About Opinion Hyperpolarization by Schweighofer et al. JASSS 2020

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The paper

- „Polarization is threatening the stability of democratic societies."
- Why does it happen practically automatically?
- How does it emerge from underlying principles?
- The authors developed an opinion dynamics (agent-based) model
- They have an opinion formation theory called „Weighted Balance Theory (WBT)" that „extends Heider's cognitive balance theory to encompass multiple weighted attitudes".

JASSS

A Weighted Balance Model of Opinion Hyper-polarization

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Emergence of Hyperpolarization (VIDEO)
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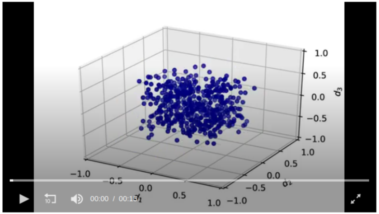
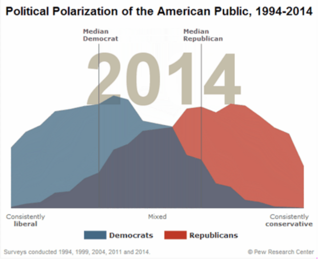


Basic concepts

- **Opinion extremeness**: how far positions are from the center
- **Issue constraint**: how positions on different issues correlate – „low issue constraint means that the positions of political actors on any one issue are independent from their positions on other issues"
- It is hard to form stable political alliances to organize collaboration
- „Thus, without issue constraint, opinion extremeness alone does not constitute polarization, but political fragmentation."
- **High issue constraint**: „a multitude of issue positions can be described by a position on a single ideological dimension with negligible loss of information." (e.g. left/right)
- **Hyperpolarization**: „the coexistence of opinion extremeness and issue constraint in a multidimensional opinion space." It is maximal if
  1. the political system is divided into two blocks, each encompassing half of the population,
  2. each of these two blocks has perfect internal consensus on all relevant issues,
  3. the blocks are in total disagreement with each other on all relevant issues
- **Assimilative influence**: individuals' opinions become more similar upon interaction
- **Backfire effect** (negative social influence, boomerang effect): interacting individuals become more dissimilar
- „Our goal is to explain the emergence of hyperpolarization from the interactions between individuals without having to assume complex social or logical structures."



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Weighted balance theory

- It is „based on the assumption that the social influence an individual j exerts on another individual i is moderated by the interpersonal attitude of i towards j (i.e., to what degree i likes or dislikes j)."
- **Balance theory**: (Heider, 1946) „attitudes can have positive or negative valence, and be directed to objects, ideas, events, or other individuals. Configurations of attitudes can be either balanced or imbalanced, and human beings strive to increase balance in their cognitive organization."
- **Application to social networks**: Structural Balance Theory by Cartwright & Harary (1956)
- Components of the model:
  - Agents: i and j ($i = 1, \dots n$)
  - Object, policy issue: d ($d = 1, \dots D$)
  - Attitude (opinion) of agent i to an issue d is $\mathbf{o}^i_d$ ($-1 < \mathbf{o}^i_d < 1$)
  - **Interpersonal attitude** of i towards j: A_{ij} ($-1 < A_{ij} < 1$)
  - Heider defines an i—j—d triad as in balance either if i has a positive attitude towards j, and i and j agree in their attitudes towards d ($\mathbf{o}^i_d$ and $\mathbf{o}^j_d$ have the same sign), or if i has a negative attitude towards j and they disagree about d ($\mathbf{o}^i_d$ and $\mathbf{o}^j_d$ have different signs).

- **Extending balance theory**: develop a rule that computes A_{ij} from $\mathbf{o}^i_d$ and $\mathbf{o}^j_d$ (opinions determine emotions). Basic requirements:
  1. „if the weight of any of the first two attitude relations in a i—j—d triad is zero, the third relation must be zero as well, in order to obtain a balanced triad. In other words, if i does not care about d either way, i will also not care about j's attitude towards d, and i's resulting attitude towards j will be neutral"
  2. „the weight of the third attitude relation should be between the weights of the first two relations"
- **Signed geometric mean**:

$$\mathrm{SGM}(x_1, \dots x_n) = \left(\prod_{i=1}^{n} \mathrm{sign}(x_i) \right) \left(\prod_{i=1}^{n} |x_i| \right)^{1/n}$$

- **Balance**: a weighted i—j—d triad is balanced if

$$B(\mathbf{o}^i_d, \mathbf{o}^j_d, A_{ij}) = 1 - \frac{1}{6} \Big(|\mathbf{o}^i_d - \mathrm{SGM}(\mathbf{o}^j_d, A_{ij})| + |\mathbf{o}^j_d - \mathrm{SGM}(\mathbf{o}^i_d, A_{ij})| + |A_{ij} - \mathrm{SGM}(\mathbf{o}^i_d, \mathbf{o}^j_d)| \Big)$$

is close to 1.

Determining interpersonal attitudes

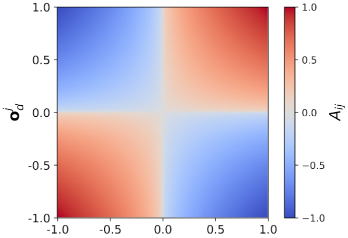
- Basically, i and j like each other ($A_{ij} \sim 1$) if their opinions toward d have the same sign and as close to 1 as possible, namely, they agree in everything.
- The interpersonal attitudes are computed as

$$A_{ij} = f\left(\overline{\mathrm{SGM}}(i,j)\right)$$

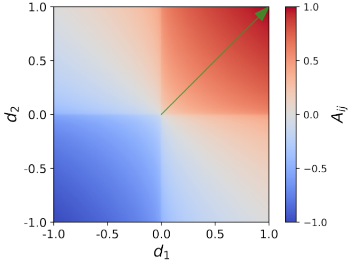
where

$$\overline{\mathrm{SGM}}(i,j) = \frac{1}{D}\sum_{d=1}^{D} \mathrm{SGM}(\mathbf{o}_d^i, \mathbf{o}_d^j)$$

is an arithmetic mean and f is a monotonous function (later).



- There is a sharp change in interpersonal attitude between the sectors of the coordinate system. This means that i is very sensitive to whether j is on the same side of all issues.
- The transition between positive and negative interpersonal attitudes happens for vectors at a 90° angle from $\mathbf{o}_d^i$.

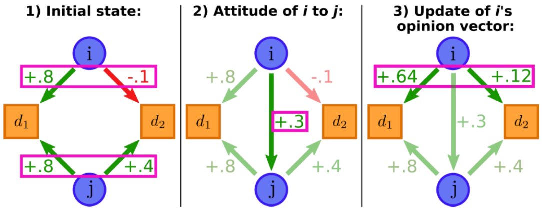


Balance maximization through opinion adjustment

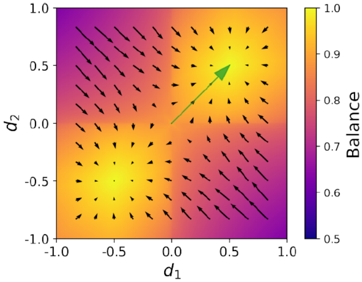
- The „driving force" of the algorithm: change opinions ($\mathbf{o}_d^i$) in a way that interpersonal relations (A_{ij}) change so that balance increases (cognitive dissonance decreases).
- The $\mathbf{o}_d^i$ vectors are changed in small steps (Eq. 5 in the paper)

$$\mathbf{b}_d^i(\text{NEW}) = \mathbf{o}_d^i(\text{OLD}) + \alpha(\mathbf{b}_d^{ij} - \mathbf{o}_d^i) + \text{noise}(z)$$

where $\mathbf{b}_d^{ij}$ is the value for the triad in balance.



- Arrows represent the resulting changes in $\mathbf{o}^i$, given an interaction between i and j. Agent j is at the green arrow.
- **Backfire effect**: „a backfire effect only occurs if $\mathbf{o}^i$ and $\mathbf{o}^j$ have a different sign in at least one dimension, and is strongest if they have different signs in both dimensions. But even in this case, the backfire effect only occurs if i is less extreme in its opinions than j."



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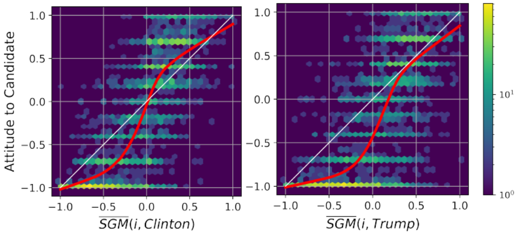
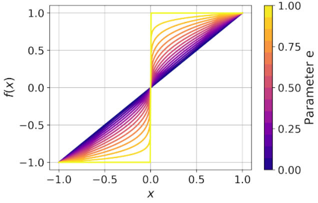
Testing the model on Hillary and Donald

- It is based on an American National Election Study (ANES). 4270 respondents were asked for their opinion on six different policy issues ranging from defense spending (increase vs decrease) to health insurance (government vs private). The respondents were also asked for their perception of the position of presidential candidates (Hillary Clinton and Donald Trump) on the same policy issues. And finally, the respondents were asked to complete two affective thermometer scale items, on which they rated their subjective feelings towards each presidential candidate.



- Choice of the f function:

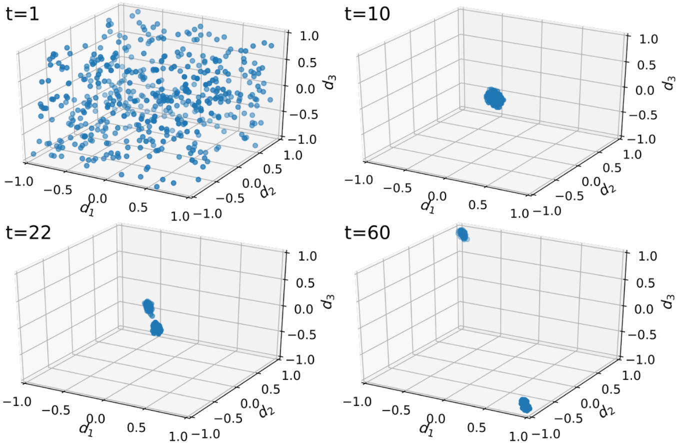
$$f(x) = \mathrm{sign}(x)|x|^{1-e}$$



- It is a sigmoid. Limiting cases: for $e = 0$ it is an identity function (straight line); for $e \to 1$ it is a step function.
- If e is larger, the curve is farther from linear, and agents like or hate Hillary/Donald more than it would follow from opinions on issues.
- **It magnifies the effect of emotions.**

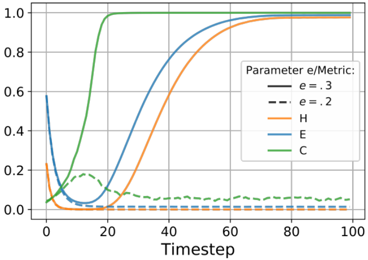
Simulation procedure

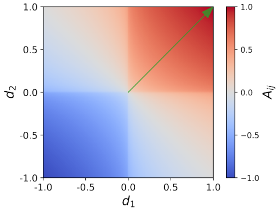
- Simulation proceeds in time steps $t = 1, \ldots T$.
- The simulation starts from a completely random configuration for $\mathbf{o}_d^i$
  1. The A_{ij} attitudes are computed
  2. A random noise (from a normal distribution) characterized by a parameter z is mixed to the process.
  3. A pair of agents i and j is selected randomly. The opinions $\mathbf{o}_d^i$ of i are changed as a result of interaction with j.
  4. We go back to #1
- Three metric numbers are computed:
  - Metric of opinion extremness: $E(\mathbf{O})$
  - Metric of issue constraint: $C(\mathbf{O})$
  - Metric of hyperpolarization containing both: $H(\mathbf{O})$
- Three parameters are changed: D, z, e
- Results for $D = 3$ to the right.



Initial collapse

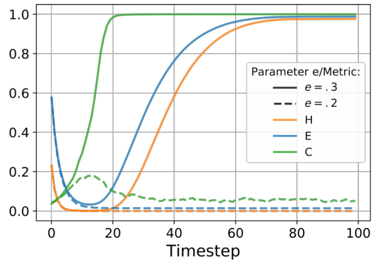
- At the beginning, all agents get clustered around the center of the opinion space.
- **Explanation**: In higher-dimensional spaces, two random vectors are much more likely to be nearly orthogonal than either aligned or opposed. If two agents' opinion vectors are orthogonal (see figure below), they have a neutral interpersonal attitude towards each other. This neutral attitude drives the opinion matrix toward the central „I am not sure/I do not care" position.
- During this process E decreases, and H with it (see solid lines in the figure to the right).
- After the agents got uniform at the center, they are ready to be polarized.

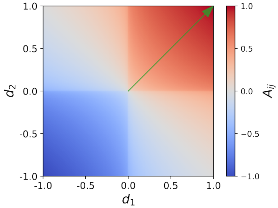




Positive feedback

- The initial decrease in extremeness (E) is accompanied by an increase of issue constraint (C).
- This increase reflects a self-organization of the agents along a single diagonal of the opinion space, in a random ideological dimension.
- The figure below illustrates the mechanism underlying this self-organization: Agents whose opinion vectors are at less than a 90° angle have a positive interpersonal relation. This motivates them to agree on even more issues, which in turn improves their relation, and so forth until the agents are perfectly aligned.
- The reverse happens if two agents are at an angle of more than 90°. Their negative relation will cause them to increase their disagreement, until their opinion vectors are diametrically opposed.





The importance of „evaluative extremeness"

- Evaluative extremeness (large e) creates a positive feedback: increase of C triggers an overreaction, a „rise of extremeness", and, thus, an increase of E.
- A first order phase transition is observed as a function of e.
- Possible origins of evaluative extremeness:
  1. „**emotional arousal** induces a tendency towards more extreme evaluations" – „The rise of 'infotainment' over the last decades has turned the induction of emotions from a side effect into the main objective of television news programs."
  2. „tendency to evaluate groups more extremely than individuals" – „increasing identification with political parties"
  3. „concept of ego involvement in Social Judgment Theory" (WTF)