Communication and the emergence of a unidimensional world

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May 2023

A multidimensional world

- Individuals have opinions on myriads of issues,

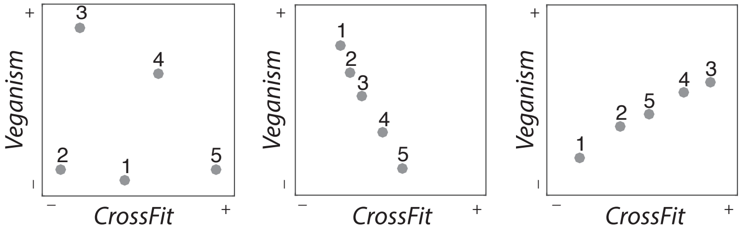
  $\rightarrow$ spanning domains such as politics, the economy or lifestyle.

- An a priori multidimensional world

  $\rightarrow$ as many dimensions as issues to have an opinion on.

- Often enough to use a unidimensional spectrum to describe opinions on all dimensions.

Fixing ideas



1. Unidimensionality
2. Relative positions
3. Direction of Disagreement

Unidimensional worlds are out there...

Majority of formal political economy models consider unidimensional space *(Downs 1957, Black 1958)*

Empirically relevant:

→ Voting patterns of US legislators can be explained by their ideology in a single dimension *(Poole and Rosenthal 1991, 1997)*.

→ Strong correlations between voters' opinions on different issues; aggr. opinions predict voting behavior *(Ansolabehere et al. 2008)*

→ Political and ideological cleavages spillover to preferences over leisure activities, consumption and art *(DellaPosta et al. 2015):*

...More motivation

2004 TV ad of Club for Growth Political Action Committee

"Howard Dean should take his tax-hiking, government-expanding, latte-drinking, sushi-eating, Volvo-driving, New York Times-reading ..."

"... Hollywood-loving, left-wing freak show back to Vermont, where it belongs."

What may give rise to unidimensionality?

We look at a model where unidimensional worlds may arise endogenously, through communication.

Questions:

- When should one expect opinions to become unidimensional?
- How can we predict the shape of disagreement?

What we do:

- Simulations that generalise previous results on unidimensionality (De Marzo et al., 2003)
- Highlight the importance of fixed communication network in predicting shape of disagreement.
- Validate the theory empirically through a lab experiment.

Literature

Opinion Dynamics

- *De Groot (1974)* –weighted averaging, huge literature–.

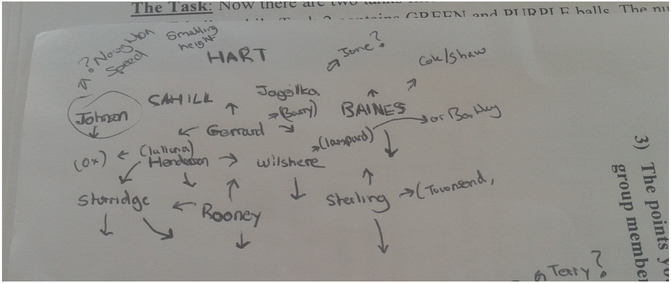
Unidimensional opinions

- *De Marzo et al. (2003)* –most closely related–
- *Spector (2000)* –cheap talk, unidimensional disagreement–
- *Poole and Rosenthal (1991)* –one dimension predicting voting–
- *McMurray (2014)* –correlated opinions, unidimensional eqm. behavior by candidates–

Experiments

- *Corazzini et at. (2012), Battiston and Stanca (2014), Brandts et al. (2015)* –all on a single dimension, focus on consensus–

Theory


The Task:
HART
CAHILL
Johnson
Gerrard
BAINES
Henderson
Wilshere
Sterling
Sturridge
Rooney
(Townsend,
Cole/Shaw
or Baines
(Lampard)
3) The points
group member

Opinion Updating (DeGroot repeated weighted averaging)

- N agents communicate repeatedly and update opinions on k issues.
- Observe noisy signals $\mathbf{s_i}(0)$ about the value of some parameter.

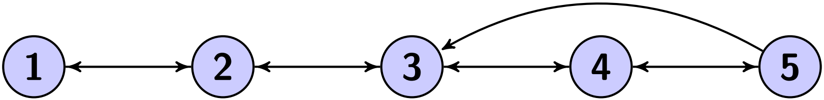
- $\mathbf{T}(t)$ models the directed weighted network of communication in period t
- $T_{i,i}(t) \in (0,1)$
- $T_{i,j}(t) \in (0,1)$ to agents she observes in t
- $T_{i,j}(t) = 0$ for all others
- $\sum_{j=1}^{N} T_{i,j}(t) = 1$.
- Same for all issues.

Opinion updating process is:

$$\mathbf{s}(t) = \mathbf{T}(t) \cdot \mathbf{s}(t-1)$$

with $\mathbf{s}(\mathbf{0})$ exogenous.

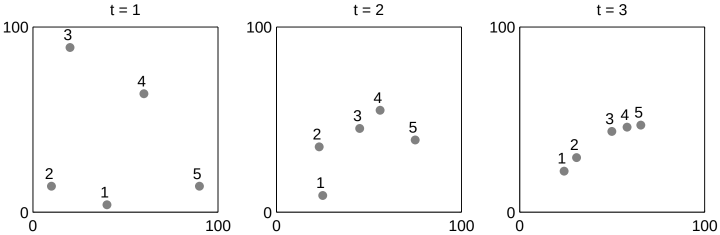
Example



- Example of a possible listening matrix:

$$T = \begin{pmatrix} 1/2 & 1/2 & 0 & 0 & 0 \\ 1/3 & 1/3 & 1/3 & 0 & 0 \\ 0 & 1/4 & 1/4 & 1/4 & 1/4 \\ 0 & 0 & 1/3 & 1/3 & 1/3 \\ 0 & 0 & 0 & 1/2 & 1/2 \end{pmatrix}$$

Prediction



Theoretical Prediction (De Marzo et. al. 2003):

1. Unidimensionality.
2. Relative positions: 1-2-3-4-5 ... Regardless of initial opinions!
3. Slope determined by initial positions and network.

Theory - Contribution

- DeMarzo, Vayanos, Zwiebel (2003) obtain their predictions assuming:

$$\mathbf{T}(\mathbf{t}) = (1 - \lambda(t))\,\mathbf{I} + \lambda(t)\mathbf{T}$$

with $\sum_{t=1}^{\infty} \lambda(t) = +\infty$

- Fixed underlying $\mathbf{T}$ crucial for all their three predictions
  $\rightarrow$ *same observed agents and same relative weights.*

- (!!!) Result holds with a general sequence of listening matrices $\mathcal{T}_t = \{\mathbf{T}(\tau)\}_{\tau=1}^{t}$
  $\rightarrow$ *possibly different observed agents and relative weights.*

Theory - Conjecture

Conjecture

Unidimensionality shall still arise often in the process described by DeMarzo, Vayanos, Zwiebel (2003) even when the listening matrix varies in each round.

- (!!!) Result holds with a broad sequence of listening matrices $\mathcal{T}_t = \{\mathbf{T}(\tau)\}_{\tau=1}^{t}$
- Regulatory conditions on the sequence of matrices.
- Network strongly connected in each period (and at the limit).
- Agents do not become stubborn quickly.

Theory - Conjecture

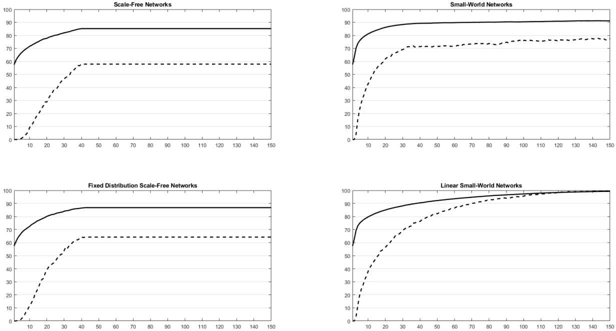


Figure: The horizontal axes measure the rounds, while the vertical axes depict percentages. Solid lines show the average $\beta^P(t)$ (in percentage terms) over the 1000 trials for each round t. Dashed lines show the percentage of trials in which $\beta^P(t)$ was larger than 85% in round t.

Theory - Conjecture

Conjecture

Predictions about the long-run relative positions of the agents, when the listening matrix is varying, are possible when adding structure to the sequence of possible listening matrices.

Theory - Conjecture

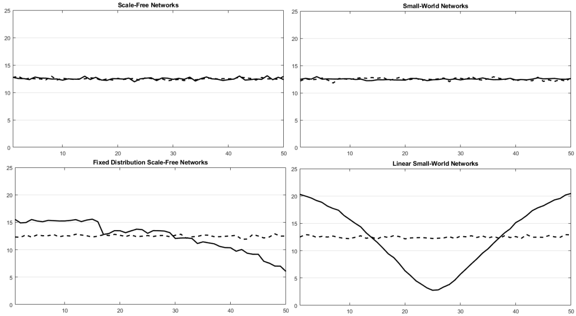
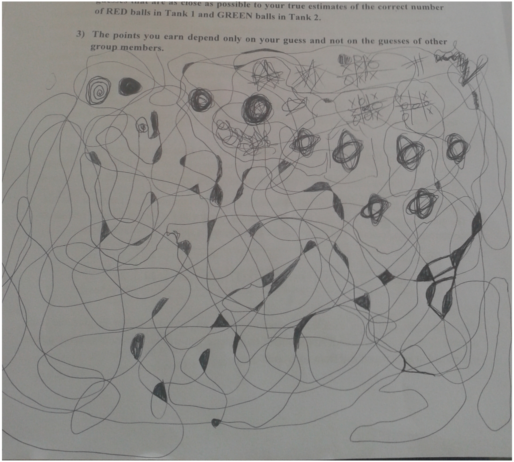


Figure: The average relative extremity of a node's opinion in the first round (dashed line) and in the last round (solid line). In FDSF networks nodes in increasing order of in-degrees. In LSWN nodes according to their position in the underlying linear network (1 leftmost, 50 rightmost). Average extremity by projecting nodes on the first PC and calculating the absolute difference between the node and the rank of the median (i.e., 25).

The Experiment



Setup

- Place: Lancaster University Management School.
- Subjects: Undergraduate students.
- Participated 180 students in 15 sessions.
- Average Payment: 7.5GBP + 3GBP participation fee.
- The experiment had three parts
  - Parts 1 and 2 make subjects familiar with the environment.
  - Part 3 (Main Task) had three identical phases
- Payment: one round (random) from each of the three phases of part 3, plus one round from each of the two previous parts.

Experimental Design

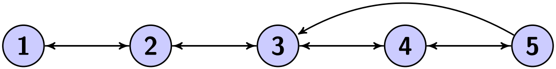
The main task:

There are two tanks with 100000 balls each:

- Tank 1 contains RED and BLUE balls. Tank 2 contains GREEN and ORANGE balls.
- The number of balls of each color in each tank is random and any combination is equally likely.
- Each subject observes a random sample of 100 balls from each tank.
- Guess the correct number of RED balls in tank 1 and of GREEN balls in tank 2. The number of RED balls in tank 1 does not depend on the number of GREEN balls in tank 2.

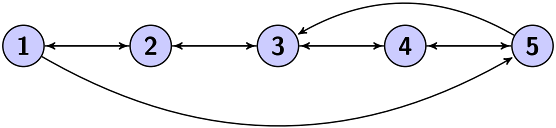
10 rounds with the same tanks: in Round 1 only your signal, in Rounds 2-10 your previous guess + guesses of some neighbours.

Treatments



12 groups X 3 phases

(a) *Fixed 1*



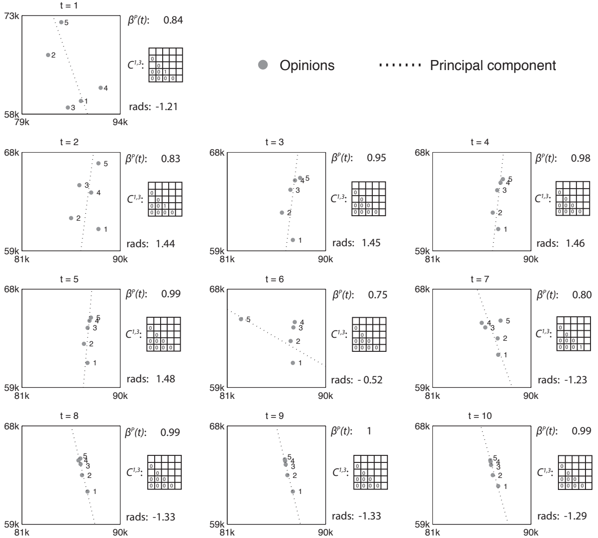
12 groups X 3 phases

(b) *Fixed 2*

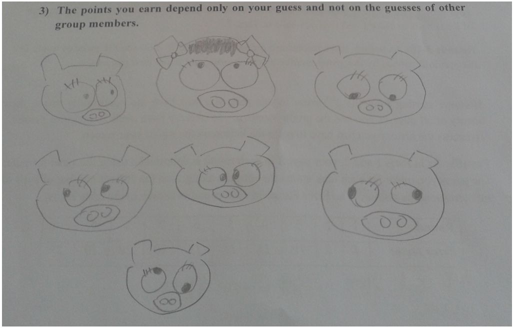
12 groups X 3 phases

(c) *Random*

One Observation



The Results


3) The points you earn depend only on your guess and not on the guesses of other group members.

Hypotheses

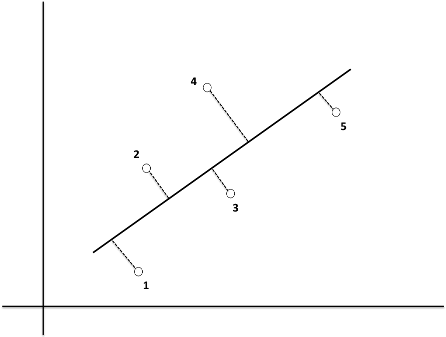
Hypothesis 1: Opinions become unidimensional in all treatments.

Hypothesis 2 (weak): Relative positions generically differ across treatments.

Hypothesis 2 (strong): Relative positions converge to predicted values.

$\rightarrow$ *Predictions depend on assumption of specific and constant weights.*
$\rightarrow$ *We test assuming equal weights to oneself and others.*

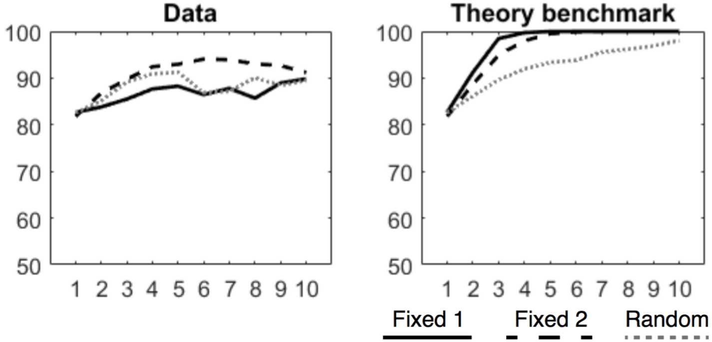
Principal component analysis



H1 (Unidimensionality): % of variance explained by 1^{st} principal component

H2 (Relative positions): projection of opinions on 1^{st} principal component

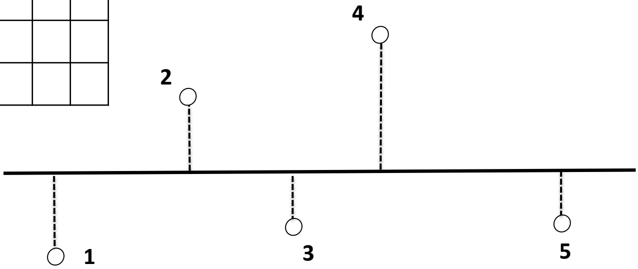
Variance explained by 1st principal component (H1)



- Non-parametric seasonal Mann-Kendall test for trend, rejects the hypothesis of no positive trend: *Fixed 1* ($p < 0.001$), in *Fixed 2* ($p < 0.001$) and in *Random* ($p = 0.002$).
- Note that the seasonal Mann Kendall test uses information from individual group observations, not just the aggregate data shown in the Figure. Furthermore, the median group has a $\beta^P(t)$ of 96.9 on average in rounds 6 to 10 in *Fixed 1*, and the same value is 90.4 for *Fixed 2* and 92.3 for *Random*.
- No significant correlation between a group's $\beta^P(0)$ and average β^P in last 5 rounds.

Relative positions (H2) - Comparison Matrix

	1	2	**3**	4	5
1			**1**		
2				1	
3	**0**				
4		0			
5					



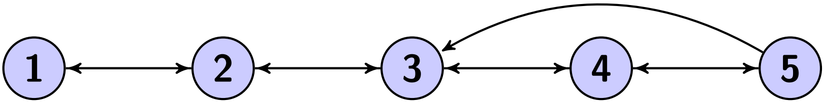
Relative positions (H2)

Hypothesis 2(weak): Convergence to different comparison matrices across treatments.

Relative positions (H2)

Hypothesis 2(strong):

- *Fixed 1*



- Listening matrix **T**:

$$\begin{pmatrix} 1/2 & 1/2 & 0 & 0 & 0 \\ 1/3 & 1/3 & 1/3 & 0 & 0 \\ 0 & 1/4 & 1/4 & 1/4 & 1/4 \\ 0 & 0 & 1/3 & 1/3 & 1/3 \\ 0 & 0 & 0 & 1/2 & 1/2 \end{pmatrix}$$

C matrix (1-2-3-4-5):

$$\hat{\mathbf{C}}^{1,3}_{\textit{fixed } 1} = \begin{pmatrix} . & . & . & . & . \\ 0 & . & . & . & . \\ . & 0 & . & . & . \\ 0 & 0 & 0 & . & . \\ 0 & 0 & 0 & 0 & . \end{pmatrix}$$

Relative positions (H2(b))

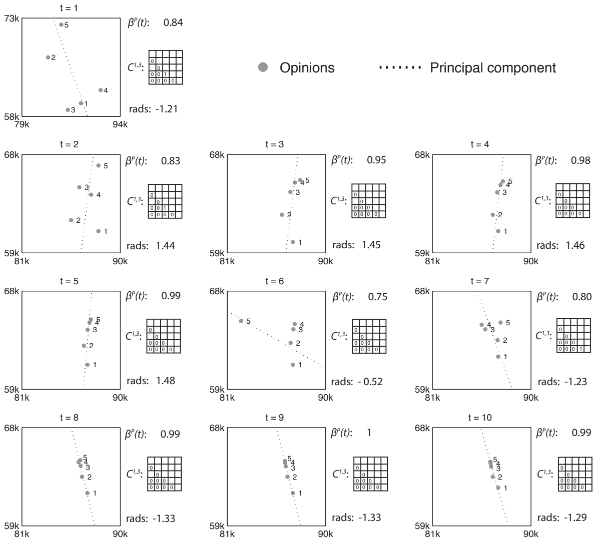
$$\hat{\mathbf{C}}^{1,3}_{fixed\ 1} = \begin{pmatrix} . & . & . & . & . \\ 0 & . & . & . & . \\ . & 0 & . & . & . \\ 0 & 0 & 0 & . & . \\ 0 & 0 & 0 & 0 & . \end{pmatrix} \qquad \hat{\mathbf{C}}^{1,3}_{fixed\ 2} = \begin{pmatrix} . & . & . & . & . \\ 0 & . & . & . & . \\ . & 0 & . & . & . \\ 0 & 0 & 0 & . & . \\ 0 & 0 & 1 & 1 & . \end{pmatrix}$$

$$E_{random}\left[\hat{\mathbf{C}}^{1,3}\right] = \begin{pmatrix} . & . & . & . & . \\ 0.18 & . & . & . & . \\ . & 0.46 & . & . & . \\ 0.18 & 0.46 & 0.55 & . & . \\ 0.21 & 0.44 & 0.45 & 0.43 & . \end{pmatrix}$$

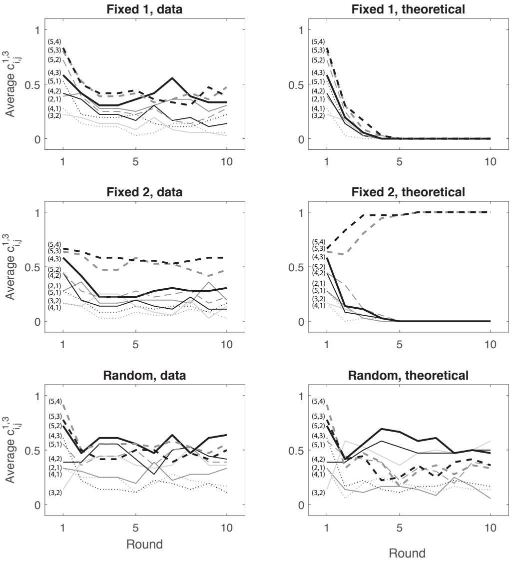
Expected order:

- Fixed 1: 1 - 2 - 3 - 4 - 5
- Fixed 2: 1 - 2 - 5 - 3 - 4
- Random: *"...random"*

Relative positions - One observation revisited



Relative positions (H2)



Relative positions (H2)

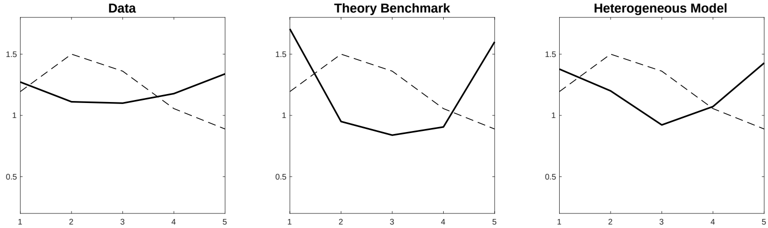


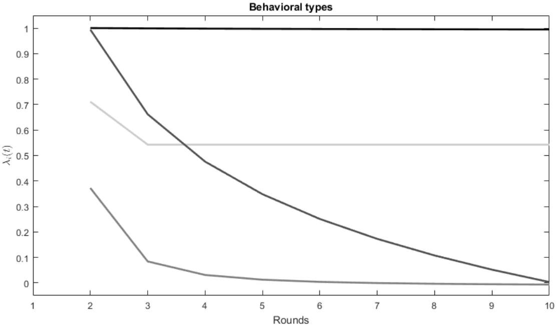
Figure: Average extremity of a node's opinion in the first round (dashed line) and in rounds 6 to 10 (solid line) in *Random* projecting opinions on the first PC and calculating the absolute difference between a node's rank, taking values from 1 to 5 and the median rank, which is 3.

1 neighbor | 2 neighbors | 3 neighbors | 2 neighbors | 1 neighbor

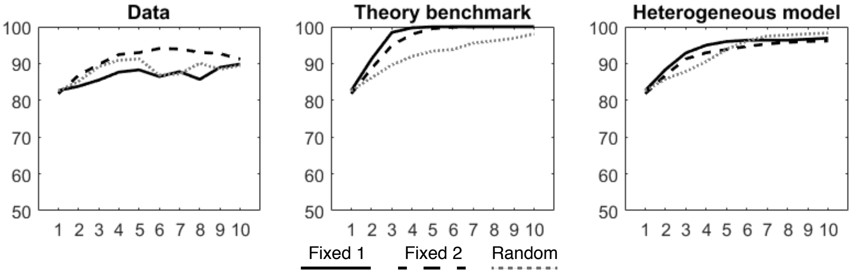
Allowing heterogeneity

$$T_{i,j}(t) = (1 - \lambda_i(t))\mathbf{1}_{i=j}(j) + \lambda_i(t)\frac{1}{|D_i(t) \cup i|}$$

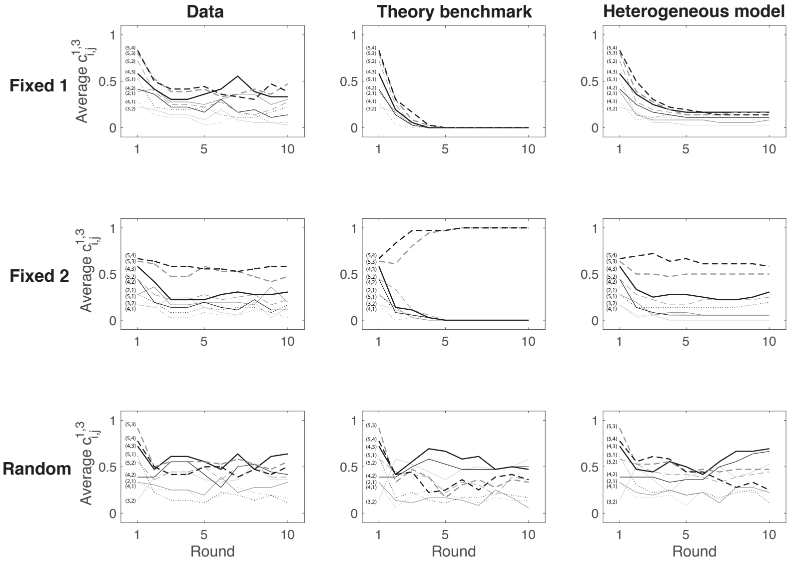
- Estimate $\lambda_i(t)$ that explains individual behavior.
- Cluster analysis: groups of subjects with similar behavior.
- Get theoretical predictions from the Heterogeneous model.



Hypothesis 1: Unidimensionality



Hypothesis 2: Relative Positions



Conclusions

1. Theory: Communication $\Longrightarrow$ Unidimensionality!

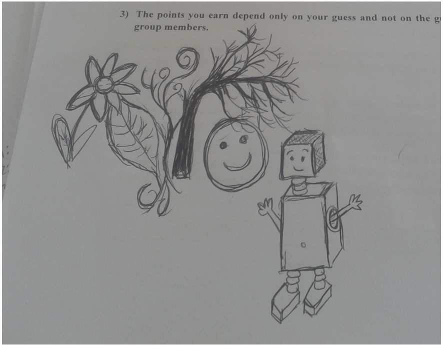
   $\rightarrow$ *And... networks are important!*

   - *... but do people put same weight on both issues?*
   - *... and what about networks endogenously formed?*

2. Experiment: Communication $\Longrightarrow$ Unidimensionality!

   $\rightarrow$ *And... networks are important! But so is heterogeneity!*

Thank you!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