the Baseline and below 85% in the Competition treatment for draws of 2 and 3 even when full unravelling is the equilibrium prediction.

Table 1: Summary of senders' disclosure decisions

Panel A				
Variables	**Baseline**		**Competition**	
	N	**% revealed**	**N**	**% revealed**
Draw=1	180	6.67	416	8.65
Draw=2	240	24.58	475	41.26
Draw=3	192	71.35	379	84.96
Draw=4	168	91.07	397	97.73
Draw=5	240	97.08	433	98.15

Panel B		
	Baseline	**Competition**
Total non-revealed draws	426	733
Average non-revealed draw	1.854	1.616

Note: In Panel A, the column "% revealed" reports the average revealing rate across all senders when they observed that particular draw. In Panel B, we report the total number of non-revealed draws and the average draw when senders did not disclose the draw in the respective treatments.

According to the theoretical prediction, we expect to see non-disclosure at most 20% of the times since senders with draw 1 in both treatments are indifferent between revealing and not revealing the number in equilibrium. A non-parametric test (excluding draw 1 from the analysis) performed on the average revealing rate of each sender suggests that there is a deviation from the full unravelling equilibrium in both the Baseline and the Competition treatment even after allowing for a 10% deviation from the unravelling prediction due to error (Wilcoxon rank-sum test $p<0.001$ for both Baseline and Competition treatment).[9]

[9] All tests conducted on senders' data consider each sender as an independent unit of observation because senders did not receive any feedback between rounds. All tests conducted on receivers' data are conducted at the matching group level which is an independent unit of observation because receivers obtained information if the draw was revealed and the receivers were randomly re-matched with a different sender pair after each round. The tests conducted to compare treatment averages of receivers with senders consider each matching group as the independent unit of observation (for example: comparing the average non-disclosed draw with the average guess

We next analyse revealing rates of specific draws by senders across treatments. Figure 1 displays the revealing rates by block for each draw across the Baseline and the Competition treatment. We find that senders in the Competition treatment reveal draws 2, 3, and 4 significantly more than the senders in the Baseline (Wilcoxon rank-sum test p=0.037 for draw 2, p=0.009 for draw 3, p=0.002 for draw 4). We do not find a significant difference in the revealing rates of draw 1 and 5 because a sender with draw 5 has no incentive to withhold the draw from the receiver in either treatments. In contrast, a sender with draw 1 has little reason to reveal in either treatment. Especially in the Competition treatment, a sender with draw 1 would never want to be chosen and hence, would never want to reveal a draw 1 due to the payoff structure.

The significant difference in revealing rates across the Baseline and the Competition treatment explains a lower average non-disclosed draw by senders in the Competition treatment than in the Baseline (1.854 in the Baseline and 1.616 in the Competition treatment), as shown in Panel B of Table 1. This difference is statistically significant (Wilcoxon rank-sum test p<0.001).

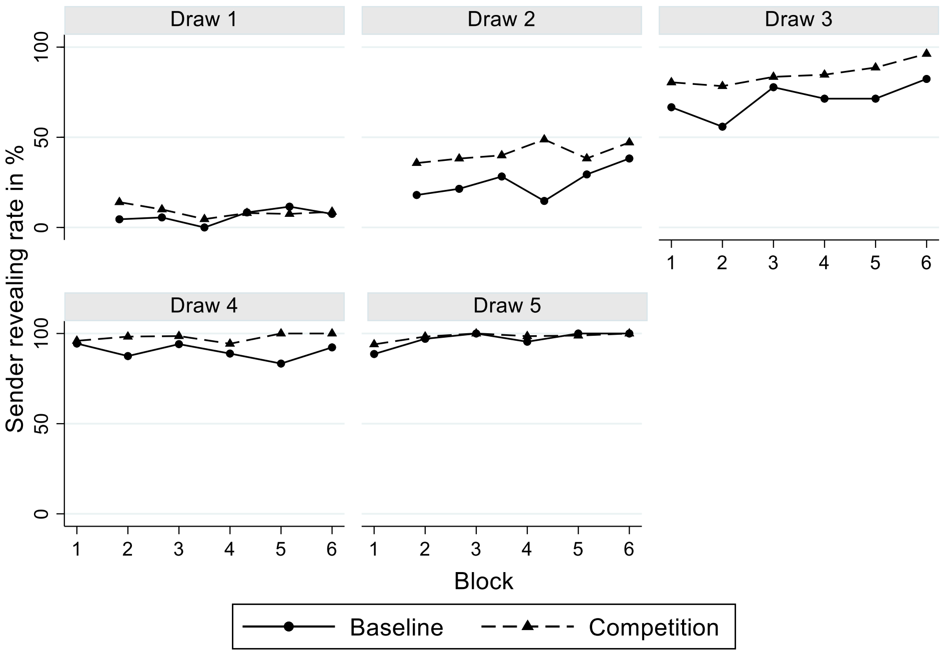

Figure 1: Sender revealing rate by draw across blocks

Result 1: Intermediate draws, i.e. draw 2, draw 3, and draw 4, are revealed more often in the Competition treatment. The average non-disclosed draw is significantly lower in the Competition treatment compared to the Baseline.

of the non-disclosed draw across treatments). This is because we use paired difference tests such as the Wilcoxon signed-rank test.

To analyse differences in the revealing behaviour of senders in the Baseline and the Competition treatment further, we conduct a regression analysis of senders' decisions to reveal (1 if the draw is revealed and 0 if it is not revealed). Our regressor of interest is a treatment dummy indicator which takes the value of 1 for senders in the Competition treatment, and 0 for senders in the Baseline. Table 2 provides marginal effect estimates from a Probit estimation for three model specifications. The standard errors are clustered at the subject level as each sender is an independent unit of observation. This is because we do not provide feedback to senders between rounds in the experiment.

Table 2: Regressions on senders' behaviour

	Sender reveals? (0/1)		
Variables	**I**	**II**	**III**
Competition treatment	0.079***	0.073***	0.072***
	(0.026)	(0.023)	(0.022)
Draw=2	0.202***	0.200***	0.148***
	(0.024)	(0.024)	(0.027)
Draw=3	0.435***	0.432***	0.342***
	(0.017)	(0.017)	(0.030)
Draw=4	0.606***	0.604***	0.489***
	(0.020)	(0.020)	(0.037)
Draw=5	0.661***	0.655***	0.538***
	(0.026)	(0.024)	(0.042)
Round	0.002***	0.002***	0.002***
	(0.0007)	(0.0007)	(0.0007)
Dummy=1 if believed guess is below the actual number			0.097***
			(0.025)
Controls	No	Yes	Yes
Observations	3,120	3,120	3,120
(Pseudo) R-squared	0.486	0.500	0.511

Note: Probit for senders (marginal effects reported in the table). Robust standard errors in parentheses (clustered at the subject level). Controls include: sex, field of study (Economics), native English speaker, having a friend in the session, risk aversion, cognitive ability questions. ***p<0.01, **p<0.05, *p<0.1.

Model I (column I) is a specification without any socio-demographic controls. We regress whether the sender reveals the draw in a given round on the Competition treatment dummy, individual draw dummies, and the number of the round. The statistically significant estimate of the treatment dummy coefficient suggests that the probability of the senders revealing the draw in the Competition treatment, on average, is 8% higher than in the Baseline (p<0.001). The omitted draw i.e. Draw 1, is the base against which the coefficients of Draw 2, Draw 3, Draw 4, and Draw 5 can be evaluated. The significance of these Draw coefficients suggests that higher draws are revealed significantly more than draw 1 (p<0.001 of all the 'Draw' coefficients). The significant effect of the Round variable suggests that senders learn over rounds even though we do not provide feedback between rounds. Rick and Weber (2010) call this 'Meaningful learning' in the absence of feedback.[10]

Model II (column II) specification builds on Model I by including controls such as sex, field of study being economics, being a native English speaker, having a friend in the session, risk aversion, and cognitive ability questions that were measured by a questionnaire.[11,12] We control for the subject's field of study being Economics because these subjects might be familiar with equilibrium concepts in games such as ours. Controlling for the cognitive ability of a subject helps us examine whether subjects with a higher cognitive ability (as measured by three questions of the Cognitive Reflection Task (Frederick, 2005) who might understand the game better than others, tend to reveal more compared to subjects with a lower score on those questions. We control for subjects' risk preferences which might influence revealing behaviour, i.e. risk-averse subjects might reveal more to avoid a low payoff from receivers' low guess of a non-disclosed draw.[13] We find that our main result of competition increasing the likelihood of revealing numbers remains significant (p=0.002). Cognitive ability has a positive and significant effect on the revealing rate of senders implying that senders who correctly answer at least one of the three cognitive ability questions are more likely to reveal a draw (p=0.001). All other controls are insignificant.

Model III (column III) specification includes controls and a dummy variable which takes the value of 1 if the sender's *believed guess* is below the actual number drawn, and 0 otherwise. Using senders' elicited beliefs at the end of each block, we calculate what they believe the receivers would guess upon observing non-disclosure and call it the believed guess of the sender. The believed guess is calculated for each sender and for every block as follows: For example, if the sender believes that upon observing non-disclosure, 30% of receivers guess 1 or 1.5, 25% guess 2 or 2.5, 20% guess 3 or 3.5, 15% guess 4 or 4.5, and 10% guess 5, then the believed guess of this sender is:

$$\frac{[(30) * 1 + (25) * 2 + (20) * 3 + (15) * 4 + (10) * 5]}{100} = 2.50$$

We assigned a value of 1 to the sender belief dummy (used in the regression) if the draw in a given round is higher than the believed guess elicited at the end of that block, and the dummy took the value of 0 otherwise. We include this dummy in the regression to analyse whether senders' actions are related to their beliefs about the actions of the receivers. The coefficient

[10] According to Rick and Weber (2010), 'meaningful learning' in the absence of feedback is like the learning that is produced when players are required to explain their behaviour (which is intended to increase deliberation). In other words, meaningful learning in the absence of feedback encourages players to think deeper about the game.

[11] The post-experimental questionnaire used to measure these control variables is provided in Appendix C: Post-experimental questionnaire. Some of the controls (like being a native English speaker, having a friend in the session) are included in the regression to replicate the analysis of the Baseline ("No Feedback treatment") results in Jin et al. (2017).

[12] We asked subjects to answer three questions from the Cognitive Reflection Task (Frederick, 2005) and coded the cognitive ability dummy included in the regression as 1 if the subject answered at least one of the three questions correctly, and 0 if no question was answered correctly by the subject. The three questions are presented in Appendix C: Post-experimental questionnaire.

[13] The risk preference variable takes a value 0 if the receiver's score is below 5 which implies extremely risk averse and 1, if it is equal to or greater than 5 which implies risk seeking (Falk et al., 2016).

on sender beliefs is positive and highly significant implying that senders reveal 10% more often if their belief of the receiver's guess upon observing non-disclosure is below the actual draw they observe ($p<0.001$). The coefficient on the Competition treatment remains positive and statistically significant suggesting that the effect of Competition on senders' revealing behaviour is robust, and competition increases information disclosure.

Result 2: Senders in the Competition treatment reveal 7-8% more than the senders in the Baseline. This is reflected in a significantly lower average non-disclosed number in the Competition treatment compared to the Baseline. However, the amount of information disclosed is still far from the complete unravelling prediction of the theory in both treatments.

3.2. Analysis of receivers' behaviour

Table 3 reports the average report by receivers in the Baseline and the Competition treatment. On average, receivers' report is very close to the actual draw when the draw is revealed by senders. The average guess of a non-disclosed number is 2.291 in the Baseline and 2.233 in the Competition treatment. This difference is not statistically significant (Wilcoxon rank-sum test $p=0.150$). Figure 2 illustrates the average guess of non-disclosed draws by receivers across the six blocks in the Baseline and the Competition treatment.

The difference between the average non-disclosed draw and the guess of the non-disclosed draw by receivers is 0.437 in the Baseline and 0.617 in the Competition treatment. This difference between the non-disclosed draw and the guess of the non-disclosed draw is statistically significant in both treatments implying that receivers are too optimistic in their guesses of the non-disclosed draw (Wilcoxon signed-rank test $p=0.027$ for both Baseline and Competition treatment). The higher difference between the guess and the non-disclosed draw in the Competition treatment is driven by a significant reduction in the average non-disclosed draw by senders.

Table 3: Summary of receivers' reports

Variables	Baseline		Competition	
	N	Mean	N	Mean
Guess (reveal=1)	12	1.08	36	1.02
Guess (reveal=2)	59	2.04	196	2.01
Guess (reveal=3)	137	2.95	322	3.01
Guess (reveal=4)	153	4.02	388	4.01
Guess (reveal=5)	233	4.98	425	4.99
Guess (reveal=blank)	426	2.291	733	2.233
Guess - draw (not revealed)	426	0.437	733	0.617

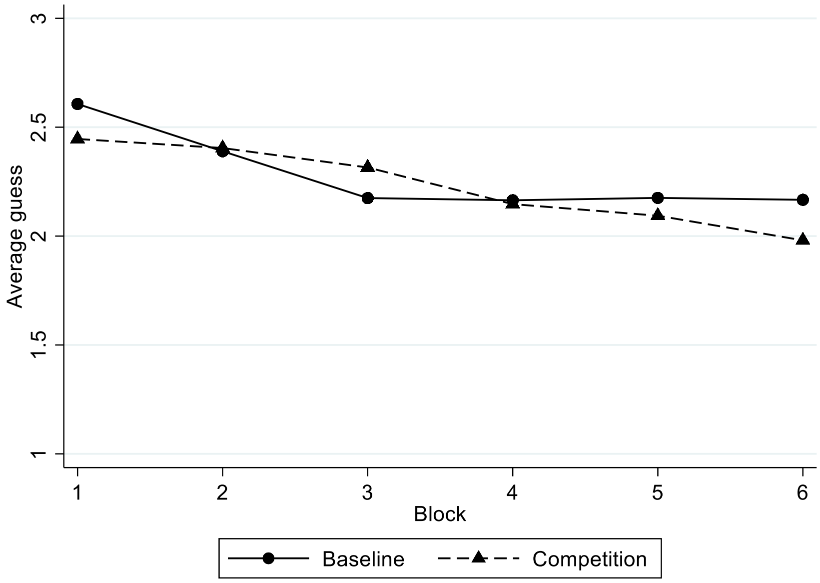

Figure 2: Average guess of non-disclosed numbers by receivers

The regressions in Table 4 confirm these results for receivers' behaviour. Models I, II and III compare receivers' behaviour across the Baseline and the Competition treatment when they observe non-disclosure. The regressions for receivers are estimated using the Ordinary Least Squares (OLS) method. The standard errors are clustered at the matching group level.

Model I (column I) is a specification without controls that examines receivers' guess of the non-disclosed number across the Baseline and the Competition treatment. The coefficient on the Competition treatment dummy is negative but not statistically significant (p=0.504). The Round variable is negative and significant implying that receivers learn to guess lower over rounds with experience of playing the game and this is robust across specifications.

Model II (column II) builds on Model I by including socio-demographic controls such as sex, field of study being economics, being a native English speaker, having a friend in the session, risk aversion, cognitive ability, negative reciprocity and general level of reciprocity that were measured by a questionnaire. We include these controls for the same reasons as in sender regressions. We conjecture that subjects motivated by reciprocal concerns guess lower upon observing non-disclosure to punish senders for not revealing a draw.[14]

We find that the Competition treatment dummy remains insignificant. In addition, we find that most controls are insignificant, except having a friend in the session and the reciprocity term which are negative and significant (p=0.024 and p=0.004 respectively). This implies that receivers who have a friend in the same session guess 0.236 lower upon observing non-

[14] The reciprocity dummies included in the regression take the value of 1 for the receivers with a score of 5 and above on the reciprocity questions, and 0 otherwise. Subjects with a score of 5 and above on the reciprocity questions are regarded as reciprocal. The specific questions are provided in Appendix C: Post-experimental questionnaire and are taken from Falk et al. (2016).

disclosure than receivers without a friend in the session. Receivers who are reciprocal guess 0.585 lower than receivers who are not reciprocal.

Table 4: Regressions on receivers' behaviour

	Receiver guess of non-disclosed numbers		
Variables	**I**	**II**	**III**
Competition treatment	-0.046	-0.022	-0.079
	(0.067)	(0.107)	(0.154)
Round	-0.017***	-0.017***	-0.012*
	(0.004)	(0.004)	(0.006)
Implied guess calculated using receivers' beliefs			0.546***
			(0.065)
Round*Competition			0.0005
			(0.007)
Constant	2.553***	3.371***	1.877***
	(0.063)	(0.232)	(0.249)
Controls	No	Yes	Yes
Observations	1,159	1,159	1,159
R-squared	0.040	0.141	0.243

Note: OLS for receivers. Robust standard errors in parentheses (clustered at the matching group level). Controls include: sex, field of study (Economics), native English speaker, having a friend in the session, risk aversion, cognitive ability questions, negative reciprocity, and reciprocity. ***p<0.01, **p<0.05, *p<0.1.

Model III further includes an interaction term between Round and Competition treatment to examine whether receivers in the Competition treatment guess lower over rounds upon observing non-disclosure. This is because receivers in the Competition treatment interact with two senders in a given round as opposed to one sender in the Baseline and therefore, observe more disclosure of draws over rounds. This might make receivers guess lower upon observing non-disclosure in the Competition treatment in the later rounds of the experiment. Model III also includes the *implied guess* of the receiver to examine whether their guesses are influenced by the beliefs they hold about the non-disclosed draw. We calculate what the receivers believe the average non-disclosed draw is and call it the *implied guess* of the receiver. The implied guess is calculated for each receiver and for every block as follows: For example, if the receiver believes that the sender revealing rate is 10% for a private number of 1, 40% for 2, 70% for 3, 90% for 4, and 95% for 5, then the implied guess of this receiver conditional on non-disclosure is:

$$\frac{[(100-10)*1+(100-40)*2+(100-70)*3+(100-90)*4+(100-95)*5]}{[(100-10)+(100-40)+(100-70)+(100-90)+(100-95)]}=1.871$$

The coefficient on receiver's beliefs about the non-disclosed number is positive and significant (p<0.001). This suggests that receivers' guess of the non-disclosed number increases by 0.546 with a one point increase in their belief of the non-disclosed number. This also gives us a measure of the receivers' ability to best respond to their beliefs about the revealing behaviour of the senders. The interaction term between Round and Competition treatment is not significant however, implying that receivers' guess of the non-disclosed draw over rounds in the Competition treatment does not differ compared to the guess of the receivers in the Baseline (p=0.942).

Result 3: Despite higher revealing rates in the Competition treatment, there is no significant difference in the average guess of the non-disclosed number by receivers across the Baseline and the Competition treatment.

We conjecture that the variance of receivers' guesses of non-disclosed numbers will be larger in the Competition treatment compared to the Baseline. This is because receivers in the Competition treatment have a more complex decision-problem to solve as they have to base their guesses of non-disclosed numbers on not only what they think the senders' beliefs are about their guess, but also what they think the senders' beliefs are about the other sender's revealing behaviour. We confirm this using a variance ratio test which compares the variances of the two distributions that show the receivers' guess of non-disclosed numbers in Figure 3 below. In line with our conjecture, the result suggests that the variance of the guesses in the Competition treatment is significantly higher than the variance of the guesses in the Baseline (p=0.004).

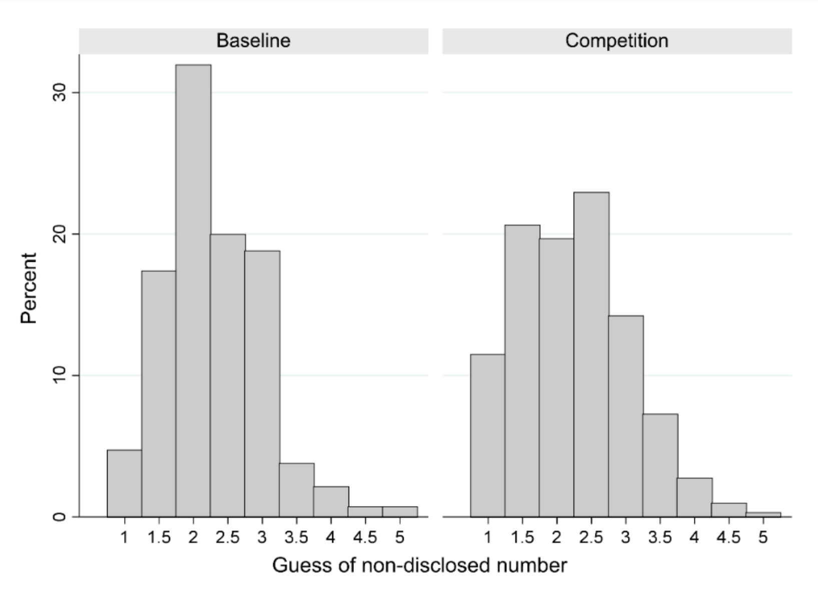

Figure 3: Distribution of guesses of non-disclosed numbers

3.3. Analysis of receivers' choice of the sender

Table 5 provides descriptive statistics of receivers' choice of the preferred sender (in percentages) in the Competition treatment. Recall that receivers are incentivised for accurate reports of the senders' draw, regardless of what the draw actually is. Consistent with these incentives, when one of the two sender reveals the draw, but the other doesn't, receivers tend to prefer the sender who reveals the draw. When both senders reveal, receivers seem to prefer senders who reveal high draws, while they choose less frequently senders who reveal low draws. The preference for senders who reveal higher draws may be explained by receivers' concern to maximise total payoffs – senders with high revealed draws earn more than senders with low revealed draws. When both draws are not revealed, we expect receivers to choose the preferred sender randomly. This expectation is confirmed as seen on the bottom right-hand side in the table where receivers choose sender 1 half of the time (50.42%) when both senders send a blank message.

Table 5: Descriptive statistics when receivers' choice is Sender 1 (in percentage) and the number of observations per cell (in brackets)

Sender 1/Sender 2	Reveal (draw=1)	Reveal (draw=2)	Reveal (draw=3)	Reveal (draw=4)	Reveal (draw=5)	Reveal (blank)
Reveal (draw=1)	-	0	20	0	0	100
	-	(n=1)	(n=5)	(n=1)	(n=4)	(n=2)
Reveal (draw=2)	100	55.56	10	20	13.33	97.44
	(n=1)	(n=9)	(n=20)	(n=10)	(n=15)	(n=39)
Reveal (draw=3)	75	88.89	66.67	20	9.52	98.51
	(n=4)	(n=18)	(n=12)	(n=70)	(n=21)	(n=67)
Reveal (draw=4)	75	50	92.31	48.48	26.47	97.18
	(n=4)	(n=14)	(n=13)	(n=33)	(n=34)	(n=71)
Reveal (draw=5)	66.67	80.95	78.13	89.47	42.55	97
	(n=9)	(n=21)	(n=32)	(n=38)	(n=47)	(n=100)
Reveal (blank)	20	7.69	2.08	0	1.75	50.42
	(n=5)	(n=39)	(n=48)	(n=67)	(n=57)	(n=119)

Result 4: Receivers choose senders that reveal the draw. When both senders disclose, most receivers choose the sender with the higher revealed draw. When neither sender reveals the draw, receivers choose randomly between the senders.

We next examine whether comparative evaluation of information leads to better guesses about non-disclosed numbers by receivers. To investigate this, we pool our data into two groups. One group consists of receivers' guesses of non-disclosed numbers when one sender does not reveal but the other sender reveals the number. The other group consists of receivers' guesses of non-disclosed numbers when both senders do not reveal the number. We average the guesses for each session in both groups (as each session is an independent unit of observation for receivers in the Competition treatment) and run a non-parametric test on this dataset. We find that receivers' guesses do not differ significantly across the two groups (Wilcoxon rank-sum test p=0.631). This suggests that comparative evaluation of information does not lead to significantly different guesses of non-disclosed numbers relative to the situations where receivers guess in the absence of any information (i.e. number) alongside the non-disclosed number.

Result 5: Comparative evaluation of information does not affect receivers' guesses of non-disclosed numbers.

3.4. Analysis of receivers' payoffs

In this sub-section, we examine the effect of competition between senders on the welfare of receivers. To do this, we analyse receivers' welfare across treatments using their realised payoffs. The realised payoff is the payoff that the receiver earns after the computer selects the payoff-relevant sender.[15] We find that the realised payoff of receivers in the Competition treatment is significantly higher than the realised payoffs of the receivers in the Baseline (Wilcoxon rank-sum test p=0.010) indicating that receivers are better-off in the Competition treatment.

We identify three potential channels that affect receivers' payoffs in the Competition treatment compared to the Baseline. First, senders reveal more in the Competition treatment than in the Baseline which helps receivers earn a higher payoff. Second, receivers do worse under Competition than in the Baseline when they are matched with a sender that did not disclose the draw. This is because receivers do not guess lower in the Competition treatment compared to the Baseline, while the actual non-disclosed numbers are lower in the Competition treatment.[16] Third, since receivers could choose a sender in the Competition treatment, they could do better by reducing the probability of them being matched with a non-disclosing sender.

Therefore, a more conservative comparison of payoffs switches off the third channel by considering the average payoffs of receivers in the Competition treatment and comparing it to the payoffs of receivers in the Baseline. The average payoffs of receivers in the Competition treatment are calculated by placing an equal weight on the receiver's reports of both senders' draws, i.e. by taking the average of the payoffs that result from the receiver's report of Sender 1's draw and of Sender 2's draw in a given round of the experiment. This method of comparison assumes away the possibility of choosing a sender and provides a conservative estimate of receivers' welfare. We find that, even after abstracting away from the possibility of choosing a sender, receivers earn significantly more in the Competition treatment than in the Baseline and this is marginally significant (Wilcoxon rank-sum test p=0.054). This implies that increased disclosure by senders in the Competition treatment outweighs the fact that receivers do worse when the number is not disclosed to them in the Competition treatment. In conclusion, despite a conservative estimate of receivers' welfare obtained using average payoffs, we find a positive and (marginally) significant effect of competition on the payoffs of receivers.

[15] The realised payoffs in the Competition treatment are determined by the computer's selection of the payoff-relevant sender, i.e. with a 75% probability, receiver's preferred sender is selected by the computer, and with a 25% probability the sender who is not preferred by the receiver is selected by the computer as the payoff-relevant sender.

[16] Recall that receivers' payoff function implies that the larger the difference between the report of the private number and the true private number, the lower is the payoff for the receiver.

Result 6: Receivers in the Competition treatment are better-off (in monetary terms) compared to the receivers in the Baseline despite no significant differences in their guesses about the non-disclosed number. This is largely driven by higher revealing rates in the Competition treatment, accompanied with accurate reports of the revealed draws by the receivers.

3.5. Beliefs

We now analyse the role of beliefs in driving the behaviour of senders and receivers in the Baseline and the Competition treatment. Senders' beliefs are summarised in Table 6. On average, the believed guess of senders is 2.213 in the Baseline and 2.184 in the Competition treatment. The difference between the senders' believed guess across treatments is not statistically significant (Wilcoxon rank-sum test p=0.827).[17] We analyse what percentage of the observations were revealed when it was optimal to do so, i.e. when the believed guess was less than the draw. We find that the senders reveal optimally 82.18% in the Baseline and 88.78% in the Competition treatment and this difference is statistically significant (Wilcoxon rank-sum test p=0.006).

In the Baseline, the optimal action was not to reveal the draw when the believed guess was greater or equal to the draw, provided senders are risk-neutral. 86.03% of the observations in the Baseline correspond to the optimal action of not revealing. In the Competition treatment, when the believed guess is greater or equal to the draw, we cannot draw inferences about the optimal action because the revealing behaviour of the sender would also depend on their beliefs about the revealing behaviour of the other sender in the pair. 77.19% of the observations in the Competition treatment were not revealed by senders and this is not significantly different from the withholding rates in the Baseline, i.e. 86.03% (Wilcoxon rank-sum test p=0.197).[18]

Table 6: Summary of elicited beliefs of senders

	Baseline	**Competition**
% of observations revealed when believed guess < draw	**82.18**	**88.78**
Rounds 1-10	79.13	85.26
Rounds 11-20	79.31	88.86
Rounds 21-30	87.95	92.11
% of observations not revealed when believed guess >= draw	**86.03**	**77.19**
Rounds 1-10	88.06	70.27
Rounds 11-20	87.04	77.69
Rounds 21-30	82.76	84.02

[17] We also calculate the believed guess of the sender by taking 1.5 (instead of 1), 2.5 (instead of 2), 3.5 (instead of 3), 4.5 (instead of 4) and 5 as the guess of the receiver. In Appendix A, we reproduce Table 6 with numbers from this calculation (see Table A 3)

[18] The difference between the believed guess and the actual guess is not statistically significant (Wilcoxon signed-rank test p=0.600 in both treatments). This implies that senders in both treatments form correct beliefs about the receivers' guess conditional on non-disclosure.

Result 7: Senders in the Baseline and the Competition treatment have similar believed guesses. When the optimal action is to reveal the draw, senders in the Competition treatment reveal significantly more often than the senders in the Baseline.

Receivers' beliefs about the sender revealing rate and the actual sender revealing rate across the Baseline and the Competition treatment are shown in Figure 4. The implied guess is 1.985 in the Baseline and 2.088 in the Competition treatment and the difference between the implied guesses across treatments is not statistically significant (Wilcoxon rank-sum test p=0.521). Receivers' beliefs about senders' revealing rate are miscalibrated for intermediate draws in the Baseline and for intermediate and high draws in the Competition treatment. The insufficient scepticism about non-disclosed information, or in other words, strategic naivety, among receivers stems from miscalibrated beliefs about intermediate and high draws as opposed to their beliefs about the revealing rate of low draws.

These miscalibrated beliefs of receivers indicate that the average belief of the non-disclosed draw (1.985 in Baseline and 2.088 in the Competition treatment) is higher than the actual average non-disclosed draw (1.846 in Baseline and 1.582 in the Competition treatment), and these differences are statistically significant (Wilcoxon signed-rank test p=0.074 for Baseline and p=0.027 for the Competition treatment). We refer to this difference as strategic naivety following Jin et al. (2017). Put differently, receivers do not sufficiently infer that non-disclosure of a draw implies that the draw is low.[19]

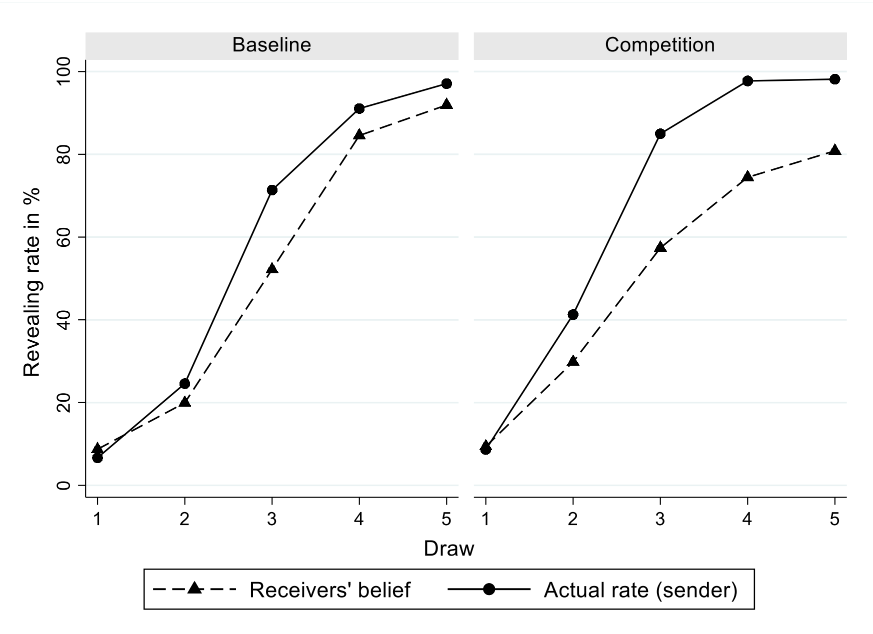

Figure 4: Actual revealing rate and receivers' belief about revealing rate

[19] Receivers in the Baseline do not best-respond to their incorrect beliefs, and in fact their guesses are much higher than their beliefs indicate (Wilcoxon signed-rank test p=0.027 between implied guess and actual guess). Receivers in the Competition treatment best-respond to their incorrect beliefs about the non-disclosed number (Wilcoxon signed-rank test p=0.173 between implied guess and actual guess). See Figure A 1 and Figure A 2 in Appendix A for a graphical representation of these statistics.

Result 8: The implied guess of receivers does not differ significantly across treatments. Strategic naivety in receivers stems from miscalibrated beliefs about the senders' revealing rate of intermediate and high draws as opposed to beliefs about the revealing rate of low draws.

We now explore whether receivers' beliefs about the non-disclosed number are systematically explained by their characteristics. To do this, we regress receiver's implied guess on the Competition treatment dummy and the characteristics of receivers such as sex, field of study being economics, risk aversion, cognitive ability questions, negative reciprocity (Falk et al., 2016), and the level of scepticism (Hurtt, 2010) measured by a questionnaire. We do a median split of the receivers' score on the Hurtt's scepticism scale (Hurtt, 2010) and calculate a dummy variable which takes the value of 1 if the receiver's scepticism score is above the median scepticism score, and 0 otherwise. We think that the receivers who score high on the scepticism scale tend to form more accurate, i.e. sceptical beliefs about the non-disclosed number. We present the regression results in Table 7 below.

We find that the implied guess of the receivers with a higher cognitive ability is lower and this implies that these receivers are closer to accuracy given the average revealing behaviour of senders (p=0.002). Our results are similar to those in Gill & Prowse (2016) and Li & Schipper (2018) who find a positive relationship between cognitive ability and participants' level of reasoning in a *p*-beauty contest game. As mentioned earlier, the implied guess of receivers is not significantly different across treatments and this is confirmed with an insignificant Competition treatment dummy (p=0.376).

Result 9: Receivers with a higher cognitive ability hold lower, and therefore more accurate beliefs about the non-disclosed number.

Table 7: Regression on the implied guess of receivers

Variables	OLS
Competition treatment	0.110
	(0.119)
Male	0.069
	(0.123)
Field of study being Economics	-0.196
	(0.134)
Cognitive ability	-0.450***
	(0.108)
Scepticism	-0.160
	(0.169)
Constant	2.355***
	(0.155)
Observations	624
R-squared	0.193

Note: Regression estimated using OLS. Robust standard errors in parentheses (clustered at the matching group level). ***p<0.01, **p<0.05, *p<0.1.

4. Discussion and conclusion

This paper identifies a market setting to increase disclosure of information in spite of the presence of naïve receivers. We provide experimental evidence to examine whether competition in the market among information senders can lead to the "truths' becoming known…" by substituting the need for receiver scepticism in generating unravelling as highlighted by Milgrom & Roberts (1986). To investigate this, we compare a setting where a sender competes with another sender to be chosen by the receiver (which can be thought of as firms competing to trade with a receiver) to a setting without competition between senders. We find that when receivers prefer senders that disclose information over those that do not, senders start competing in disclosing information to receivers, thereby significantly increasing the amount of information that is disclosed. This is largely driven by differences in the revealing rates of intermediate draws. The higher rate of information disclosure under competition is consistent with the results in Penczynski & Zhang (2017) who also find that senders in a duopoly reveal more pieces of information in comparison with the senders in a monopoly market structure.

Our results are in contrast to those in Jin (2005) who empirically studies whether Health Maintenance Organisations (HMOs) voluntarily disclose quality information through National Committee of Quality Assurance (NCQA). She finds that the primary reason for disclosing via NCQA is to differentiate from competitors, and in relatively competitive areas, HMOs are less likely to disclose via NCQA over time. We conjecture that the difference between our results is because HMOs could build their reputation in their local areas over time based on quality, and therefore, compete on a different dimension (such as price as opposed to quality) to attract consumers. In contrast, we prevented the possibility of senders forming reputation over rounds by design (i.e. implementing random re-matching) and gave them no other dimension to compete on. Therefore, we find that competition increases disclosure of information in situations characterised by our setting.

This paper also explores whether comparative evaluation of information, which is a feature of introducing competition between senders, affects the scepticism and guesses of non-disclosed numbers by receivers. We find that receivers who are presented with information in a comparative manner do not guess significantly lower upon observing non-disclosure than when receivers do not have the option of evaluating information in a comparative manner. Receivers also do not form significantly different beliefs about non-disclosed numbers in the Competition treatment compared to the Baseline.

We believe that comparative evaluation may not have helped in our set-up due to two reasons. First, it is possible that receivers may not have engaged with the "additional" and readily available comparative information provided to them with the presence of another sender alongside. This is because receivers may already have had enough information to consider while making their decisions - such as the payoff table and the draws revealed by senders in the experiment that the receiver was matched with. Therefore, receivers may be imperfectly attentive or cognitively limited to consider any additional information provided to them while making their decisions. Second, receivers' may have thought about what information *is* revealed rather than what *is not* revealed during the belief elicitation stage. In other words, framing the belief questions differently may have an impact on the way receivers interpret the non-disclosed information, and this is open to future research.[20]

Interestingly, we find that receivers earn a higher payoff in the Competition treatment than in the Baseline despite no significant differences in their guesses of non-disclosed numbers. The results regarding higher welfare in the Competition treatment are in contrast with the results in Penczynski & Zhang (2017). We reason that the difference may be due to the nature of the games that subjects play in both experiments. In Penczynski & Zhang (2017), buyers bid a price for the seller's product and in the process, were required to discount for the publication bias of the disclosed pieces of evidence from the set of all available pieces of evidence that the sellers had available to them. In contrast, the decision problem for the receivers in our experiment is simpler compared to theirs, i.e. receivers choose the number if the seller disclosed it to earn the highest possible payoff and guess in the absence of disclosure from the sender.

In conclusion, we provide experimental evidence that shows competition between senders increases disclosure of information even when receivers are naïve about non-disclosed information. This finding can inform policy-makers about conditions under which unravelling of information is more likely to occur. Regulatory authorities can use the tools at their disposal to facilitate competition between firms to increase information disclosure and consumer welfare, particularly in environments that are closely captured by our setup.

[20] Currently, we elicit beliefs about senders' revealing behaviour by asking receivers to think about how many senders *revealed* a given draw. The alternative would be to elicit these beliefs by asking receivers to think about how many senders *did not* reveal a given draw.

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Appendix A

Table A 1: The table shows the earnings in points for the [selected] S Player and R Player

Points S, R	R 1's report: 1	R 1's report: 1.5	R 1's report: 2	R 1's report: 2.5	R 1's report: 3	R 1's report: 3.5	R 1's report: 4	R 1's report: 4.5	R 1's report: 5
Private number 1	-29, 110	-6, 102	17, 90	38, 75	57, 57	75, 38	90, 17	102, -6	110, -29
Private number 2	-29, 90	-6, 102	17, 110	38, 102	57, 90	75, 75	90, 57	102, 38	110, 17
Private number 3	-29, 57	-6, 75	17, 90	38, 102	57, 110	75, 102	90, 90	102, 75	110, 57
Private number 4	-29, 17	-6, 38	17, 57	38, 75	57, 90	75, 102	90, 110	102, 102	110, 90
Private number 5	-29, -29	-6, -6	17, 17	38, 38	57, 57	75, 75	90, 90	102, 102	110, 110

Table A 2: Summary statistics

Variables	**N**	**Mean**	**Standard deviation**
Economics (dummy)	5190	0.248	0.432
Competition treatment	5190	0.606	0.488
Male (dummy)	5190	0.416	0.492
Native English (dummy)	5190	0.624	0.484
Friend in the session (dummy)	5190	0.179	0.383
Cognitive ability (dummy=1 if at least 1 correct answer)	5190	0.682	0.465
Age	5190	21.21	3.76

Table A 3: Summary of elicited beliefs of senders (with higher point of the interval)

	Baseline	**Competition**
% of observations revealed when believed guess < draw	**88.95**	**94.41**
Rounds 1-10	86.03	91.44
Rounds 11-20	87.18	93.20
Rounds 21-30	93.27	98.47
% of observations not revealed when believed guess >= draw	**80.67**	**71.22**
Rounds 1-10	84.47	65.95
Rounds 11-20	80.69	71.95
Rounds 21-30	76.39	76.05

Note: The believed guess is calculated taking the higher point of the interval (Table 6 is calculated taking the lowest point of the interval).

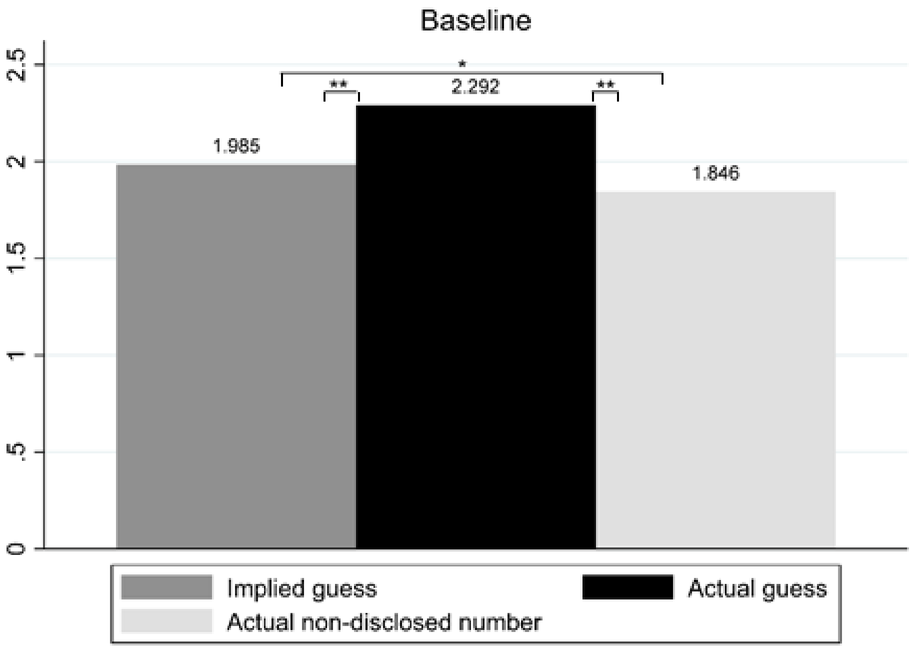


Figure A 1: Actual guess, implied guess and actual non-disclosed number in the Baseline

Note: ***p<0.01, **p<0.05, *p<0.10

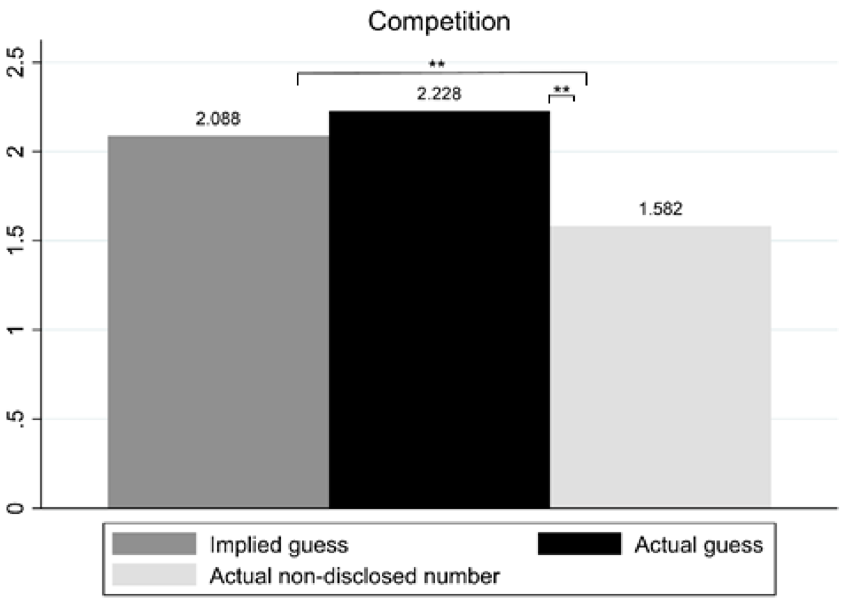


Figure A 2: Actual guess, implied guess and actual non-disclosed number in the Competition treatment

Note: ***p<0.01, **p<0.05, *p<0.10

Appendix B: Experimental Instructions

{Baseline only} [Competition treatment only]

Welcome

Thank you for taking part in this experiment on decision-making. For participating in this experiment, you will be paid a £4 show up fee. Moreover, you will be paid an additional amount of money that will depend on yours and other participants' decision, and on chance. You will be paid in cash, privately at the end of the experiment.

Please silence and put away your mobile phones now.

The entire session will take place through your computer terminal. Please do not talk with other participants during the session.

During this experiment we will calculate your earnings using points. For your final payment, your earnings will be converted into Pounds at the ratio of 75:1 (75 points=£1). Any negative earnings you may make during the experiment will be subtracted from your show-up fee of £4.

We will start with a brief instruction period. During the instruction period you will be given a description of the main features of the experiment. If you have any questions during this period, please raise your hand and the experimenter will come to you to answer your question.

Instructions

The experiment consists of 6 blocks with 5 rounds in each block, making it a total of 30 rounds. At the end of each block, you will be asked to answer 5 questions, and at the end of the final block, you will be asked to fill out a questionnaire.

At the beginning of block 1, some of you will be randomly assigned to be the S Player and the others to be the R Player. [If you are assigned to be the S Player, you will further be assigned to be either S Player 1 or S Player 2.] You will remain in these roles for the entire duration of this experiment. [The computer will randomly pair one S Player 1 with one S Player 2 and you will remain in these pairs for the entire duration of this experiment.].

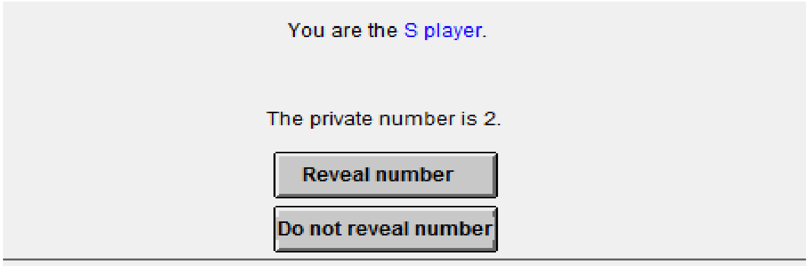
Decision-making stage

In each round, an R Player will be randomly matched with *{*an S Player*}* [a pair S Players] and in each new round, the R Player will be matched with a *{*different S Player*}* [new pair of S Players]. You will not learn the identity of the other participants you are matched with, nor will the other participants learn your identity.

For every matching of an R Player with *{*an S Player*}* [a pair of S Players], the computer program will [separately] generate *{*a*}* [two] private number[s] that *{*is*}* [are] randomly drawn from the set {1, 2, 3, 4, 5} [,one for S Player 1 and the other for S Player 2.]. Each of these numbers is equally likely to be generated. The computer will then send *{*the private number to the S Player*}* [one private number to S Player 1 and the other private number to S Player 2. Each S Player will see only their own private number.]. After receiving the private number, *{*the*}* [each] S Player will choose whether to reveal his private number to the R Player. If *{*the*}* [an] S Player chooses to reveal [his] number, the R Player will receive this message: "The number S Player [1] received is:" [or "The number S Player 2 received is:"]

followed by the actual private number. Otherwise, the R Player will receive no message from {the S Player} [an S Player who chooses not to reveal his private number].

This is a screenshot of {the} [an] S Player's screen. As you can see, the S Player **cannot lie or misreport** the true private number.



After seeing the message from [each of] the S Player[s], the R Player will report the value[s] of the private number[s] revealed by the S Player[s]. If the private number is not revealed by {the} [an] S Player, the R Player will guess the value of the private number. R Player can report the following numbers {1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5}. The numbers {1.5, 2.5, 3.5, 4.5} can be used, for example, when the R Player is unsure about the true value of the private number.

[R Player will also choose her preferred S Player by clicking on the button "Choose S Player 1" or "Choose S Player 2". This choice will determine the earnings for the decision-making stage as described below.]

Earnings for the decision-making stage

[The preferred S Player will be selected by the computer with a 75% probability, and the other S Player with a 25% probability, to be matched with the R Player to earn points. The S Player not selected by the computer will earn 0 points. In other words, the preferred S Player has a higher probability of being selected by the computer to earn points, and the R Player has a higher probability of earning points for her preferred S Player.]

The S Player [selected by the computer] will earn the points that result from the report of the R Player. The R Player will earn points based on her own report and the true value of the private number [of the selected S Player]. The specific earnings [for the selected S Player and the R Player] are shown in the table below, which is displayed again before the S Player[s] and the R Player make their decisions. In each cell of the table, the points for the [selected] S Player are on the left, and the points for the R Player are on the right. As you can see from the table, the [selected] S Player earns more when the R Player makes a higher report, and the R Player earns more when her report is closer to the true private number [of the selected S Player].

The table shows the earnings in points for the [selected] **S Player** and the **R Player**.

Points S, R	**R 1's report: 1**	**R 1's report: 1.5**	**R 1's report: 2**	**R 1's report: 2.5**	**R 1's report: 3**	**R 1's report: 3.5**	**R 1's report: 4**	**R 1's report: 4.5**	**R 1's report: 5**
Private number 1	-29, 110	-6, 102	17, 90	38, 75	57, 57	75, 38	90, 17	102, -6	110, -29
Private number 2	-29, 90	-6, 102	17, 110	38, 102	57, 90	75, 75	90, 57	102, 38	110, 17

Private number 3	-29, 57	-6, 75	17, 90	38, 102	57, 110	75, 102	90, 90	102, 75	110, 57
Private number 4	-29, 17	-6, 38	17, 57	38, 75	57, 90	75, 102	90, 110	102, 102	110, 90
Private number 5	-29, -29	-6, -6	17, 17	38, 38	57, 57	75, 75	90, 90	102, 102	110, 110

{Example 1 – Earnings for a decision-making stage

Suppose in Round 18 of the experiment:

The computer program generates the private number for S Player as: **2**

S Player chooses not to reveal the private number 2 to the R Player.

Hence, the R Player sees this message on her screen:

"The number S Player received is: "

R Player guesses the value of the private number of S Player as: **4.5**

Therefore,

S Player earns = **102 points** for that round

R Player earns = **38 points** for that round

Example 2 – Earnings for a decision-making stage

Suppose in Round 26 of the experiment:

The computer program generates the private number for S Player as: **3**

S Player chooses to reveal the private number 3 to the R Player.

Hence, the R Player sees this message on her screen:

"The number S Player received is: 3"

R Player reports the value of the private number of S Player as: **3**

Therefore,

S Player earns = **57 points** for that round

R Player earns = **110 points** for that round

Now please answer questions 1 and 2. After you have finished answering both the questions, please raise your hand and the experimenter will come to you to check your answers.

1. Calculate the points earned by the players in this round. Suppose that:

The computer program generates the private number for S Player as: **5**

S Player chooses not to reveal the private number 5 to the R Player.

Hence, the R Player sees this message on her screen:

"The number S Player received is: "

R Player guesses the value of the private number of S Player as: **2.5**

S Player earns = _____ **points**

R Player earns = _____ **points**

2. Calculate the points earned by the players in this round. Suppose that:

The computer program generates the private number for S Player as: **2**

S Player chooses to reveal the private number 2 to the R Player.

Hence, the R Player sees this message on her screen:

"The number S Player received is: **2**"

R Player reports the value of the private number of S Player as: **2**

S Player earns = _____ **points**

R Player earns = _____ **points}**

[Example 1 – Earnings for a decision-making stage

Suppose in Round 18 of the experiment:

The computer program generates the private number for S Player 1 as: **1**

The computer program generates the private number for S Player 2 as: **4**

S Player 1 chooses not to reveal the private number 1 to the R Player.

S Player 2 chooses to reveal the private number 4 to the R Player.

Hence, the R Player sees these messages on her screen:

"The number S Player 1 received is: "

"The number S Player 2 received is: **4**"

R Player guesses the value of the private number of S Player 1 as: **1.5**

R Player reports the value of the private number of S Player 2 as: **4**

R Player chooses S Player 2. The computer selects S Player 2. Therefore,

S Player 1 earns = **0 points** for that round

S Player 2 earns = **90 points** for that round

R Player earns = Points based on her report of the private number of the selected S Player (S Player 2)

= **110 points** for that round

Example 2 – Earnings for a decision-making stage

Suppose in Round 26 of the experiment:

The computer program generates the private number for S Player 1 as: **3**

The computer program generates the private number for S Player 2 as: **4**

S Player 1 chooses <u>to reveal</u> the private number 3 to the R Player.

S Player 2 chooses <u>not to reveal</u> the private number 4 to the R Player.

Hence, the R Player sees these messages on her screen:

"The number S Player 1 received is: **3**"

"The number S Player 2 received is: "

R Player reports the value of the private number of S Player 1 as: **3**

R Player guesses the value of the private number of S Player 2 as: **2**

R Player chooses S Player 2. The computer selects S Player 2. Therefore,

S Player 1 earns = **0 points** for that round

S Player 2 earns = **17 points** for that round

R Player earns = Points based on her report of the private number of the selected S Player (S Player 2)

= **57 points** for that round

Now please answer questions 1 and 2. After you have finished answering both the questions, please raise your hand and the experimenter will come to you to check your answers.

Calculate the points earned by the players in this round. Suppose that:

The computer program generates the private number for S Player 1 as: **5**

The computer program generates the private number for S Player 2 as: **3**

S Player 1 chooses <u>not to reveal</u> the private number 5 to the R Player.

S Player 2 chooses <u>to reveal</u> the private number 3 to the R Player.

Hence, the R Player sees these messages on her screen:

"The number S Player 1 received is: "

"The number S Player 2 received is: **3**"

R Player guesses the value of the private number of S Player 1 as: **2.5**

R Player reports the value of the private number of S Player 2 as: **3**

R Player chooses S Player 2.

1. If the computer selects S Player 1

S Player 1 earns = _____.**points**

S Player 2 earns = _____ **points**

R Player earns = _____ **points**

2. If the computer selects S Player 2

S Player 1 earns = _____ **points**

S Player 2 earns = _____ **points**

R Player earns = _____ **points]**

Questions at the end of each block

At the end of each block, S Players will answer the following question:

Think about the last 5 rounds. When S Players did not reveal the private number, what percentage of R Players in this room do you think reported the number:

a) 1 or 1.5:

b) 2 or 2.5:

c) 3 or 3.5:

d) 4 or 4.5:

e) 5:

In a block, if all S Players have revealed the private number the earnings for that block will be determined at random for the S Players.

At the end of each block, R Players will answer the following 5 questions:

What percentage of S Players do you think revealed the private number:

a) When the true private number was 1:

b) When the true private number was 2:

c) When the true private number was 3:

d) When the true private number was 4:

e) When the true private number was 5:

The following rule will be used to calculate your earnings for the answers to each of the 5 questions:

70 - (Your answer - Correct answer), if your answer is higher than the correct answer of that question

Or

70 - (Correct answer - Your answer), if your answer is lower than the correct answer of that question

Example – Earnings for the questions at the end of each block

Suppose you are an **S Player** and your answer to one of the above questions is: **30**

But the correct answer is: **50**

Your answer is lower than the correct answer. Therefore, we will use the following rule to determine your earnings for that question:

Your earnings = 70 - (Correct answer - Your answer)

= 70 - (50 - 30)

= **50 points**

Suppose you are the **R Player** and your answer to one of the above questions is: **45**

But the correct answer is: **30**

Your answer is higher than the correct answer. Therefore, we will use the following rule to determine your earnings for that question:

Your earnings = 70 - (Your answer - Correct answer)

= 70 - (45 - 30)

= **55 points**

Now please answer questions 1 and 2. After you have finished answering both the questions, please raise your hand and the experimenter will come to you to check your answers.

1. Suppose the S Player's answer to any one of the 5 questions above is **55** but the correct answer is **50**, what would be the earnings in points for that question? ______

2. Suppose the R Player's answer to any one of the 5 questions above is **25** but the correct answer is **40**, what would be the earnings in points for that question? ______

Payment

At the end of the experiment, the experimenter will call two participants to roll two six-sided dice one after another. The number rolled on the two dice will determine the two blocks that all participants will be paid for. You will be paid the total earnings accumulated for the 5 rounds in the decision-making stage for the block determined by the first die roll. For example, if the number rolled on the first die is 1, you will be paid the total amount you have accumulated in the 5 rounds in the decision-making stage in block 1. You will be paid for the accuracy of your answers to the 5 questions at the end of the block determined by the second die roll. For example, if the number rolled on the second die is 2, you will be paid for the accuracy of your answers to the 5 questions in block 2. If the number rolled on the second die is the same as the number rolled on the first die, the second die will be rolled again. In other words, you will be paid once for the total amount you have accumulated in the 5 rounds in the decision-making stage of one of the blocks, and once for the accuracy of your answers to the 5 questions in a different block.

Please raise your hand if you have any questions.

Appendix C: Post-experimental questionnaire

General questions:

1. What is your gender?
2. Is English your first or native language?
3. How old are you?
4. Do you have a friend participating in the session today?
5. What advice would you give to a friend if they were going to take your spot in this experiment?
6. Answer if you were an S Player. How did you decide whether or not to reveal the private number?
7. Answer if you were an R Player. How did you decide which number to report or guess?
8. What is your academic major or your planned academic major?

Cognitive ability questions:

9. A bat and a ball cost £1.10 in total. The bat costs £1 more than the ball. How much does the ball cost? ______ pence
10. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? _____ minutes
11. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half the lake? ______ days

Risk preference:

12. Please tell me, in general, how willing or unwilling you are to take risks. Please use a scale from 0 to 10, where 0 means you are "completely unwilling to take risks" and a 10 means you are "very willing to take risks". You can also use any numbers between 0 and 10 to indicate where you fall on the scale.

Negative Reciprocity:

13. On a scale from 0 to 10, where 0 means you are "completely unwilling to do so" and a 10 means you are "very willing to do so", how willing are you to punish someone who treats YOU unfairly, even if there may be costs for you?

General reciprocity:

14. How well does the following statement describe you as a person? Please indicate your answer on a scale from 0 to 10, where 0 means "does not describe me at all" and a 10 means "describes me perfectly".
    When someone does me a favour I am willing to return it.

Positive reciprocity:

15. Please think about what you would do in the following situation. You are in an area you are not familiar with, and you realise that you lost your way. You ask a stranger for

directions. The stranger offers to take you to your destination. Helping you costs the stranger about 20 Pounds in total. However, the stranger says he or she does not want any money from you. You have 6 presents with you. The cheapest present costs 5 Pounds, the most expensive one costs 30 Pounds. Do you give one of the presents to the stranger as a "thank-you"-gift? If so, which present do you give to the stranger?

No present
The present worth 5 Pounds
The present worth 10 Pounds
The present worth 15 Pounds
The present worth 20 Pounds
The present worth 25 Pounds
The present worth 30 Pounds

Hurtt's Scepticism Scale:

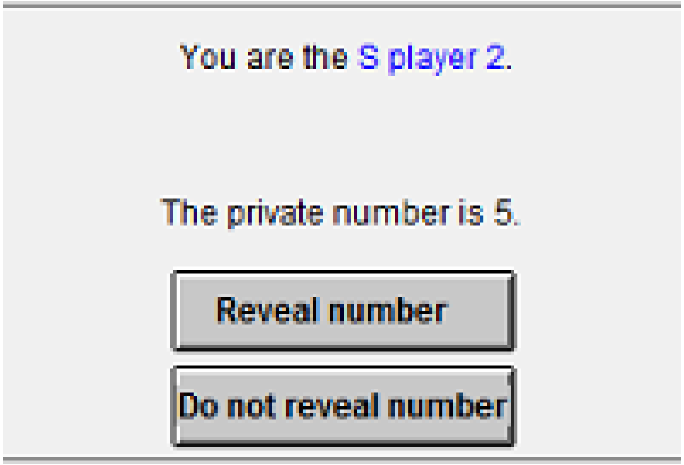
Please indicate your answer on a scale from 1 to 6, where 1 means "Strongly disagree" and 6 means "Strongly agree".

1. I often accept other people's explanations without further thought.
2. I feel good about myself.
3. I wait to decide on issues until I can get more information.
4. The prospect of learning excites me.
5. I am interested in what causes people to behave the way that they do.
6. I am confident of my abilities.
7. I often reject statements unless I have proof that they are true.
8. Discovering new information is fun.
9. I take my time when making decisions.
10. I tend to immediately accept what other people tell me.
11. The actions people take and the reasons for those actions are fascinating.
12. I am self-assured.
13. My friends tell me that I usually question things that I see or hear.
14. I like to understand the reason for other people's behavior.
15. I think that learning is exciting.
16. I usually accept things I see, read or hear at face value.
17. I don't feel sure of myself.
18. I usually notice inconsistencies in explanations.
19. Most often I agree with what the others in my group think.
20. I relish learning.
21. I have confidence in myself.
22. I don't like to decide until I've looked at all of the readily available information.
23. I like searching for knowledge.
24. I frequently question things that I see or hear.
25. It is easy for other people to convince me.

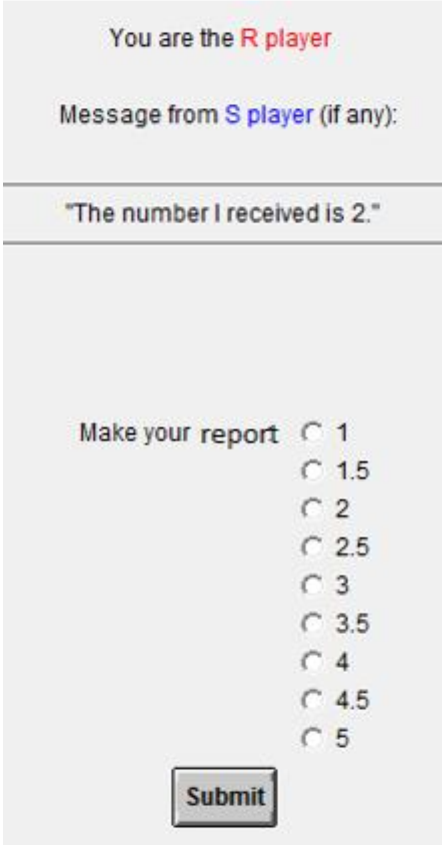
Appendix D: Screenshots of players' screen

Senders' screen - Baseline

Senders' screen - Competition



Receivers' screen - Baseline



Receivers' screen – Competition treatment