Information Bias, Communication, and Financial markets: An Experimental Study

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IMEBESS, Valencia, May 2025

Objectives of our study

- Understand the effects on financial markets of the presence of social media communication, in particular the segmentation of communication and the presence of biased information sources (news).

- There are some salient instances of the impact of social media communication: Game Stop, Silicon Valley Bank.

- We will look at differences across a number of experimental treatments of
  - Information aggregation by prices.
  - Market quality (price accuracy, liquidity, others).
  - Information sharing and communication content.

Research questions

- How does biased information (vs. unbiased) affect markets?

- How does segmented communication (vs non-segmented) affect them?

- How does the interaction affect them?

Information aggregation in experimental markets

- Plott and Sunder (1988) study information aggregation in experimental markets in a continuous double auction with a simpler information setting. They find that in single securities markets and homogeneous payoffs, they find that rational expectations equilibria work well. They predict no trade.

- Corgnet et al. (2022) replicated their study with more observations (higher power) and find that rational expectations equilibria is fragile.

- Halim et al. (2019) study information acquisition through a network. They find that information exchange increases trading volume, improves liquidity and enhances the ability of asset prices to reflect the aggregate amount of information in the market, but fails to improve price accuracy.

- Page and Siemroth (2021) find that in experimental markets, public information is almost always completely reflected in prices but very little private information is (less than 50%).

Design

1. Eight participants are each endowed with 1000 units of cash and four units of a risky asset of uncertain binary common value (the fundamental or state).

2. There are three successive stages to an experimental round.

3. Information stage: Participants receive independent binary private signal about the asset value, which might be biased or unbiased.

4. Communication stage: After receiving the private signals, (sub-) sets of participants engage in free-form communication.

5. Market stage: Then, all eight participants can trade in a continuous double auction for several minutes.

The treatments

- Between subjects.
- 2x3 design: treatments vary two dimensions: (i) Information: whether private signals about the value of the asset are biased or unbiased; (ii) Communication:communication structure (not connected, fully connected, segregated communication).

	Biased Signals	**Unbiased signals**
No communication	B-NoCom	U-NoCom
Segregated communication	B-Seg	U-Seg
Full connectedness	B-FuCon	U-FuCon

Information Stage: fundamentals and signal

- The fundamental is binary, i.e, $\theta \in \Theta := \{O, G\}$, which we call Orange and Green fundamental.

- The risky asset pays off 10 if $\theta = O$ and 500 if $\theta = G$.

- The prior probability distribution on Θ is p and has $Pr(\theta = G) = p_0$, and we consider scenarios where the prior is either green-leaning, $p_0 > 0.5$, or orange-leaning, $p_0 < 0.5$.

- Each agent receives a signal from an information structure σ, which is a stochastic mapping from the space of fundamentals to the space of signals. The signal s is binary and $S := \{o, g\}$.

- Conditional of each signal, an information structure induces a posterior over the state space.

- **HERE IS THE CRUCIAL DESIGN FEATURE: The information structure might be unbiased or biased (but with the goal that they have the same level of informativeness)**.

Parametrization: Information design

- (Two priors: one orange-leaning and one green-leaning). Orange structure: Orange signal more 'reliable' than green signal. Green structure: Green signal more 'reliable' than orange signal (The two biased information structures that are "on average" equally informative as an unbiased one). Unbiased: Both signals equally reliable.

Biased Information Structures

Biased towards orange

Prior	state	Signal= orange	Signal= green
0.6 or 0.4	orange	0.8	0.2
0.4 or 0.6	green	0.4	0.6

Biased towards green

Prior		Signal= orange	Signal= green
0.6 or 0.4	orange	0.6	0.4
0.4 or 0.6	green	0.2	0.8

Unbiased Information Structure

Prior	state	Signal= orange	Signal= green
0.6 or 0.4	orange	0.7	0.3
0.4 or 0.6	green	0.3	0.7

Posterior probabilities and mutual information in our information structures. (We use the notion of an advisor)

Biased towards orange

BiasedO (0.8,0.6), p(0.6/0.4)

Asesor A (biased towards orange)	Urna 1 6 bolas naranjas; 4 bolas verdes	Urna 2 4 bolas naranjas; 6 bolas verdes
El asesor dice: "La bola es naranja"		
Probabilidad que la bola sea naranja	75%	57%
Probabilidad que la bola sea verde	25%	43%
El asesor dice: "La bola es verde"		
Probabilidad que la bola sea naranja	33%	18%
Probabilidad que la bola sea verde	67%	82%

Mutual information: I=0.12
I-H(p)=0.85

Biased towards green

BiasedG (0.8,0.6), p(0.6/0.4)

Asesor B (biased towards green)	Urna 1 6 bolas naranjas; 4 bolas verdes	Urna 2 4 bolas naranjas; 6 bolas verdes
El asesor dice: "La bola es naranja"		
Probabilidad que la bola sea naranja	82%	67%
Probabilidad que la bola sea verde	18%	33%
El asesor dice: "La bola es verde"		
Probabilidad que la bola sea naranja	43%	25%
Probabilidad que la bola sea verde	57%	75%

Mutual information: I=0.12
I-H(p)=0.85

Unbiased (0.7, 0.7)

Unbiased (0.7,0.7), p(0.4, 0.6)

	Urna 1 6 bolas naranjas; 4 bolas verdes	Urna 2 4 bolas naranjas; 6 bolas verdes
El asesor dice: "La bola es naranja"		
Probabilidad que la bola sea naranja	78%	61%
Probabilidad que la bola sea verde	22%	39%
El asesor dice: "La bola es verde"		
Probabilidad que la bola sea naranja	39%	22%
Probabilidad que la bola sea verde	61%	78%

**Mutual information: I=0.12**
I-H(p)=0.85

Communication and market stages

- Communication. Three different cases: no communication, segmented, all. In segmented with biased information the segmentation keeps those agents with the same advisor together.

- Market. A standard continuous double auction.

Experimental procedures: Number of participants

- Use o-Tree
- Two trial rounds.
- Each treatment will have 6 independent sessions
- In each session there will be 48 participants
- These 48 participants will be grouped in 6 markets of 8 subjects (6x8) that will play for 12 rounds.
- Total of 288 subjects.
- Show-up fee 5 euros.
- Experiments took place at the LINEEX lab in Valencia.
- Sessions lasted an average of 75 minutes and average pay was between 15-20 Euros.

Price Accuracy: Mean Absolute Error Between Price and Fundamentals
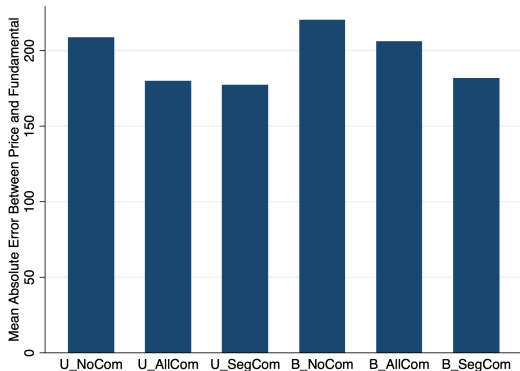
Prices are more accurate when All Communicate and Unbiased, and when Segregated Communication. Prices are less accurate when there is No Communication or when All Communicate and signals are Biased.

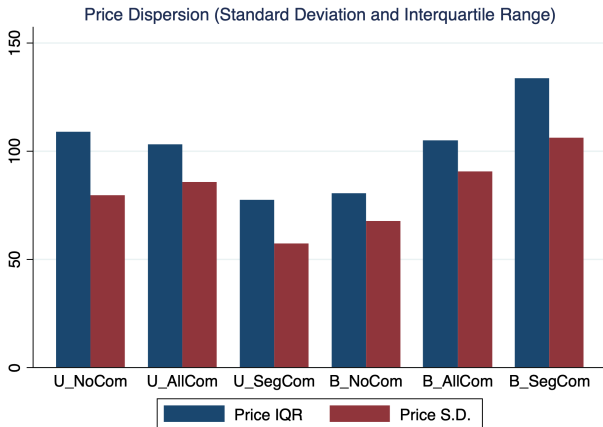# Mean Absolute Error Between Price and Fundamentals: Regression

	(1) MAE	(2) MAE
UnBiasedInfo	-11.88	-5.441
	(16.74)	(13.45)
SegCom	-43.22***	-30.23**
	(15.51)	(13.76)
AllCom	-9.723	-14.04
	(11.43)	(11.89)
AllCom×UnBiasedInfo	-18.94	-6.976
	(23.81)	(19.49)
SegCom×UnBiasedInfo	16.40	11.76
	(25.95)	(22.38)
Round	-2.397	-1.826
	(1.458)	(1.309)
Drawn Ball		72.66***
		(17.94)
Belief FE		180.9***
		(21.45)
Belief Dispersion		-38.59
		(52.01)
Constant	233.7***	119.5***
	(10.88)	(16.58)
N	432	432

Price Accuracy

- Prices are more accurate in Segregated Communication Treatments.

- Prices are slightly more accurate in All Communicate and Unbiased.

- The benefits of communication for price accuracy disappear when signals are Biased and All Communicate.

- Prices are less accurate when beliefs are less accurate and when the drawn ball has the highest fundamental value.

- No learning over rounds.

Price Volatility

Price Dispersion (Standard Deviation and Interquartile Range)

Price Volatility

	(1) Price S.D.	(2) Price S.D.	(3) Price IQR	(4) Price IQR
UnBiasedInfo	11.88	12.70	28.43	29.35
	(20.80)	(21.11)	(30.01)	(29.79)
SegCom	38.63	37.99	53.29	53.07
	(25.22)	(25.04)	(34.01)	(33.43)
AllCom	23.00	22.95	24.41	23.29
	(18.23)	(18.39)	(26.92)	(26.80)
AllCom×UnBiasedInfo	-16.88	-17.79	-30.31	-30.35
	(23.65)	(23.95)	(33.88)	(33.97)
SegCom×UnBiasedInfo	-60.83**	-61.04**	-84.66**	-85.27**
	(29.14)	(29.19)	(40.16)	(39.68)
Round	-4.056***	-3.976***	-4.786***	-4.689***
	(1.037)	(1.033)	(1.061)	(1.051)
Drawn Ball		9.009**		14.67**
		(4.420)		(5.754)
Belief F.E.		-10.40		-21.87
		(18.22)		(18.57)
Belief Dispersion		-8.563		33.51
		(36.05)		(56.11)
Constant	93.97***	94.97***	111.6***	106.2***
	(19.69)	(21.20)	(26.88)	(29.27)
N	432	432	432	432

Standard errors clustered at the independent group level in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Prices are less disperse when Communication is Segregated and signals are Unbiased. There is less price dispersion over rounds.

Liquidity: The Bid-Ask Spread of Trades
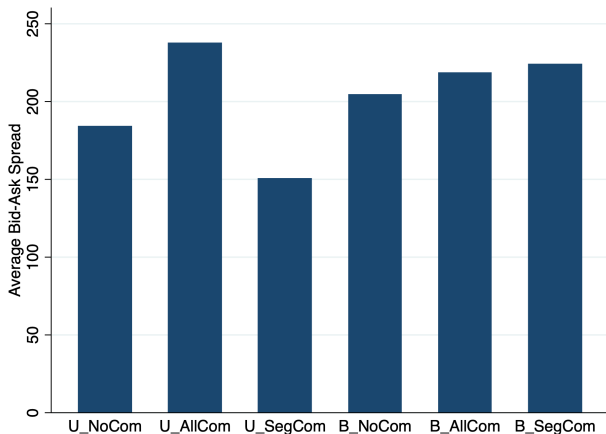
The Unbiased with Segmented Communication has the highest liquidity (lowest bid-ask spread), while Unbiased with All Communication has the lowest liquidity (highest bid-ask spread) and this difference is statistically significant.

No difference of average payoffs across treatments.

Players' Average Payoffs

Payoff Inequality (S.D. of Payoffs)
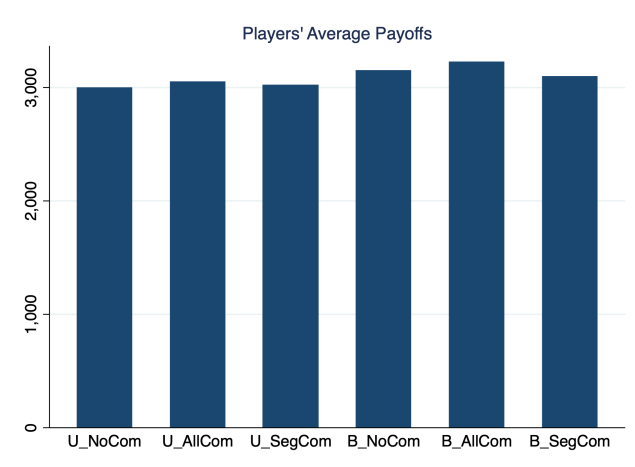
Standard deviation of payoffs
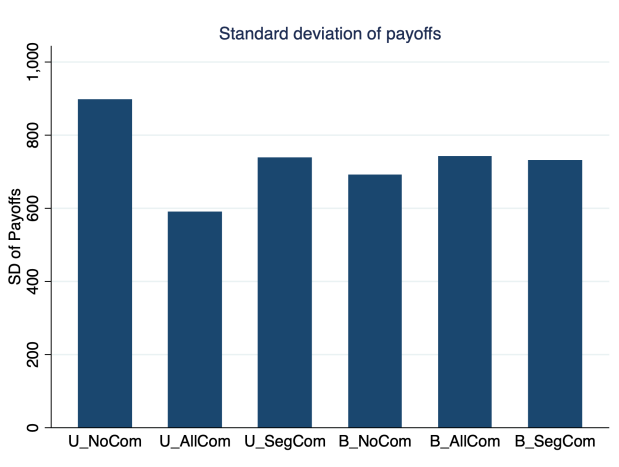
The highest payoff inequality is with No Communication and Unbiased Signals. The lowest payoff inequality is with All Communication and Unbiased Signals.

Payoff Inequality (S.D. of Payoffs): Regression

|	(1) SD Payoff	(2) SD Payoff	(3) Range Payoffs	(4) Range Payoffs
UnbiasedInfo	205.8***	224.8***	659.0***	718.5***
	(77.58)	(83.52)	(252.3)	(272.9)
SegCom	39.09	52.49	288.0	324.3
	(144.9)	(140.9)	(459.2)	(447.1)
AllCom	50.01	39.32	140.8	108.2
	(68.80)	(69.79)	(183.9)	(184.5)
AllCom×UnbiasedInfo	-358.2***	-346.8***	-982.3***	-953.1***
	(111.0)	(121.1)	(326.1)	(360.7)
SegCom×UnbiasedInfo	-197.9	-214.7	-705.4	-752.1
	(177.3)	(175.8)	(553.1)	(549.8)
Round	-16.64***	-14.70***	-51.55***	-45.57***
	(5.919)	(5.669)	(16.34)	(15.69)
Signal More Informative		-108.5		-252.9
		(76.38)		(221.7)
Drawn Ball		238.6***		740.5***
		(76.37)		(222.2)
Constant	800.1***	720.6***	2294.6***	2002.3***
	(53.39)	(83.41)	(156.4)	(241.0)
N	432	432	432	432

Standard errors in parentheses

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Trading Volume by Treatment and Round

Trading Volume by Treatment and Round
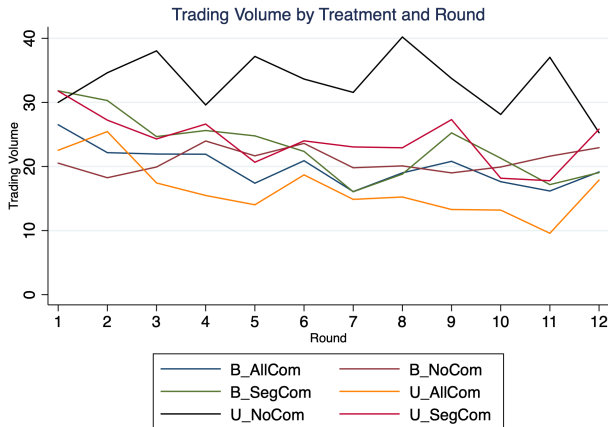
Trading Volume: Panel Regression

	(1) TV	(2) TV
UnBiasedInfo	6.931	6.776
	(5.753)	(5.627)
SegCom	0.639	0.612
	(3.450)	(3.528)
AllCom	-0.583	-0.426
	(2.790)	(2.785)
AllCom×UnBiasedInfo	-10.99*	-11.03*
	(6.244)	(6.130)
SegCom×UnBiasedInfo	-5.347	-5.248
	(6.860)	(6.776)
Round	-0.572***	-0.588***
	(0.124)	(0.123)
Drawn Ball		-2.258***
		(0.544)
Belief FE		1.912
		(1.820)
Belief Dispersion		-3.739
		(3.726)
Constant	22.76***	23.95***
	(2.092)	(2.384)
N	432	432

Standard errors clustered at the group level in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Trading Volume: Post-estimation tets

- There is less trading volume when All Communicate and Information is Unbiased. This suggests that higher trading in other treatments could be for informational reasons.

- The highest trading volume is when No Communication and Unbiased Information.
- There is less trading volume over rounds.
- There is less trading volume when the ball drawn has the highest value.

Communication Stage: Methodology

- Two independent coders have looked through the data at the group/Round level and answered our questions from our protocol.

- Questions included issues such as sharing signals/beliefs, whether they reached consensus, social aspects of conversations, boredom, doubts, etc.

- The analysis presented here is only using the data from 1 of the coders.

Communication Stage: The Data

session_code	id_in_session	participant_c	channel	nickname	body	timestamp
a9paxf6t	2	84a0oz29	1-trading-1_	?üê•	la bola es naranja	1706614188
a9paxf6t	8	65or6zmq	1-trading-1_	?üâ≥	Que piensan	1706614201
a9paxf6t	5	tyg3llyx	1-trading-1_	?üâ≥	sv≠, yo creo que es naranja	1706614209
a9paxf6t	6	sw337bib	1-trading-1_	?üçÑ	yo creo que es verde	1706614213
a9paxf6t	7	3bdj849p	1-trading-1_	?üê•	que es naranja	1706614216
a9paxf6t	1	qcqvxnpq	1-trading-1_	?üçÑ	nos sale a todos el mismo assesor?	1706614221
a9paxf6t	7	3bdj849p	1-trading-1_	?üê•	vaya jajaja	1706614225
a9paxf6t	3	9lmbydcc	1-trading-1_	?üê¨	la bola es naranja al 100%	1706614228
a9paxf6t	6	sw337bib	1-trading-1_	?üçÑ	jajajaj	1706614229
a9paxf6t	5	tyg3llyx	1-trading-1_	?üâ≥	El b	1706614229
a9paxf6t	2	84a0oz29	1-trading-1_	?üê•	si, el b	1706614229
a9paxf6t	3	9lmbydcc	1-trading-1_	?üê¨	si b	1706614231
a9paxf6t	7	3bdj849p	1-trading-1_	?üê•	estv" bastante igualado	1706614233
a9paxf6t	5	tyg3llyx	1-trading-1_	?üâ≥	la cosa es que es la urna 2 y hay mas bolas verdes	1706614240
a9paxf6t	1	qcqvxnpq	1-trading-1_	?üçÑ	la verde vale mv"s	1706614245
a9paxf6t	8	65or6zmq	1-trading-1_	?üâ≥	creo que es naranja pero si ponemos verde ganamos mv"s que perdemos	1706614247
a9paxf6t	7	3bdj849p	1-trading-1_	?üê•	al ser la primera podemos probar	1706614256
a9paxf6t	5	tyg3llyx	1-trading-1_	?üâ≥	el asesor dice que es naranja pero hay un 30% de que sea verde	1706614256
a9paxf6t	6	sw337bib	1-trading-1_	?üçÑ	ya es eso	1706614258
a9paxf6t	2	84a0oz29	1-trading-1_	?üê•	si pero en la otra sale mayor probabilidad la naranja	1706614263
a9paxf6t	7	3bdj849p	1-trading-1_	?üê•	hay mucha probabilidad, casi el 50%	1706614273
a9paxf6t	2	84a0oz29	1-trading-1_	?üê•	y 0 de la verde	1706614277
a9paxf6t	6	sw337bib	1-trading-1_	?üçÑ	lo intentamos	1706614277
a9paxf6t	7	3bdj849p	1-trading-1_	?üê•	sii	1706614282
a9paxf6t	1	qcqvxnpq	1-trading-1_	?üçÑ	entonces es mejor comprar o vnder	1706614283
a9paxf6t	8	65or6zmq	1-trading-1_	?üâ≥	vale	1706614283
a9paxf6t	7	3bdj849p	1-trading-1_	?üê•	naranja	1706614286
a9paxf6t	5	tyg3llyx	1-trading-1_	?üâ≥	ya, eso no lo he entendido bien	1706614288
a9paxf6t	8	65or6zmq	1-trading-1_	?ü¶ã	es naranja	1706614648
a9paxf6t	6	sw337bib	1-trading-1_	?üê¨	es naranja	1706614648
a9paxf6t	2	84a0oz29	1-trading-1_	?üê•	es la bola verde	1706614651
a9paxf6t	7	3bdj849p	1-trading-1_	?üê•	si	1706614652
a9paxf6t	5	tyg3llyx	1-trading-1_	?ü¶ã	A mi me ha dicho que es naranja	1706614652
a9paxf6t	8	65or6zmq	1-trading-1_	?ü¶ã	ni me lo pienso	1706614652
a9paxf6t			1-trading-1_		a mi verde	1706614666

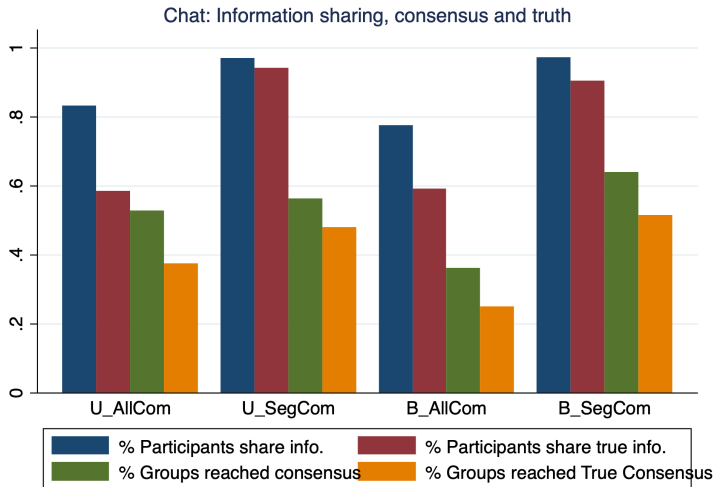# Chat: Number of Messages

Average Number of Messages in the Chat
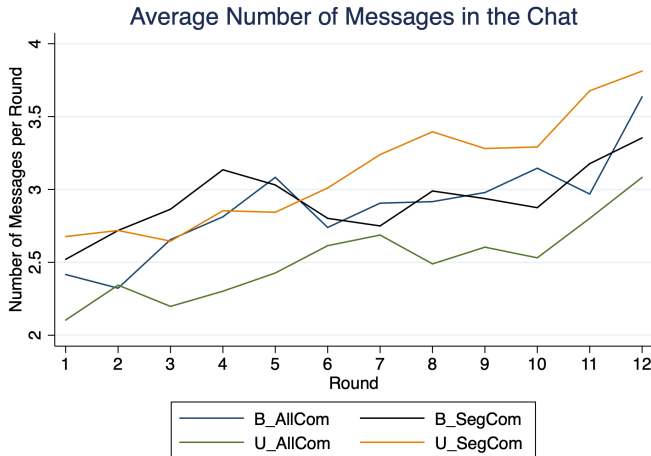
There is a significantly higher number of messages in the chat Segmented Communication and Unbiased compared to All Communicate and Unbiased.

Chat: Number of Messages and Other elements

- On average, subjects chat more in Segregated Communication Treatments compared to treatments where All Communicate and Unbiased Information.

- No effect on the group size in the Biased Information treatments.

- They chat more as Rounds increase.

- Demographics and Number of messages: age (-); CRT score (+); use social media to receive messages (+).

Chat: Information sharing & Consensus


Chat: Information sharing, consensus and truth

Legend:
- % Participants share info.
- % Participants share true info.
- % Groups reached consensus
- % Groups reached True Consensus

Categories: U_AllCom, U_SegCom, B_AllCom, B_SegCom

Chat: information Sharing & Consensus

	(1) Num M. Share Info	(2) Num M. share true info.	(3) Consensus color of ball	(4) Truthful consensus
UnBiasedInfo	0.458	-0.0556	0.771	0.640
	(0.557)	(0.646)	(0.592)	(0.546)
SegCom	1.583***	2.493***	3.430***	2.504***
	(0.516)	(0.628)	(0.721)	(0.562)
SegCom×UnBiasedInfo	-0.472	0.354	-1.154	-0.362
	(0.617)	(0.684)	(0.913)	(0.738)
Round	-0.0621**	-0.0597***	-0.0643	-0.0347
	(0.0307)	(0.0214)	(0.0438)	(0.0402)
Constant	6.598***	5.124***	-0.222	-0.955*
	(0.479)	(0.638)	(0.366)	(0.516)
N	288	288	288	288

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In Segregated Communication treatments there is more sharing of signals/beliefs, more truthful sharing, more consensus on the colour of the ball, and true consensus than when All Communicate.
Less sharing over time.

Chat: Do they propose to coordinate across time?

% Groups that talk about Coordinating across time?
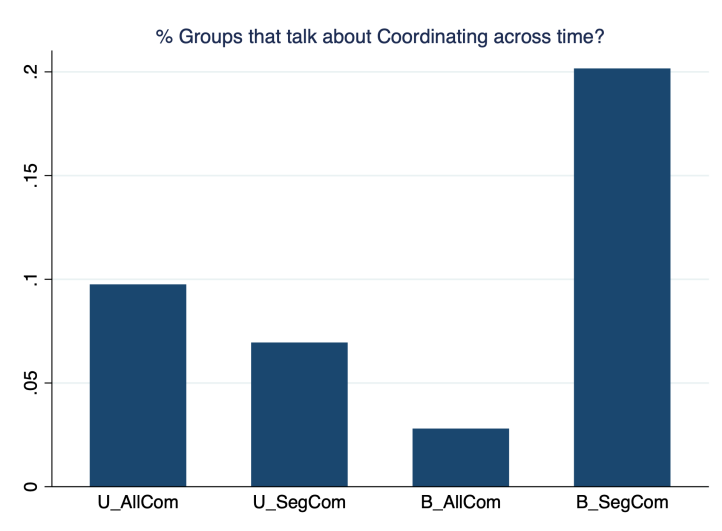
When Communication is Segregated and Information is Biased there is a higher % of Groups that propose to coordinate over time.

Chat: Social aspects

Social Aspects of Conversations

Legend:
- % Prosocial conversations
- % Anti-social Conversations
- % Boredom in conversations
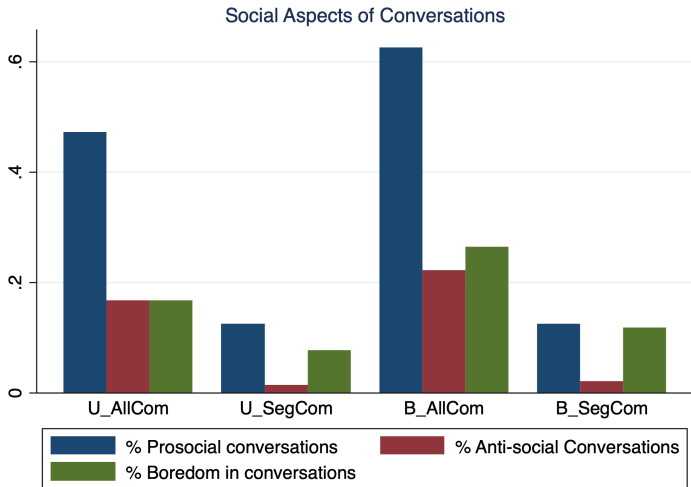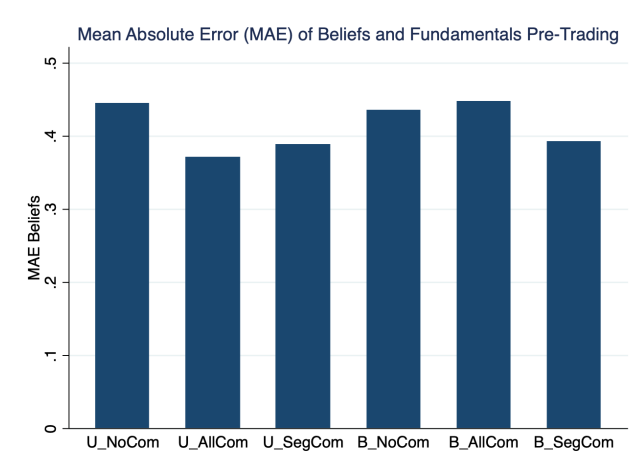
Conversations are more social when All Communicate.
Anti-social communication only occurs in All Communicate treatments.

Belief Forecast Error Pre-Trading by Treatment

Mean Absolute Error (MAE) of Beliefs and Fundamentals Pre-Trading

Beliefs are more accurate when Communication is Segregated (both with and without bias) or when All Communicate and information is Unbiased.

When are beliefs more accurate? A Panel Regression

	(1) MAE_belief	(2) MAE_belief
UnBiasedInfo	0.00791	0.00985
	(0.0141)	(0.00736)
SegCom	-0.0650***	-0.0490***
	(0.0176)	(0.0157)
AllCom	0.0190	0.0231
	(0.0162)	(0.0185)
AllCom×UnBiasedInfo	-0.0905***	-0.0725***
	(0.0250)	(0.0219)
SegCom×UnBiasedInfo	0.0147	-0.0100
	(0.0305)	(0.0260)
Round	0.0000657	0.000792
	(0.00255)	(0.00205)
Drawn Ball		-0.0294***
		(0.0103)
More informative signal		-0.298***
		(0.0172)
Constant	0.433***	0.607***
	(0.0196)	(0.0192)
N	432	432

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Belief Accuracy: Which factors matter?

- Belief Accuracy is higher in Segregated Communication Treatments (both with and without bias) that when there is No Communication.

- Belief Accuracy is higher when All Communicate and Unbiased signals. In the All Communicate and Biased signals, beliefs are not more accurate than when there is No Communication.

- Belief Accuracy does not improve over rounds.

- Beliefs are more accurate when the signal is more informative and the drawn ball has higher value.

These results do not depend on the measure used for belief accuracy.

Belief Dispersion

	(1) S.D. Belief	(2) S.D. Belief	(3) IQR Belief	(4) IQR Belief
UnBiasedInfo	0.00894	0.00949	0.0299	0.0303
	(0.0225)	(0.0227)	(0.0376)	(0.0378)
SegCom	-0.0241	-0.0231	-0.0690*	-0.0645
	(0.0244)	(0.0246)	(0.0391)	(0.0395)
AllCom	0.0232	0.0232	0.0547	0.0559
	(0.0293)	(0.0295)	(0.0496)	(0.0507)
AllCom×UnBiasedInfo	-0.0376	-0.0366	-0.145**	-0.140*
	(0.0367)	(0.0370)	(0.0733)	(0.0747)
SegCom×UnBiasedInfo	0.00682	0.00528	0.0168	0.00990
	(0.0323)	(0.0324)	(0.0578)	(0.0579)
Round	0.000719	0.000801	0.00323	0.00342
	(0.00106)	(0.00104)	(0.00280)	(0.00278)
Drawn Ball		0.00383		-0.00991
		(0.00543)		(0.0159)
Signal More Informative		-0.0158		-0.0842**
		(0.0147)		(0.0346)
Constant	0.193***	0.199***	0.277***	0.327***
	(0.0187)	(0.0215)	(0.0287)	(0.0330)
N	432	432	432	432

Standard errors clustered at the group level in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Beliefs (inter-quartile range) are less dispersed when All Communicate and Information is Unbiased, and when the signal is more informative.

Final remarks.

- Goal is to understand what drives informational inefficiencies in markets with different communication set-ups and information which might be biased or unbiased (both both have the same precision).

- We did not anticipate these results: segmented communication 'works better' than non-segmented and the presence of 'biased' information does not matter so much.

- Issue: perhaps our representation of biased information is too 'delicate'.