The fragility of opinion formation in a complex world

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A motivating experience

In 2014, a series of protests, political demonstrations, and civil insurrection began in Venezuela...

https://philosophicaldisquisitions.blogspot.com

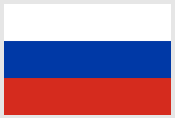
A motivating experience

In 2014, a series of protests, political demonstrations, and civil insurrection began in Venezuela...

Venezuela's government should address the people's legitimate grievances...

Asked all deaths and reports of abuses by the government security forces to be investigated...

We must respect the right to peaceful protest...



We trust that the government of President Maduro will preserve the constitutional order...

President of Syria Bashar al-Assad expressed his support in a letter to President Maduro,...

`https://en.wikipedia.org/wiki/Reactions_to_the_2014-2017_Venezuelan_protests`

A motivating experience

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Question #1:

Should we trust

Maduro's government?

A motivating experience

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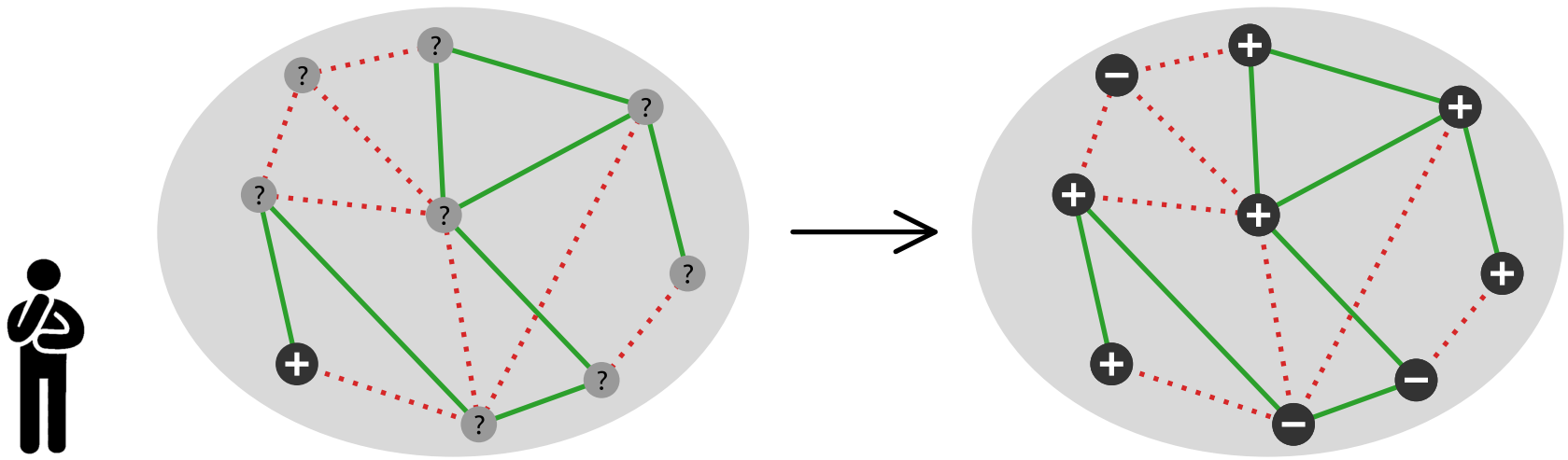
Question #2:

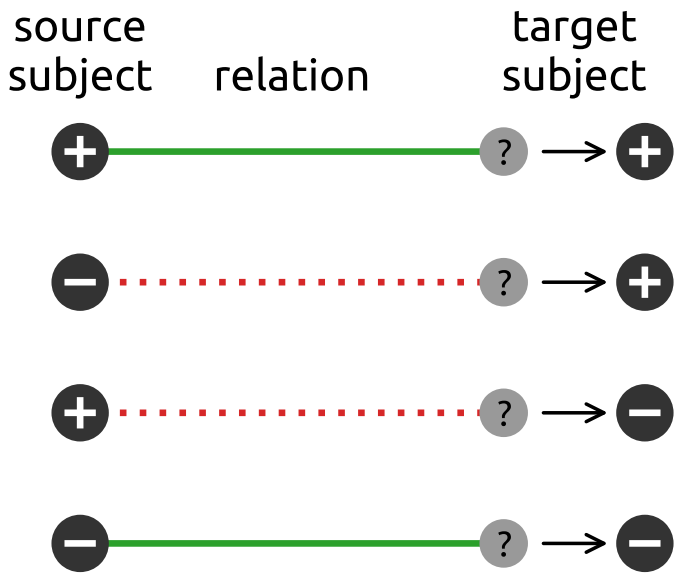
What happens when we generalize from this single occassion to a whole learning process?

Abstract model



- The observer: outside, no social network
- Nodes: subjects on which opinions are to be made
  - Countries and other entities in world politics
  - Information and misinformation sources
  - Employees of a company
  - ...
- Links: signed relations between the subjects

Opinion formation process



- Cognitively simple (average Joe can do it)
- Based on the social balance theory (Heider, 1946)

Opinion formation process

1. Choose target subject t without an opinion at random
2. From neighbors of t:
   - n_{pos} signal positive opinion on t
   - n_{neg} signal negative opinion on t
3. If $n_{pos} = 0$ and $n_{neg} = 0$, go to step 1
4. Two model variants:
   - Probabilistic: Adopt the signal from a random neighbor
   - Majority: Adopt the majority signal
5. Go to step 1

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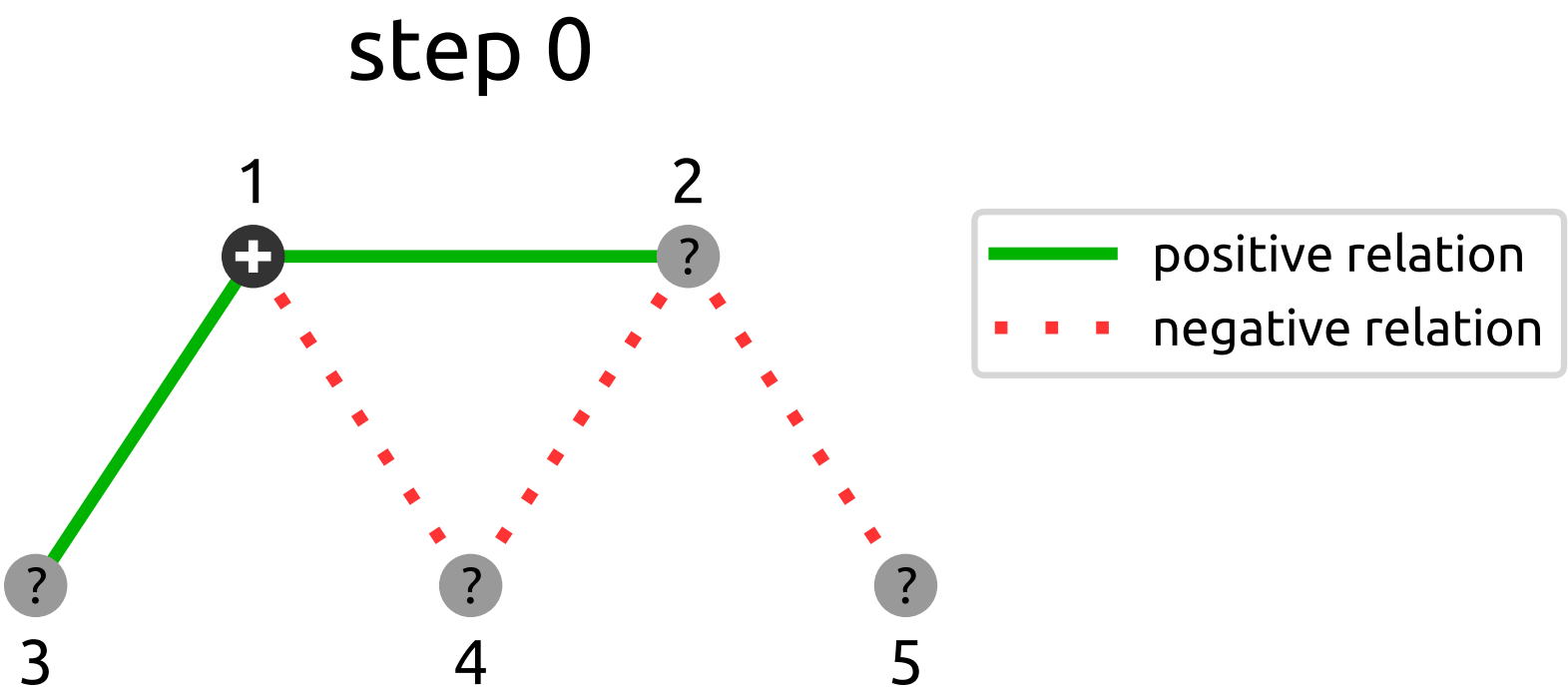

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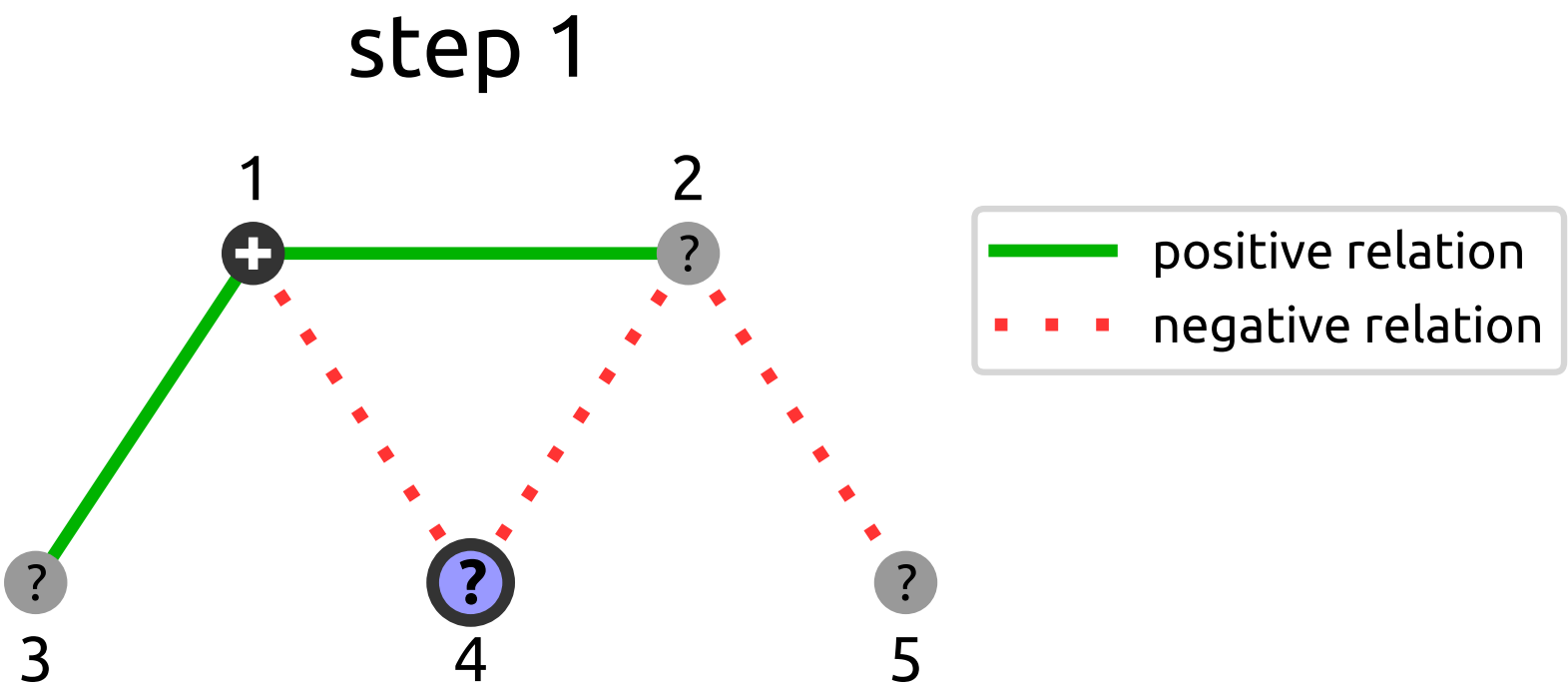

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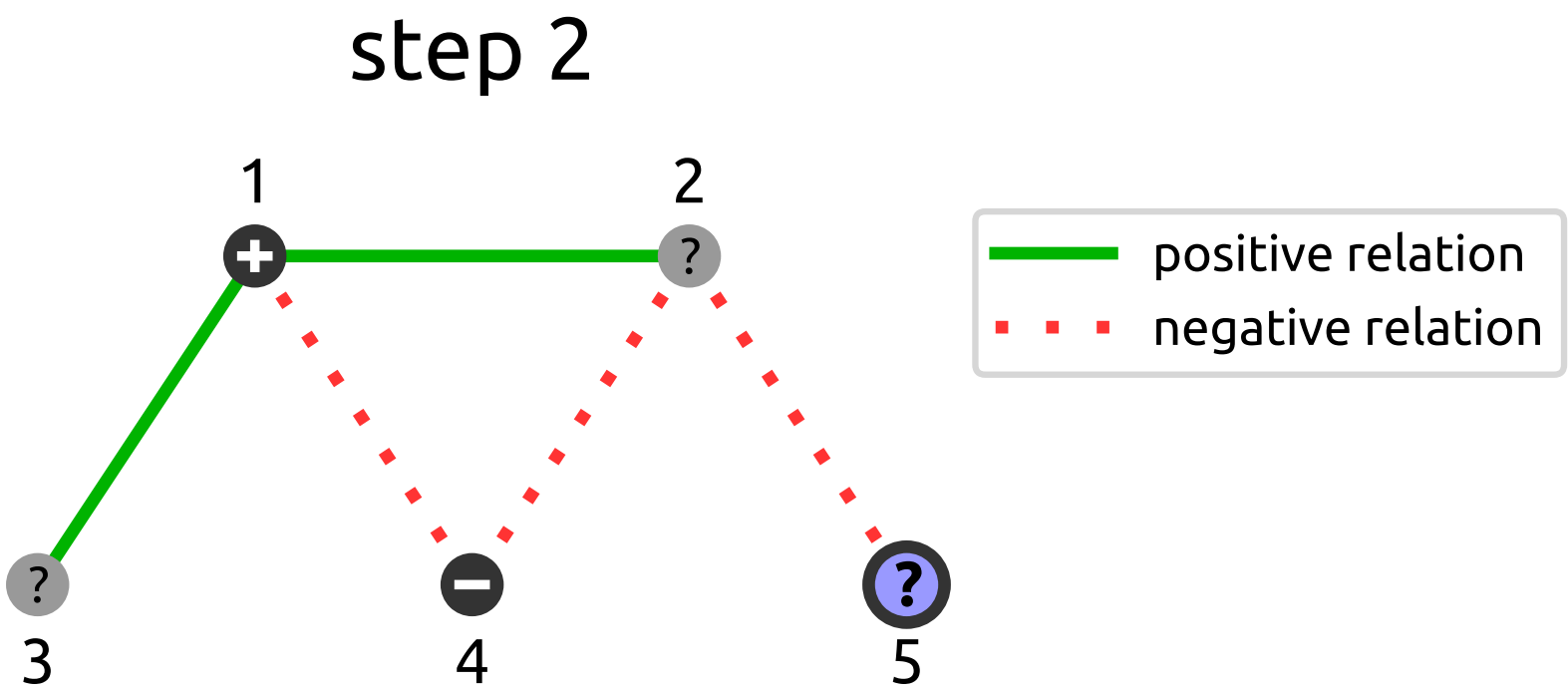

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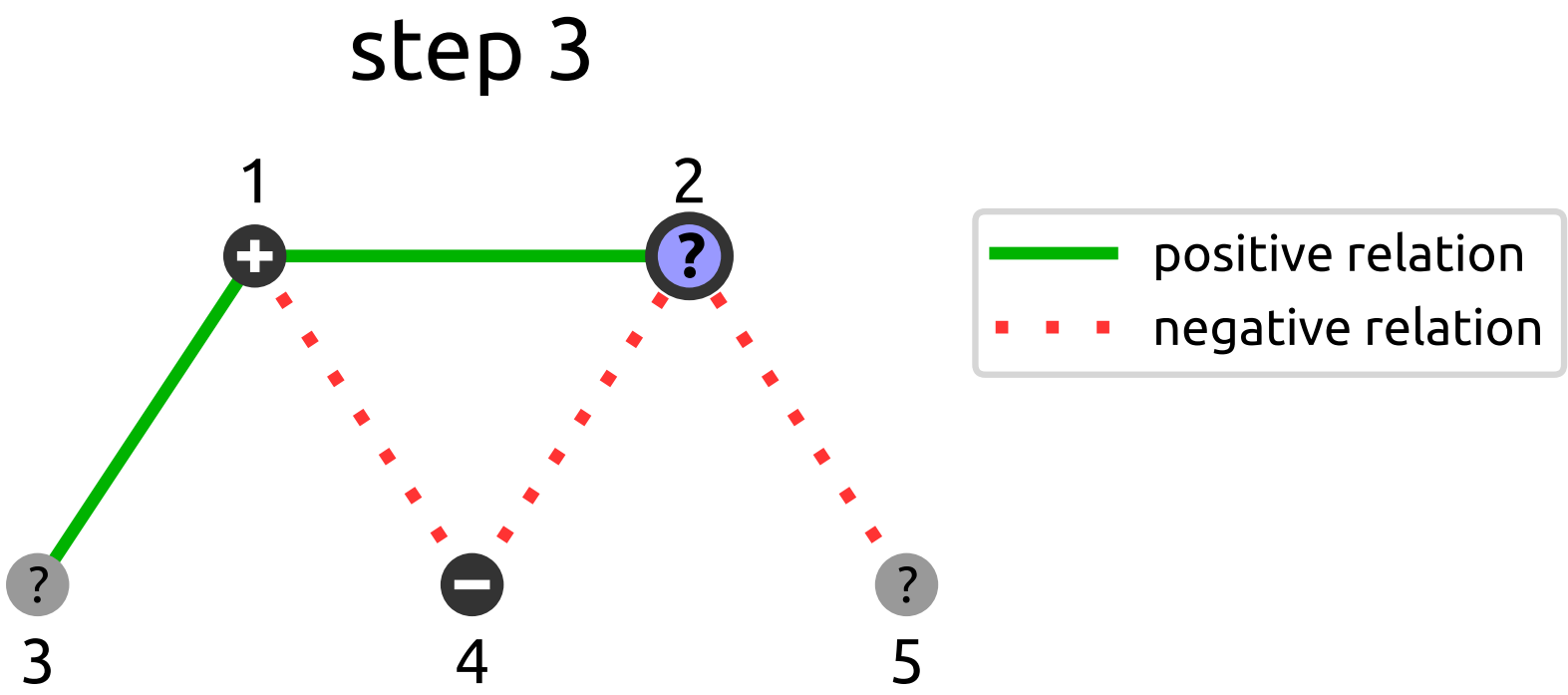

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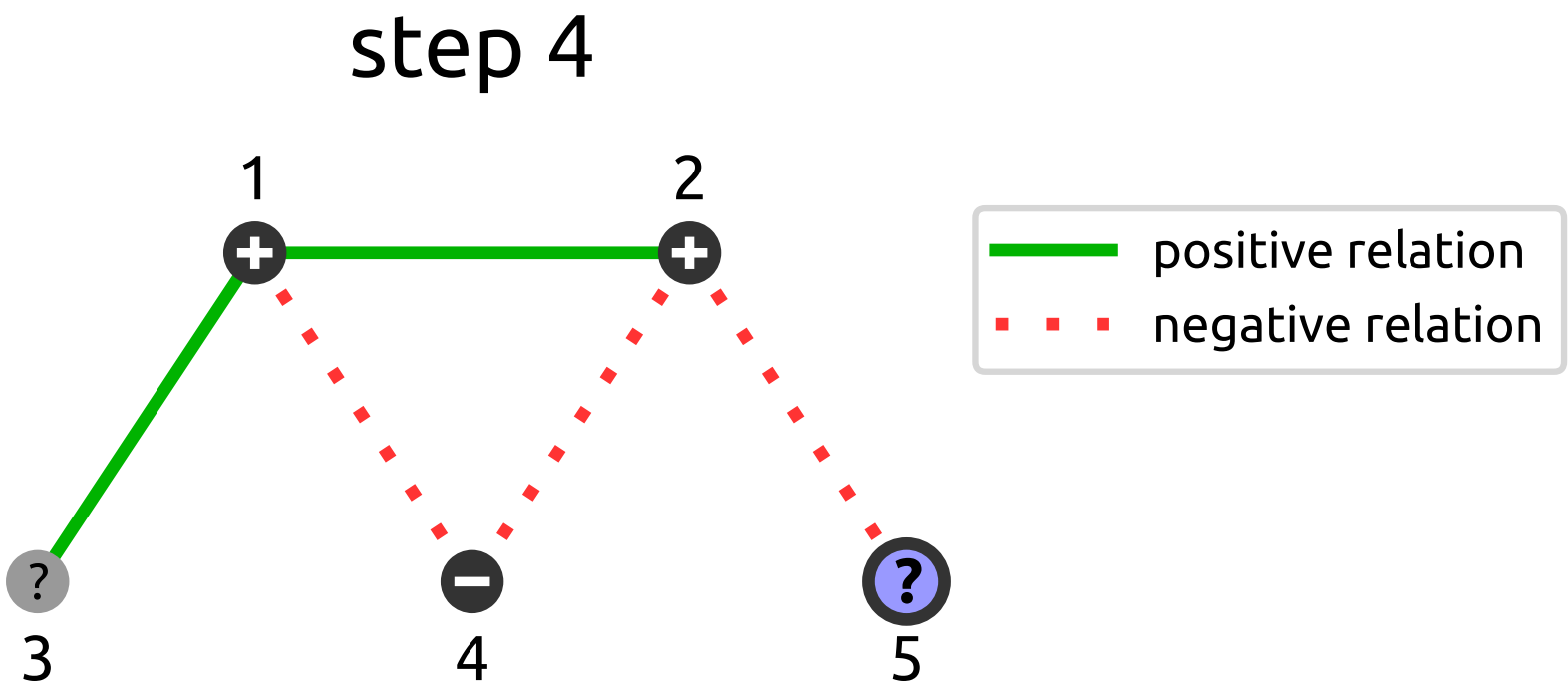


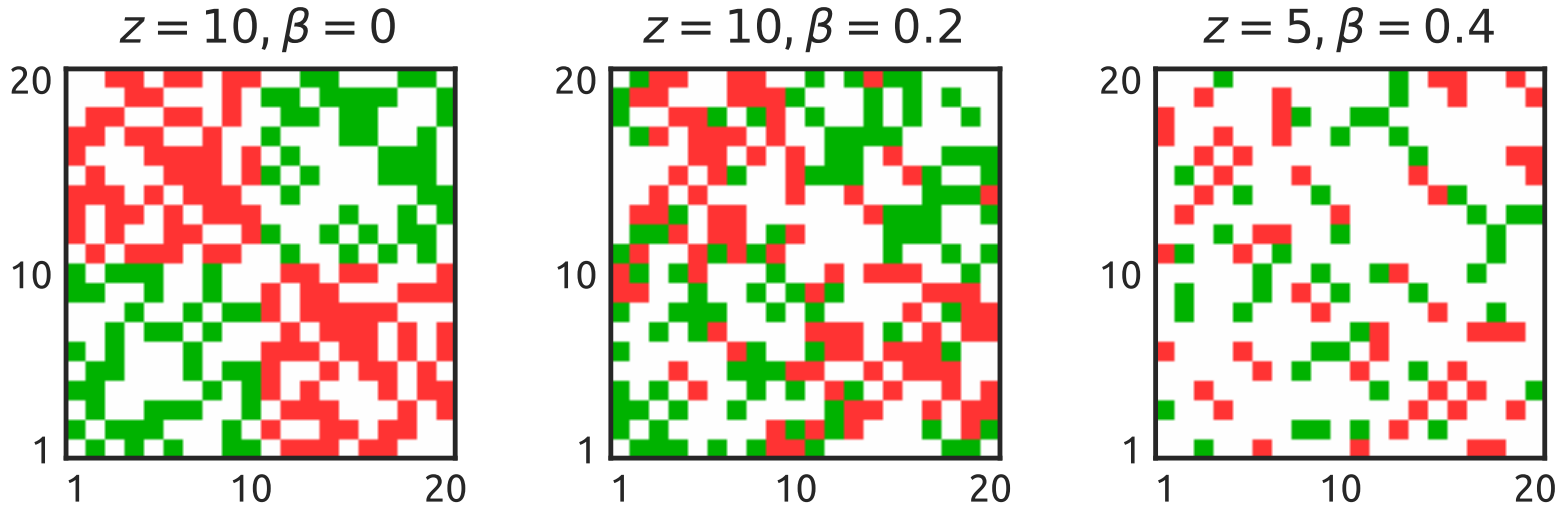
Opinion formation process

Again: No social interactions

Gracie Williams/KANSAN

Setting up a synthetic signed network

- N subjects divided in two opposing camps
- Random network with mean degree z
- Links inside a camp are positive
- Links between the camps are negative
- Noise: we invert each link with probability β



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- To measure that, we introduce opinion consistency

$$C := \frac{1}{N-1} \sum_{i \neq s} o_i T_i$$

where $T_i = 1$ for $i = \{1, \ldots, N/2\}$ and $T_i = -1$ otherwise

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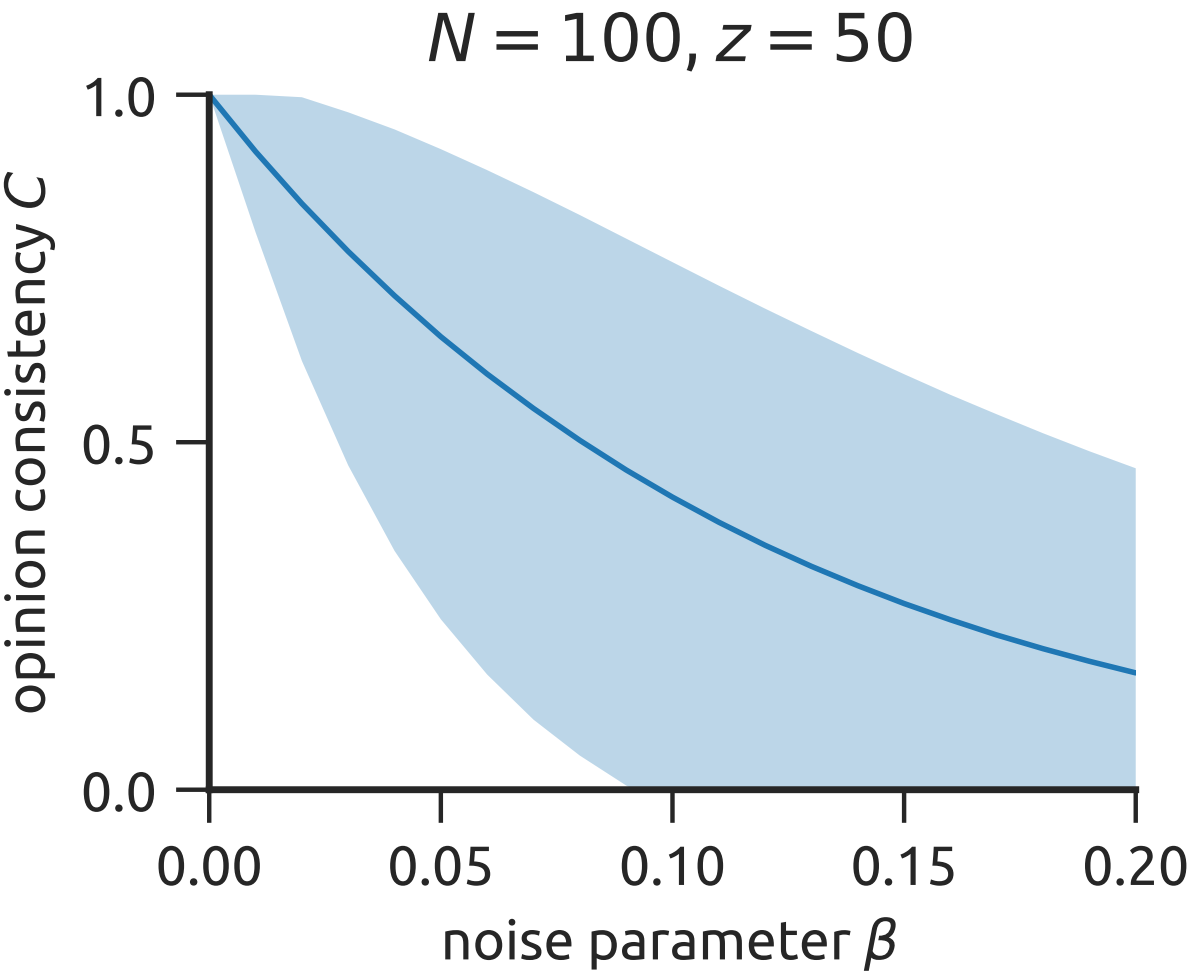
  - Opinions in line with the two-camp structure: $C = 1$
  - Random opinions: $C = 0$

Consistency in the two-camp scenario



Shaded areas: 10th–90th percentile consistency range

Master equation solution

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$$P(c;n) = P(c-1;n-1)\,\frac{c(1-2\beta)+\beta(n+1)-1}{n-1} + P(c;n-1)\left[1-\beta-\frac{c(1-2\beta)}{n-1}\right]$$

$$\Downarrow$$

$$\mu_C(N) = \ldots$$

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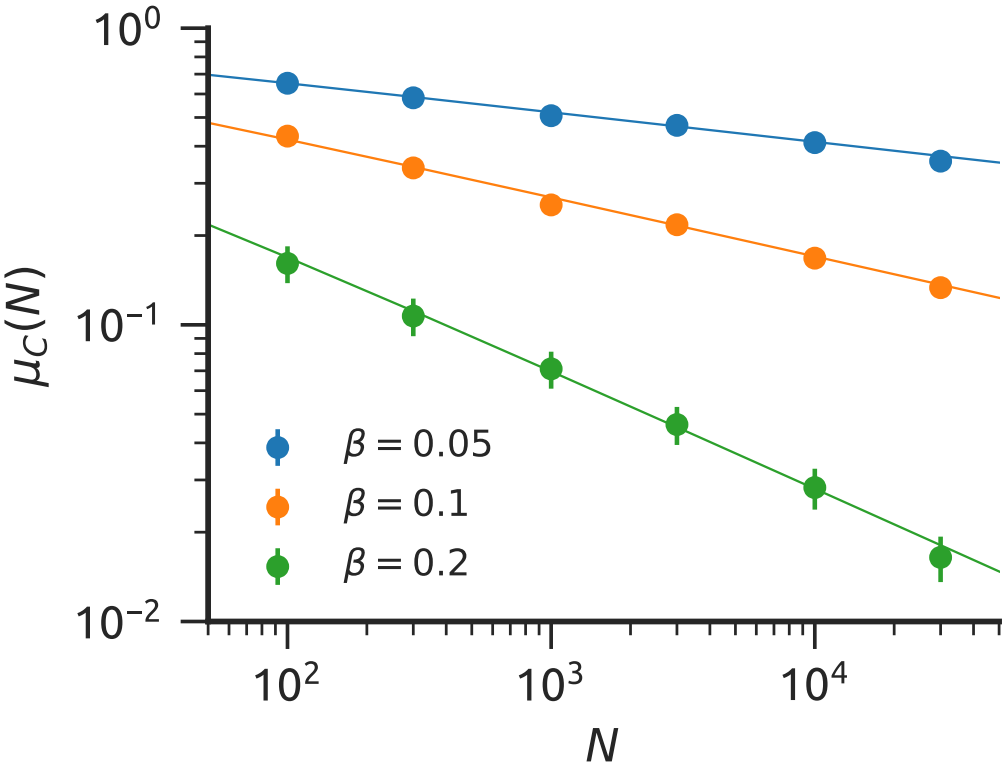

slope: -2β (for $\beta \leq 1/4$)

Lesson #1

Even at small noise,
resulting opinions show
high inconsistency and variability

Lesson #2

As the system size grows,
limit opinion consistency is zero
regardless of how small the noise is

To make sense
of a complex world
is difficult

Further results

1. With Manuel Mariani and Linyuan Lü:
   - Vanishing consistency can be prevented by making the number of seed opinions proportional to N
   - Majority rule yields “better” opinions than probabilistic rule
   - Opinion formation can be studied also on real signed networks

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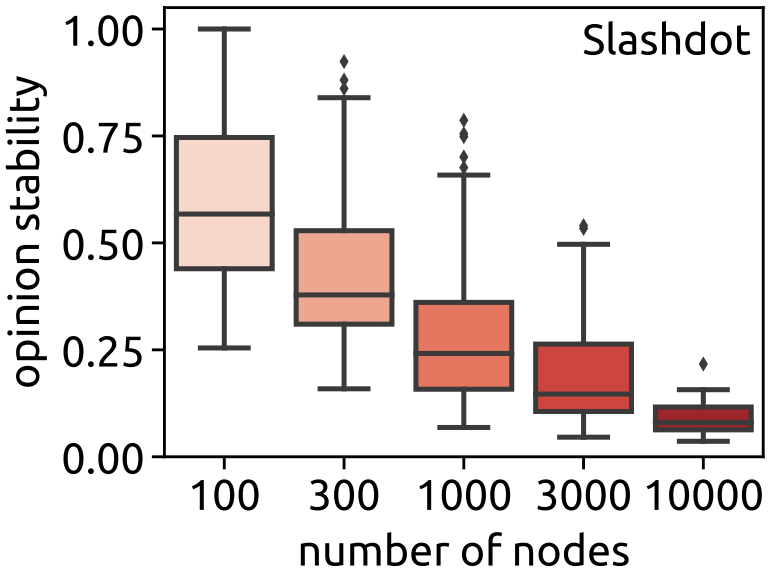

Further results

2. With Berno Buchel and Fanyun Meng:
    - Bayesian solution (summation over 2^N terms)
    - Shortest-path heuristic
    - Various network topologies

Summary

- Opinion/trust formation on a signed network
- Different from other opinion formation models (voter model, DeGroot,...)
  - One agent (observer), N subjects
- Litlle cognitively-demanding opinion formation
- Resulting opinions very sensitive to noise in the system

Further questions

1. Which rules yield consistent opinions without being excessively complicated?
2. Which opinion seeds yield the most stable opinions?
3. Which spurious links distort the results most?
4. Fuzzy subject relationships
5. Combination with social opinion-formation models
6. ...

Thank you for your attention!

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