An Experiment on Network Density and Sequential Learning

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Main Question

Q: do people learn better from their peers when there are more social connections?

Model and Contributions

Sequential Social Learning: people take turns guessing an unknown state, after observing a private signal and some predecessors' guesses

This paper: an experiment comparing learning outcomes when people have many social observations (dense network) and few social observations (sparse network)

Results:

- Social learning is **worse** with more social observations
- Accuracy gain from social learning twice as large on sparse network vs. dense network
- Matches predictions of a naive learning model but not rational learning model

Setup

Basic setup

- Binary state of the world $\omega \in \{L, R\}$, equally likely
- Sequence of 40 agents indexed by $i = 1, 2, 3, \ldots$, move in turn

On agent i's turn

- Observe private signal s_i
- Observe actions of some previous agents (next slide)
- Choose action $a_i \in \{L, R\}$ to match state

Setup

Gaussian private signals

- $s_i \sim \mathcal{N}(1, \sigma^2)$ when $\omega = 1$
- $s_i \sim \mathcal{N}(-1, \sigma^2)$ when $\omega = 0$
- Signals conditionally i.i.d. given ω

Network observation

- Agent i observes each predecessor with probability q
- Each network either sparse ($q = \frac{1}{4}$) or dense ($q = \frac{3}{4}$)
- Compare average guess accuracy on sparse and dense networks

Logistics

Subjects

- Experiment done on Amazon Mechanical Turk, 1040 subjects
- Must pass a three-question comprehension check
- Each plays 10 games with same density in same position
- Subjects know network-generating process
- $0.25 per correct guess, plus $0.25 completion fee. Average: $2.08 for less than 10 min

Logistics

Signals and accuracy

- Private signal $\sim \mathcal{N}(-1, 4)$ in state L, and $\sim \mathcal{N}(1, 4)$ in state R
- Can have accuracy 69% from using private signal alone
- $\tilde{y}_j$ — fraction of last 8 agents who guess correctly in game j

Dataset: 260 games, half with each density. Regress across games

$$\tilde{y}_j = \beta_0 + \beta_1 q_j + \epsilon_j$$

The experiment — including sample size, measure of long run accuracy, and statistical analysis — was pre-registered prior to data collection on the AsPredicted registry.

Results

Accuracy gain from social learning:

- In dense networks, last 8 agents guess correctly 5.7% more often than if they had no social observations
- This accuracy gain is 12.6% in sparse networks, more than twice as large (p-value 0.0239)
- This comparative static is consistent with our naive-learning model (in 3 slides) but not with the rational-learning model

Results

	Dependent variable:
	FractionCorrect
NetworkDensity	−0.092**
	(0.041)
Constant	0.802***
	(0.022)
Observations	260
R^2	0.020
Adjusted R^2	0.016
Residual Std. Error	0.164 (df = 258)
F Statistic	5.166** (df = 1; 258)
Note:	*p<0.1; **p<0.05; ***p<0.01

Results

Source of this difference in accuracy:

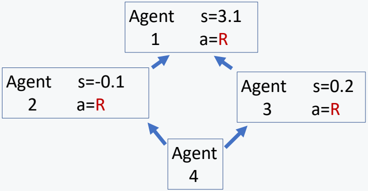
- Agent goes against signal if guess L with a positive signal or guess R with a negative signal
- Among agents in the last 8 positions, 138 instances of this in sparse networks, 136 instances in dense networks
- Accuracy conditional on going against signal:
  - 82% in sparse networks
  - 71% in dense networks
- So difference in accuracy driven by differential effectiveness of social learning on networks of different densities

Proposed Mechanism: Inferential Naiveté

Inferential naiveté

- Agents wrongly believe predecessors' actions only reflect their private info, not their observations of still others (Eyster and Rabin, 2010)
- i observes $(a_j)_{j \in N_i}$ and thinks $a_j = \mathbb{P}[\omega = 1 \mid s_j]$ for each $j \in N_i$
- Agents are Bayesians except for this mistake

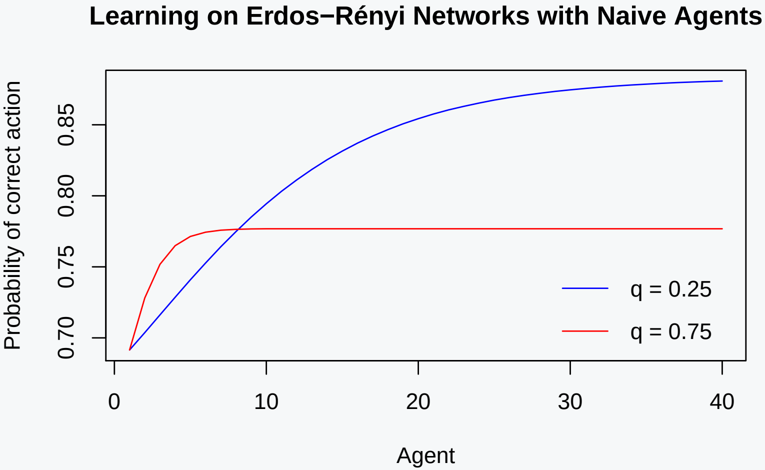
Proposed Mechanism: Inferential Naiveté



Overcounting

- Under inferential naiveté, early agents' private signals are overcounted
- This overcounting is more severe on denser networks
- So later agents' guesses will be less accurate in denser networks (shown theoretically in Dasaratha and He, 2020)

Predictions under Inferential Naiveté



Predictions for Rational Agents

Rational Agents

- Results of Acemoglu, Dahleh, Lobel, and Ozdaglar (2011) imply asymptotic learning of state regardless of q
- Is 40 agents enough for this limit?
- Using technique similar to Lobel and Sadler (2015)'s neighborhood choice function, can compute explicit lower bound on the accuracy of rational agents
- This lower bound is 97% for 33rd agent on dense network — so sparse network cannot improve accuracy much, if at all

Conclusion

- Conducted an experiment testing how network density affects social learning outcomes
- Found social learning is more effective on sparser networks
- Provides evidence for a naive model of updating

Thank you!