Modeling the effects of social influence on individual estimates over simple estimation tasks

(Initial results)

Presenter: Mohammad S. Jalali

Dr. Hazhir Rahmandad

Ilka Deluque

Isabel Bignon

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Introduction

The present study examines individual's mechanisms of revising estimates in presence and absence of social influence.

We base our modeling and estimation work on data of an experiment by (Lorenz, Rauhut, Schweitzer, & Helbing, 2011) where each individual, in 12 groups of 12 people, makes five estimates for six factual questions.

Our question: how social influence impacts wisdom of crowds?

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Aggregation of individual estimates

The average of multiple estimates from different individuals is more accurate than average of multiple estimates from one individual [1].

Surowiecki in his book, *the Wisdom of Crowds*, suggests that the results of aggregating individual estimates are superior to even those provided by the best individuals [2].

In fact, research shows that averaging ensures that the result has lower variability, lower random error, lower systematic error, and converges towards the true forecast [3].

[1] Herzog & Hertwig, 2009; Hogarth, 1978; Larrick & Soll, 2006; Lee, Zhang, & Shi, 2011; Rauhut & Lorenz, 2011; Soll & Larrick, 2009; Wright & Rowe, 2011; Yaniv, 2004a, 2004b

[2] Surowiecki, 2004

[3] see: Bonaccio & Dalal, 2006; Herzog & Hertwig, 2009; Hourihan & Benjamin, 2010

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Aggregation of individual estimates

Although early scientists did not trust averaging [4], recent research shows that averaging increases the accuracy because different individuals' estimates often bracket the true value and thus averaging yields a smaller error than randomly choosing one estimate [5].

Even if estimates do not bracket the truth, average would be as accurate as a random estimate [6].

[4] Soll & Mannes, 2011

[5] Herzog & Hertwig, 2009; Hogarth, 1978; Larrick & Soll, 2006; Lee, Zhang, & Shi, 2011; Rauhut & Lorenz, 2011; Soll & Larrick, 2009; Wright & Rowe, 2011; Yaniv, 2004a, 2004b

[6] Herzog & Hertwig, 2009; Larrick & Soll, 2006; Soll & Larrick, 2009; Soll & Mannes, 2011

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When wisdom of crowd doesn't work

Although some believe that information exchange improves individual estimates (e.g., Farrell, 2011), but social influence through information exchange can diminish independency of estimates [7].

Consequently, when the group is under social influence, the wisdom of crowd may not properly work to increase the accuracy, because of [8]:

1) diminishing the diversity of the group without improvements in accuracy

2) close clustering around a wrong value

3) boosting individual's confidence in their estimates without collective improvements in accuracy

[7] Rauhut, et al., 2011

[8] Lorenz, et al., 2011

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Research questions

How individuals' estimates are influenced by their previous estimates and the group influence?

Are the confidence levels that individuals declare the real confidence they have when they are making estimates?

How the Wisdom of Crowds effect is impacted by the social influence?

Contents:

Experiment [8]

12 Groups x 12 Subjects/group = 144 Subjects

Each subject makes five estimates for six factual questions

Each subject declares an initial and final confidence level (at first and fifth estimates).

Confidence level (CL) is measured in a scale from 1 to 6, where the maximum CL is 6.

		One Group				
		Subjects				
		1	2	3	….	12
Q1		**Estimate 1**				
		Estimate 2				
		Estimate 3				
		Estimate 4				
		Estimate 5				
Q2		**Estimate 1**				
		Estimate 2				
		Estimate 3				
		Estimate 4				
		Estimate 5				
⋮		⋮				
Q6		**Estimate 1**				
		Estimate 2				
		Estimate 3				
		Estimate 4				
		Estimate 5				

[8] Lorenz, et al., 2011

Contents:

Experiment [8]

Questions were asked in three different scenarios (two questions for each scenario):

1) no information provided (No info)
2) group average provided (Aggregated info)
3) all group's estimates provided (Full info)

	1	2	3	4	5	6	7	8	9	10	11	12
no info	Q1	Q5	Q3	Q4	Q2	Q6	Q1	Q5	Q3	Q4	Q2	Q6
no info	Q4	Q2	Q6	Q1	Q5	Q3	Q4	Q2	Q6	Q1	Q5	Q3
aggregated info	Q2	Q6	Q1	Q5	Q3	Q4	Q2	Q6	Q1	Q5	Q3	Q4
aggregated info	Q5	Q3	Q4	Q2	Q6	Q1	Q5	Q3	Q4	Q2	Q6	Q1
full info	Q3	Q4	Q2	Q6	Q1	Q5	Q3	Q4	Q2	Q6	Q1	Q5
full info	Q6	Q1	Q5	Q3	Q4	Q2	Q6	Q1	Q5	Q3	Q4	Q2

Table is extracted from Lorenz, et. al, 2011

Participants are undergraduate students. They respond questions in independent computers (different cubicles, no debate allowed).

There is monetary reward for accuracy in responses.

[8] Lorenz, et al., 2011

Contents:

Experiment [8]

Experiment questions:

1. What is the population density in Switzerland in inhabitants per square kilometer?
2. What is the length of the border between Switzerland and Italy in kilometers?
3. How many more inhabitants did Zurich gain in 2006?
4. How many murders were officially registered in Switzerland in 2006?
5. How many rapes were officially registered in Switzerland in 2006?
6. How many assaults were officially registered in Switzerland in 2006?

The questions were designed in such a way that individuals were not likely to know the exact answer, but could still have some clue [8].

[8] Lorenz, et al., 2011

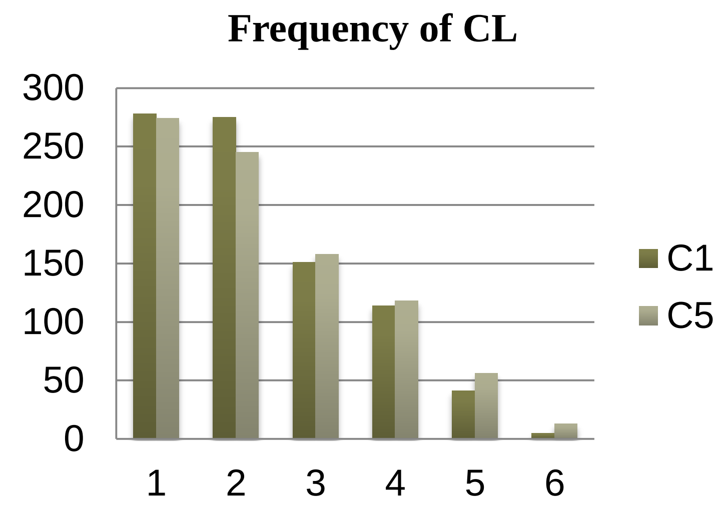
Contents:

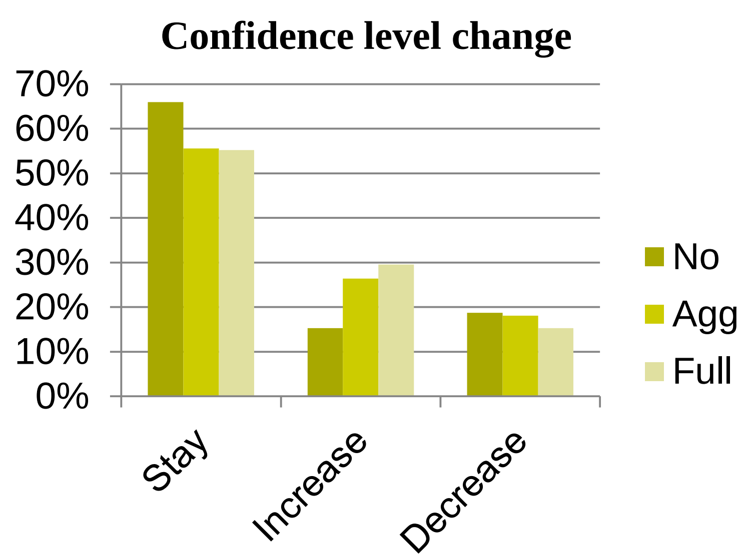
Data Analysis
Confidence level

For both CLs at times 1 and 5, around 60% of the subjects declare a CL of 1 or 2.

In all three scenarios, more than 50% of the respondents did not change their CL from the first to the last estimate.

90% of the subjects, who changed their CL, went up or down one level.





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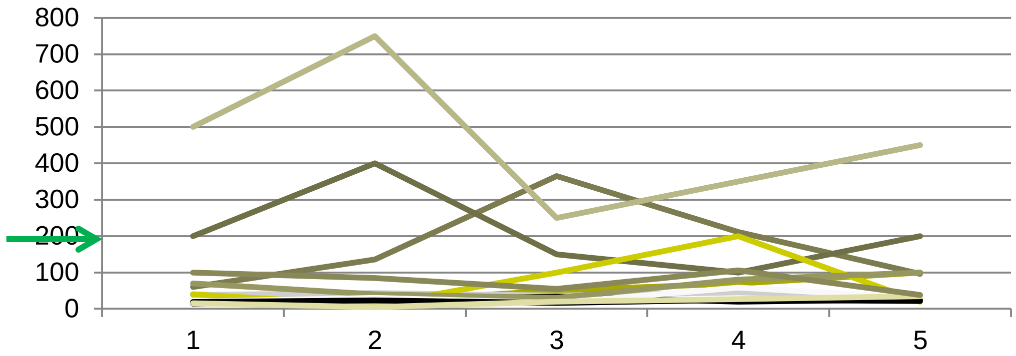
Data Analysis

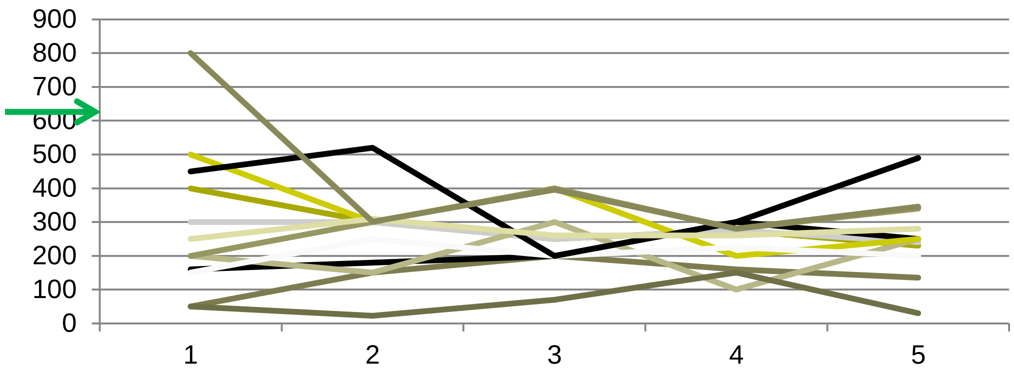
Some examples of bracketing



No info

Group 7, Question 4
correct answer = 198

Bracketing in all rounds



Aggregated info

Group 7, Question 5
correct answer = 639

Bracketing only in the 1st round

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Wisdom of Crowds Metric

We define a Wisdom of Crowds metric (WOC):

$$WOC = \frac{{}^{1}/_{I}\sum_{i=1}^{I}|ES_i - TR| - \left| {}^{1}/_{I}\sum_{i=1}^{I} ES_i - TR \right|}{{}^{1}/_{I}\sum_{i=1}^{I}|ES_i - TR|}$$

Where,

I: Number of Individuals per group

i: Individual

ES: Estimate

TR: Truth

$${}^{1}/_{I}\sum_{i=1}^{I}|ES_i - TR| \neq 0$$

Note:

$$0 \leq WOC \leq 1 \qquad WOC = \begin{cases} 0 & \text{when there is no bracketing} \\ 1 & \text{when average of group equals the truth} \end{cases}$$

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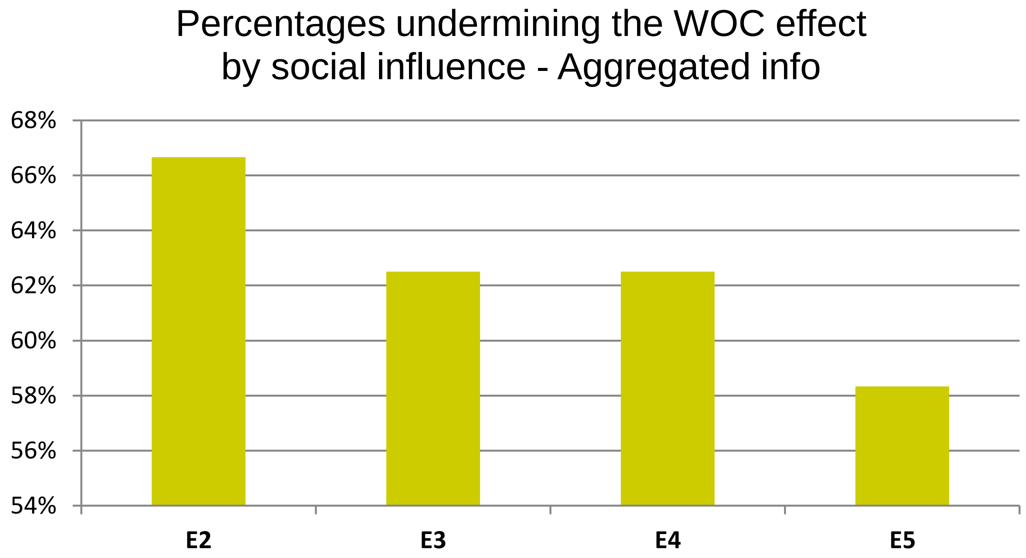
Wisdom of Crowds Metric

In the aggregated info scenario, there is no social influence effect at the first round. Hence, other rounds which are affected by the social influence are compared with the first round.



Note: In the graph Ei is compared with E1.

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Modeling – No Info

Key Hypotheses

People change their estimates depending on the previous estimates and some random variations.

The higher the initial confidence level the less variation will be observed in the estimates.

Two alternative scenarios are modeled.

1) Estimates are generated anchoring on the initial estimate.
2) Estimates are generated anchoring on all previous estimates (a weighted average of those).

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Modeling – No info

1st Scenario

Estimated Next Estimates (*ENE)* are generated based on the initial estimate and some variations (*V).*

$$ENE_i^{(r)} = ES_i^{(1)} V_i^{(r)}$$

i: Individual *(r): Round (r^th^ estimate)*

$V_i^{(1)}$ is generated using a log-normal random number:

(to simplify the equations (*r*) is not shown)

Vi = EXP($Mean_i$ + $St.dev_i$* RANDOM NORMAL(-6,6,0,1,seed))

Where,

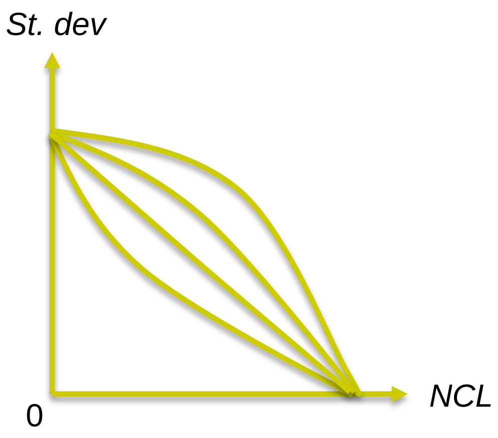
$$St.dev_i = \gamma_1(\beta_1 + (1 - NCL_i^{\alpha_1})(1 - \beta_1)$$

$$NCL_i = \frac{(CL_i - 1)}{5}$$

$\alpha_1 > 0$

$0 < \beta_1 < 1$

$0 < \gamma_1$



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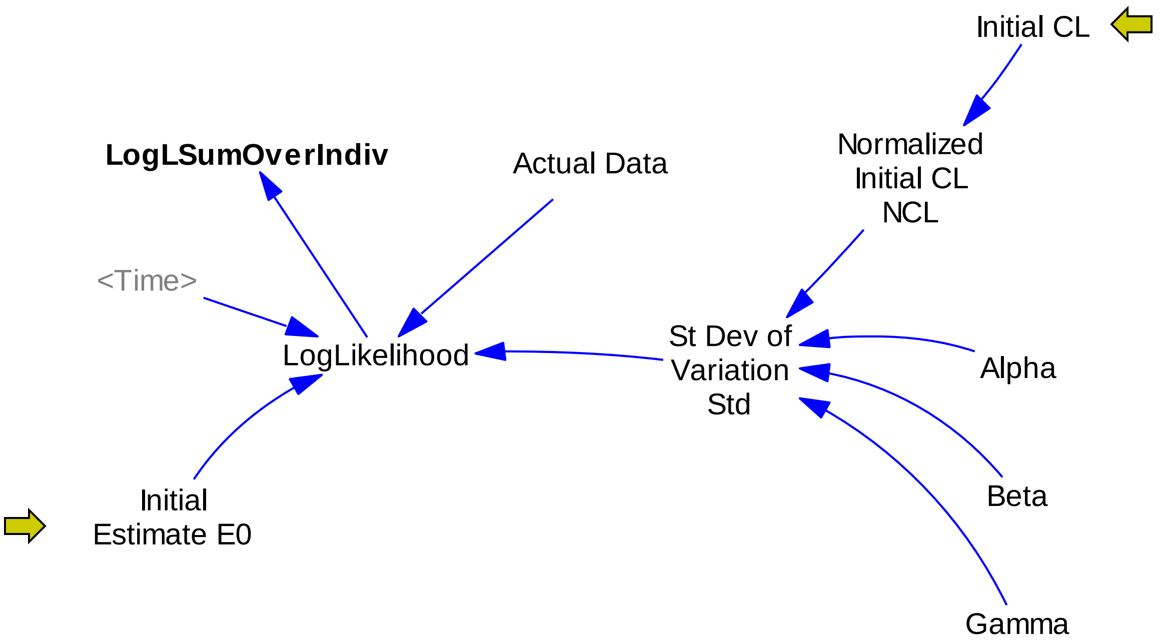
Modeling – No info

1st Scenario

Estimation Model Structure:



Contents:

Modeling – No info
1st Scenario

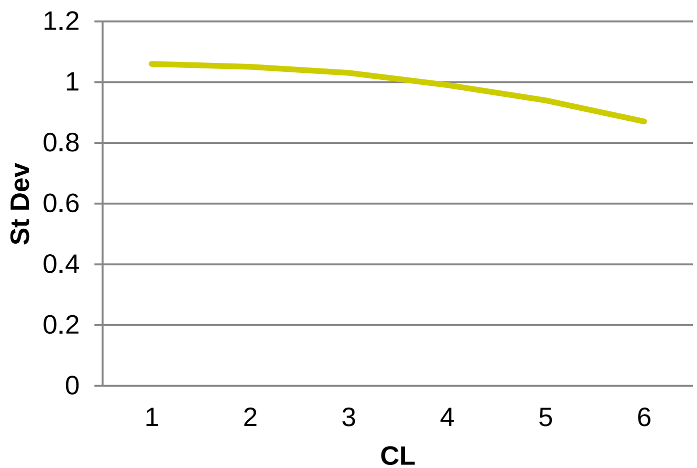
Maximum Likelihood is used to estimate parameters.

Parameter estimation results:

Parameter	Optimum value	95% Confidence Interval
α	2.09	<= α <= 2.0911
β	0.82	0.6340<= β <= 0.9546
γ	1.06	1.0556 <= γ <= 1.0718

Hence:

CL	St. Dev. of LogNormal Distribution
1	1.06
2	1.05
3	1.03
4	0.99
5	0.94
6	0.87



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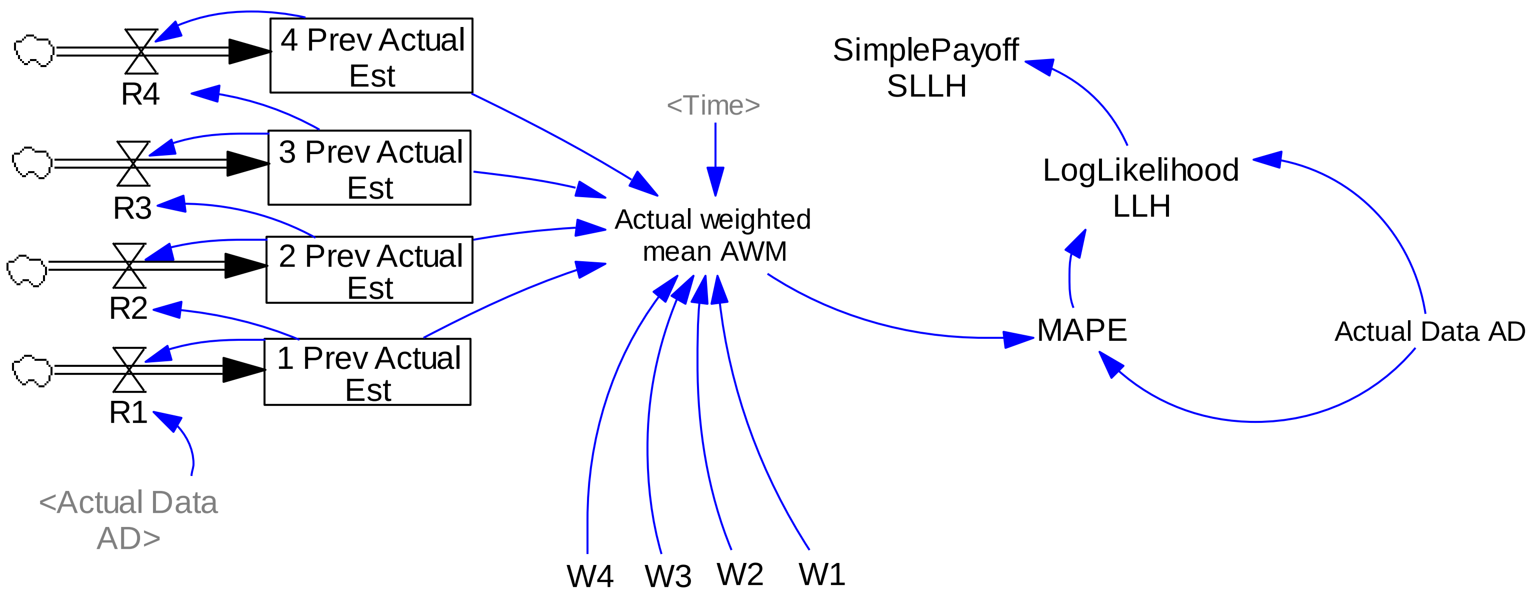
Modeling – No info

2nd Scenario

Estimation Model Structure:



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Modeling – No info

2nd Scenario

Estimates are generated based on all previous estimates.

$$E^*(t) = \begin{cases} E0\,, & time = 1 \\ \frac{E0*W1}{W1}\,, & time = 2 \\ \frac{E0*W2+1P*W1}{W2+W1}\,, & time = 3 \\ \frac{E0*W3+2P*W2+1P*W1}{W1+W2+W3}, & time = 4 \\ \frac{E0*W4+3P*W3+2P*W2+1P*W1}{W1+W2+W3+W4}, & time = 5 \\ 0, & otherwise \end{cases}$$

E* is a linear combination of previous estimates changing over time. It depends on the weights assigned to the estimates at different rounds, i.e., W1, W2, W3, and W4.

Parameter estimation results:

Parameter	Optimum value	95% Confidence interval
W1	1 (fixed)	W1= 1
W2	0.33	0.2666 <= W2 <= 0.3970
W3	0	W3= 0
W4	0	W4 = 0

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Modeling – Aggregated info

The main idea is that individuals make estimates based on the followings:

1) A weighted average of their own estimates (E*), as same as E* in the second scenario of the No info model
2) Group average

Individuals also consider the group average based on two parameters:

1) Degree of compliance
2) Threshold (T), e.g. they do not take into account the group average when it is T times bigger/smaller than their own estimate.

If an individual makes a very large/small estimate, that estimate bias the group average significantly; therefore, in the next round most individuals would not use that average as any kind of anchor and they will likely ignore it.

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Modeling – Aggregated info

The model runs for 144 individuals simultaneously for 2 aggregated questions

Database structure:

			1st aggregated question					2nd aggregated question					
	Subjects	**Truth**	**E1**	**E2**	**E3**	**E4**	**E5**	**E1**	**E2**	**E3**	**E4**	**E5**	**Truth**
Group 1	S1	734	350	302	320	346	334	98	302	400	258	260	639
	S2	734	50	180	150	210	250	50	180	230	110	300	639
	S3	734	500	400	350	300	370	3000	2000	1000	1500	2500	639
	S4	734	100	200	300	300	300	300	500	600	400	450	639
	S5	734	320	280	260	301	340	95	260	400	310	500	639
	S6	734	240	210	300	284	314	50	1500	576	974	210	639
	S7	734	300	330	350	370	270	50	100	180	250	300	639
	S8	734	1200	700	800	450	320	456	520	980	620	1100	639
	S9	734	164	270	450	320	290	725	634	695	812	518	639
	S10	734	30	100	200	60	150	100	441	550	50	200	639
	S11	734	190	550	450	620	420	365	450	660	590	750	639
	S12	734	120	250	270	360	340	10	30	30	60	60	639
Group 2	S1	10067	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	9272
	S2	10067	2600	5486	6798	4652	3620	2700	6452	5216	3260	1230	9272
	S3	10067	3	4500	2000	10000	6000	1500	9800	7650	3500	25000	9272
	S4	10067	65000	10000	11000	9015	8385	2500	3000	3500	3500	9432	9272
	S5	10067	5000	15000	12000	5000	8000	20000	15000	10000	12500	10000	9272
	S6	10067	25600	12500	11800	8600	8290	15000	10000	5319	8933	13588	9272
	S7	10067	10000	13000	8000	10000	6000	2000	5000	7000	2000	1000	9272
	S8	10067	10000	11000	9000	7500	9600	50000	10000	13001	15000	10000	9272
	S9	10067	9000	15000	12000	11000	13000	2000	13000	15000	9000	5000	9272
	S11	[illegible]0067	700	[illegible]	5000	8000	2500	10000	[illegible]000	6000	13000	[illegible]	[illegible]
	S[illegible]	[illegible]	100[illegible]	[illegible]	10000	[illegible]	[illegible]	650[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Modeling – Aggregated info

How individuals deal with group average

As noted earlier, individuals consider the group average based on DOC and T.

Five hypotheses are designed to study the effect of DOC and T.

Hypothesis 1:	Fixed *DOC* *No T*	$DOC^{(H2)}$
Hypothesis 2:	Fixed *DOC* Fixed *T*	$DOC^{(H2)}$ $T^{(H2)}$
Hypothesis 3:	Fixed *DOC* Variable *T*	$DOC^{(H3)}$ $T_i^{(H3)} = \rho^{(H3)} + \omega^{(H3)} CL_i$

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Modeling – Aggregated info

How individuals deal with group average

Hypothesis 4: Variable *DOC*
Fixed *T*

$$DOC_i{}^{(H4)} = \gamma_2{}^{(H4)}(\beta_2{}^{(H4)} + (1 - CL_i{}^{\alpha_2{}^{(H4)}})(1 - \beta_2{}^{(H4)}))$$

$$T^{(H4)}$$

Hypothesis 5: Variable *DOC*
Variable *T*

$$DOC_i{}^{(H5)} = \gamma_2{}^{(H5)}(\beta_2{}^{(H5)} + (1 - CL_i{}^{\alpha_2{}^{(H5)}})(1 - \beta_2{}^{(H5)}))$$

$$T_i{}^{(H5)} = \rho^{(H5)} + \omega^{(H5)} CL_i$$

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Modeling – Aggregated info
How individuals deal with group average

Five models are designed to find errors and variances for each hypothesis.

The results of F-test analysis of variances:

Comparison	Hypothesis with less variance
H. 1 vs. H. 2	H. 2
H. 2 vs. H. 3	H. 2
H. 2 vs. H. 4	H. 4
H. 3 vs. H. 4	H. 4
H. 3 vs. H. 5	H. 5
H. 4 vs. H. 5	H. 5

Therefore, hypothesis 5 is used where Threshold and Degree of Compliance are variable.

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Modeling – Aggregated info
How individuals deal with group average

Estimation results:

Parameter	Optimum value
W1	1 (Fixed)
W2	0.22
W3	0
W4	0

$$\boldsymbol{DOC_i}^{(H5)} = \boldsymbol{\gamma_2}^{(H5)}(\boldsymbol{\beta_2}^{(H5)} + (\mathbf{1} - \boldsymbol{CL_i}^{\alpha_2^{(H5)}})(\mathbf{1} - \boldsymbol{\beta_2}^{(H5)}))$$

$\alpha_2^{(H5)} = 1.25$

$\beta_2^{(H5)} = 0$

$\gamma_2^{(H5)} = 0.54$

CL	DOC	T
1	0.54	4.95
2	0.47	5.56
3	0.37	6.16
4	0.25	6.77
5	0.13	7.37
6	0.00	7.98

$$\boldsymbol{T_i}^{(H5)} = \boldsymbol{\rho}^{(H5)} + \boldsymbol{\omega}^{(H5)}\boldsymbol{CL_i}$$

$\rho^{(H5)} = 4.95$

$\omega^{(H5)} = 3.03$

Contents:

Discussions

Answers to research questions

How people weight their previous estimates in forming new estimates?

In no info and aggregated info models, individuals use only one previous and two previous estimate to generate new estimates, where two previous estimate has lower weight.

How important is the first estimate to make the final estimate?

The initial estimate has no influence on the final estimate in no info and aggregated info models. This is not consistent with some research, such as Mannes (2009) that found participants place too much weight on their initial beliefs.

Contents:

Discussions
Answers to research questions

How do individuals include estimates of others in their next estimate?

They consider two variables, threshold and degree of compliance, as functions of confidence level.

Do individuals have any threshold to ignore the group average if it is farther from their own estimate?

Yes, individuals have a threshold, in average, about 6.5 to consider the group average. This is in accordance with Yaniv's study (2007) that participants selectively weight the opinions that are close to their own, while ignoring those that are distant from their own prior opinion.

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Discussions

Answers to research questions

Lorenz et. al note that the wisdom of crowd effect is valuable for society, but using it multiple times creates collective overconfidence in possibly false beliefs; however, Lorenz et al. do not quite prove it. Accordingly, how the Wisdom of Crowds effect is undermined by the social influence?

Our WOC metric confirms that the social effect undermines the wisdom of crowds but it does not confirm that if wisdom of crowds is used multiple times it creates collective overconfidence and the results become worse. In fact, using our WOC metric on Lorenz et. al.'s data reveals that the wisdom of crowds in the last estimate is higher than previous rounds.

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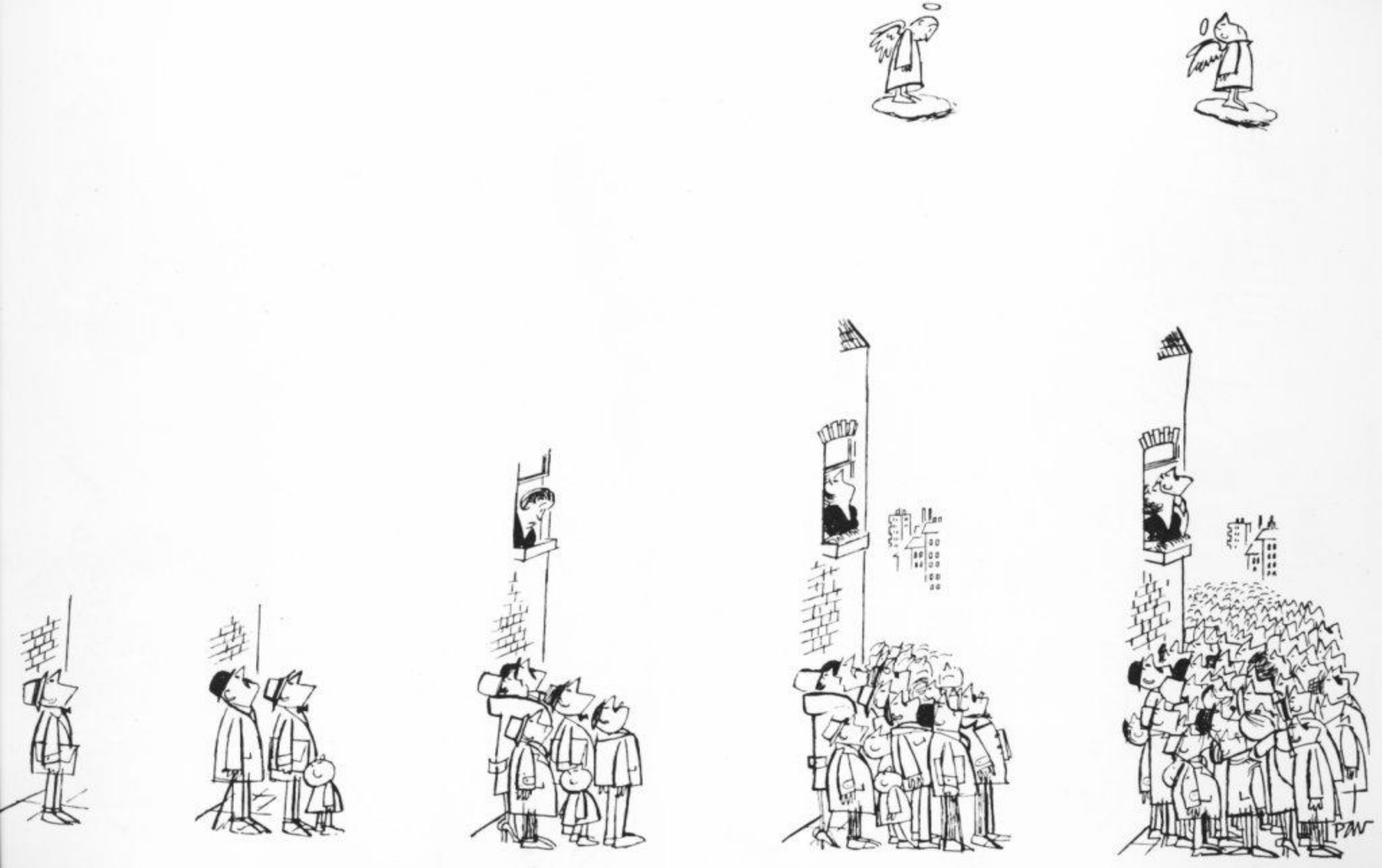
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