CONSTRUCTOR UNIVERSITY

How **assimilative** and **idiosyncratic** attitude **change** generate **oscillations** of **public policy mood**

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Measuring, Modeling and Mitigating Opinion Polarization and Political Cleavage (MMM)
2023-09-13 @ ETH Zurich, Chair of Systems Design

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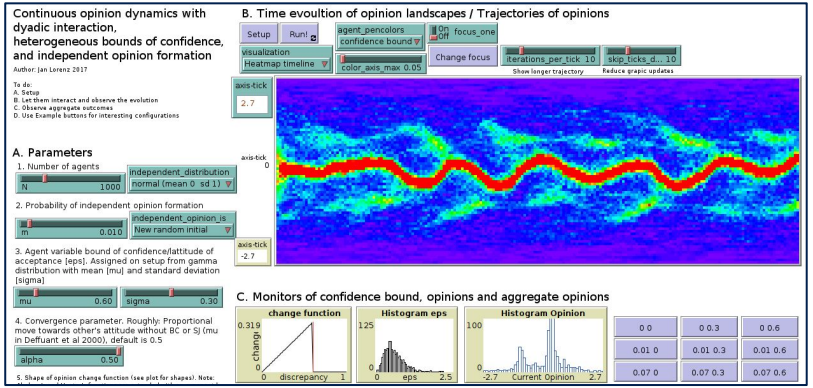
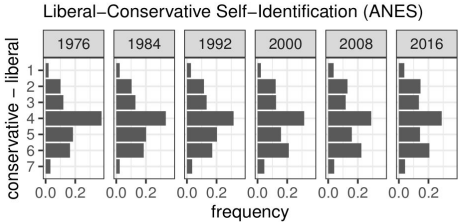
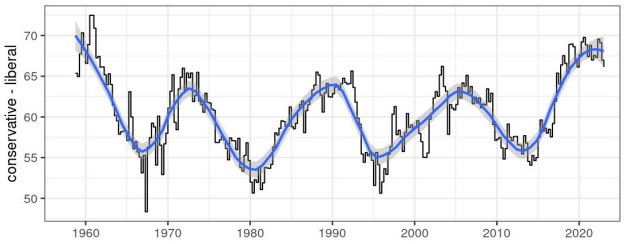
Outline

1. ~~Measuring~~ **Defining polarization**
   (for the sake of this talk)
2. **Agent-based model of opinion dynamics**
   a. under bounded confidence
   b. with idiosyncrasy/turn-over/noise
   c. with heterogeneous bounds of confidence
3. **Map it to real data**







Blue line from ggplot2::stat_smooth with loess method and span=0.2
Data from Stimson (2019)

Terminology for this talk:

opinion = attitude
bound of confidence = latitude of acceptance

This Talk within the Scope of this Workshop

General Definition: **Polarization is the Accentuation of Differences**

This talk is about

- **unidimensional**
- polarization of **attitudes**
- ranging **continuously** between extremes over moderate and neutral
- of the **general population**

Ideological alignment over multiple issues.

Issue partisanship (difference between groups / party supporters)

not about

Polarization in income, employment, or ethnicity.

Yes-No issues

Affective polarization (emotion towards other political groups)

not about

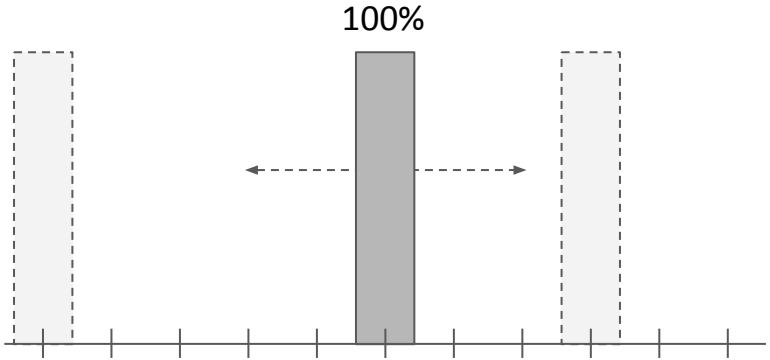
Polarization in **elites**, **party**, or **media**

Measuring one-dimensional polarization

Polarization is a measure of a distribution. On a **bounded scale** there is agreement what is minimally and maximally polarized.

Minimum (Polarization = 0)

- All have the same opinion
- Does not matter where

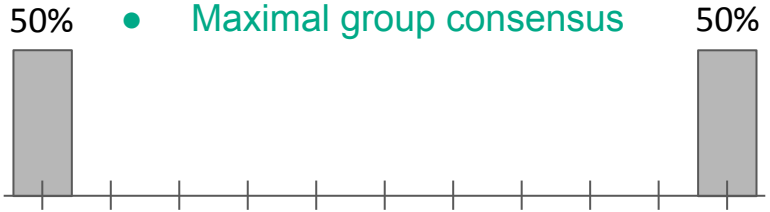


Maximum (Polarization = 1)

- One half maximally positive
- Other half maximally negative

Two groups with

- Maximal size parity
- Maximal distance between group
- Maximal group consensus

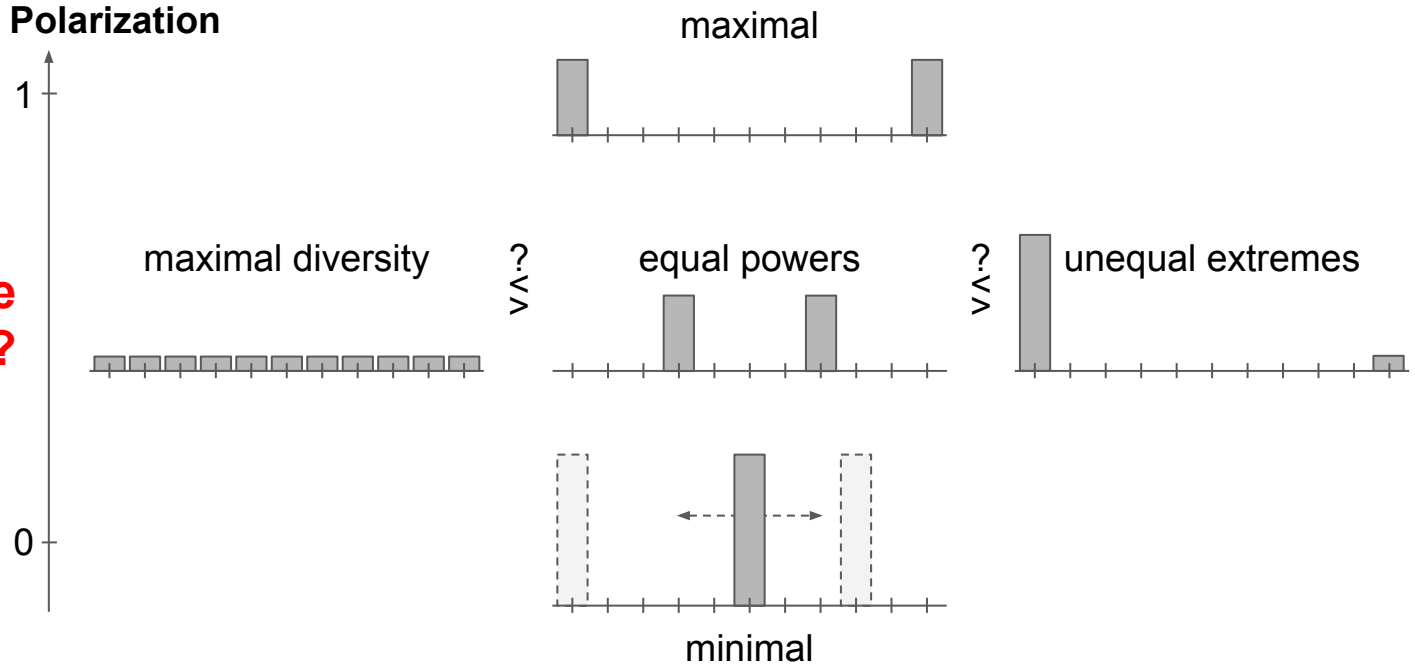


Bramson, A., Grim, P., Singer, D. J., Fisher, S., Berger, W., Sack, G., & Flocken, C. (2016). Disambiguation of social polarization concepts and measures. The Journal of Mathematical Sociology, 40(2), 80–111. https://doi.org/10.1080/0022250x.2016.1147443

But what is moderate polarization?

The conceptual measurement problem:

What is more polarized?



The core measure: Average Pair Discrepancy / Antagonism

For n opinion 0, 1, 2, …, n and populations p_0, p_1, p_2, …, p_n (summing up to one).

$$\mathrm{Pol}_0(p) = \frac{2}{n} \sum_{i,j=0}^{n} p_i p_j |i - j|$$

Normalization such that polarization is bounded by one

Probability of a **pair** with opinion i and j

Discrepancy / Antagonism between i and j

Note: Without normalization called *mean absolute difference*.

Gestefeld, M., Lorenz, J., Henschel, N. T., & Boehnke, K. (2022). Decomposing attitude distributions to characterize attitude polarization in Europe. SN Social Sciences, 2(7), 110. https://doi.org/10.1007/s43545-022-00342-7

Extension: Identification-weighted Polarization

$$\mathrm{Pol}_1(p) = \frac{4}{n} \sum_{i,j=0}^{n} p_i^2 p_j |i - j|$$

antagonism weight more when a person has more peers

We use a definition impliying this is not much polarized.

least polarized

maximal diversity

$\mathrm{Pol}_0 = 0.727$

$\mathrm{Pol}_1 = 0.132$

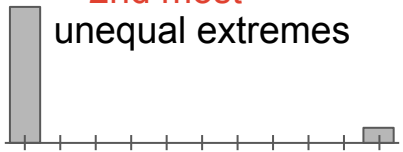
Most polarized

equal powers

$\mathrm{Pol}_0 = \mathrm{Pol}_1 = 0.4$

2nd most

unequal extremes



$\mathrm{Pol}_0 = \mathrm{Pol}_1 = 0.36$

With Pol_0 and Pol_1 we can differentiate peaked distribution from uniform

Esteban, J. M., & Ray, D. (1994). On the measurement of polarization. Econometrica: Journal of the Econometric Society, 819-851.

Micro Opinion Dynamics I:
Assimilation under Bounded Confidence

Bounded Confidence Model *Deffuant et al. style*

The Micro-Interaction:

Agent *i* hears the opinion of (randomly selected) agent *j* and updates opinion as

$$x_i(t+1) = \begin{cases} x_i(t) + 0.5(x_j(t) - x_i(t)) & \text{if } |x_i(t) - x_i(t)| < \lambda \\ x_i(t) & \text{otherwise} \end{cases}$$

Parameter λ:
Bound of Confidence
(or latitude of acceptance)

Agent *i* assimilates in the direction of *j*'s opinion when close enough.

Deffuant, G., Neau, D., Amblard, Frédéric., & Weisbuch, G. (2000). Mixing Beliefs among Interacting Agents. Advances in Complex Systems, 3, 87–98. https://doi.org/10.1142/S0219525900000078

Micro Opinion Dynamics II:
Idiosyncratic Opinion Change

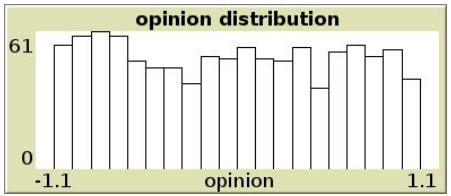
Bounded Confidence Model *Deffuant et al. style* with *Pineda et al. style "noise"*

The Micro-Action:

Parameter θ

Sometimes (with idiosyncrasy probability θ) agent *i* selects a **random opinion idiosyncratically** from the distribution of initial opinions.

Initial and idiosyncratic opinions can come from uniform or normal distribution



Pineda, M., Toral, R., & Hernandez-Garcia, E. (2009). Noisy continuous-opinion dynamics. Journal of Statistical Mechanics: Theory and Experiment, 2009(08), P08001 (18pp). http://stacks.iop.org/1742-5468/2009/P08001

Micro Opinion Dynamics III:
Heterogeneous Bounds Confidence

Bounded Confidence Model *Deffuant et al. style*

The Micro-Interaction:

Agent *i* hears the opinion of (randomly selected) agent *j* and updates opinion as

$$x_i(t+1) = \begin{cases} x_i(t) + 0.5(x_j(t) - x_i(t)) & \text{if } |x_i(t) - x_i(t)| < \lambda_i \\ x_i(t) & \text{otherwise} \end{cases}$$

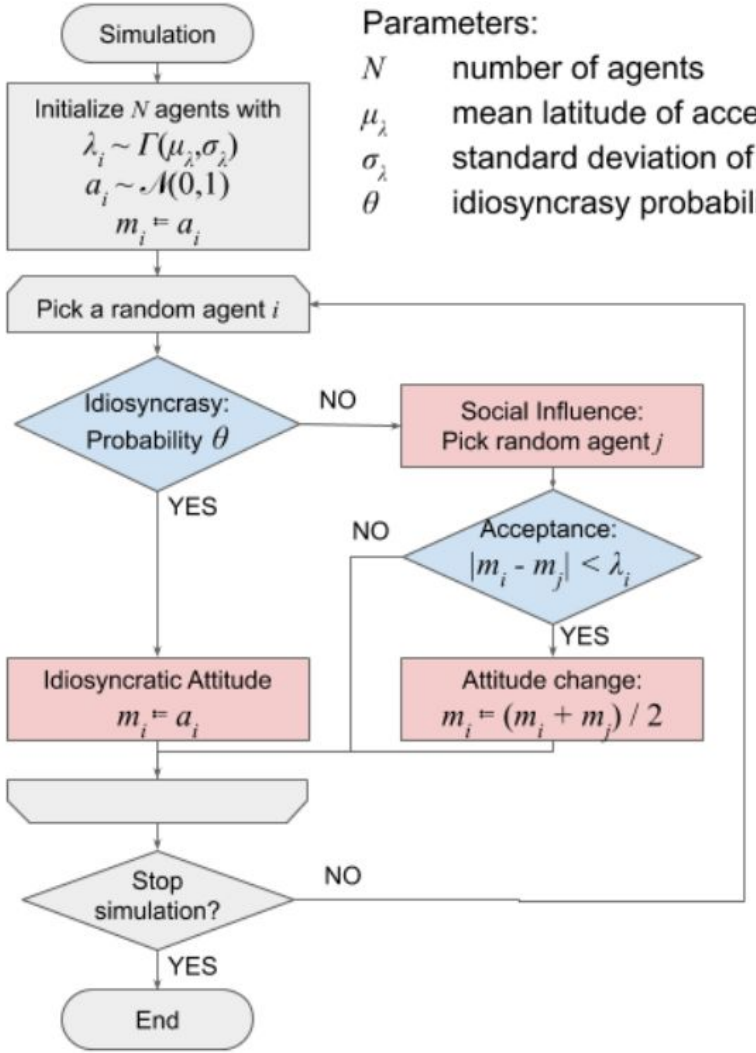
Parameter λ become static agent variable λ_i
Drawn from **Gamma distribution** with
mean μ_λ and
standard deviation σ_λ
(two new distribution parameters)

Agent *i* assimilates in the direction of *j*'s opinion when close enough.

Deffuant, G., Neau, D., Amblard, Frédéric., & Weisbuch, G. (2000). Mixing Beliefs among Interacting Agents. Advances in Complex Systems, 3, 87–98. https://doi.org/10.1142/S0219525900000078

From Micro to Macro Opinion Dynamics: Society model with Computer Simulation

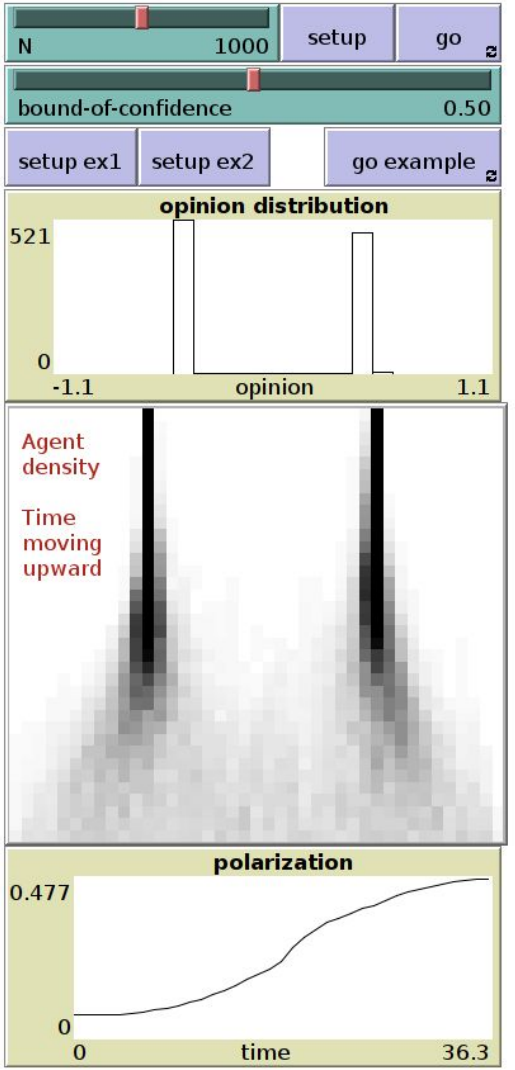
- Initialize some 1,000 agents with idiosyncratic opinions
- Repeatedly, sweep over all agents and let them update their opinion through
  - listening to others (randomly) or
  - (occasionally) changing idiosyncratically



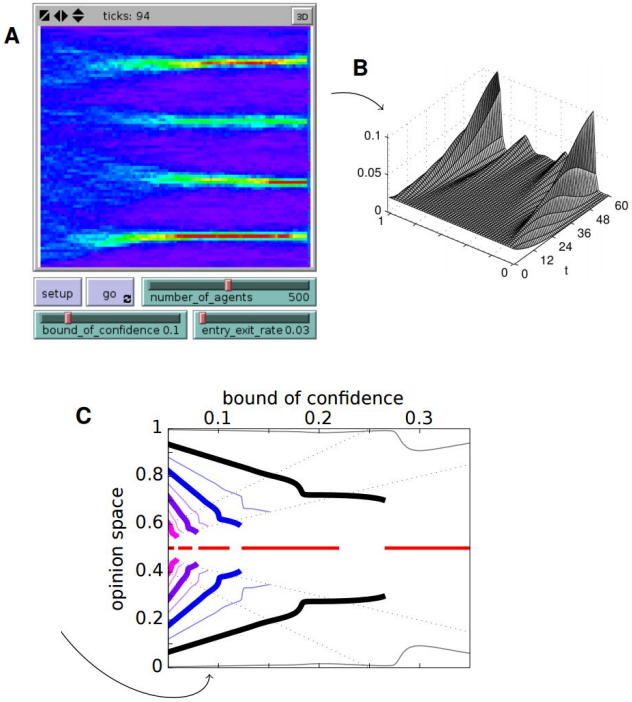
Specification of a society model motivated from social psychology:
Lorenz, J., Neumann, M., & Schröder, T. (2021). Individual attitude change and societal dynamics: Computational experiments with psychological theories. Psychological Review, 128(4), 623–642. https://doi.org/10.1037/rev0000291

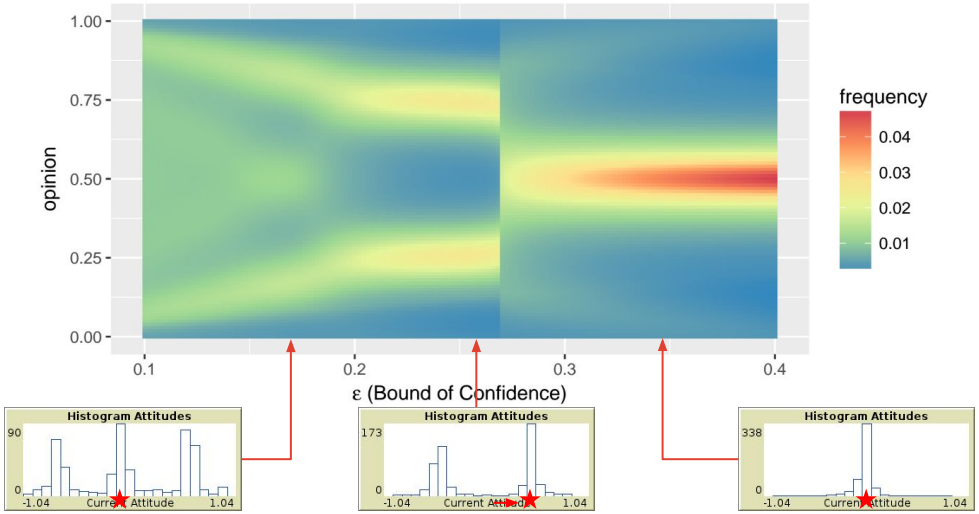
Macro Opinion Dynamics I: **Assimilation under Bounded Confidence can trigger Polarization**

Polarization in some extreme (and unrealistic) form of two peaks.



Macro Opinion Dynamics II.a: **With idiosyncrasy stochastic stable distributions evolve**



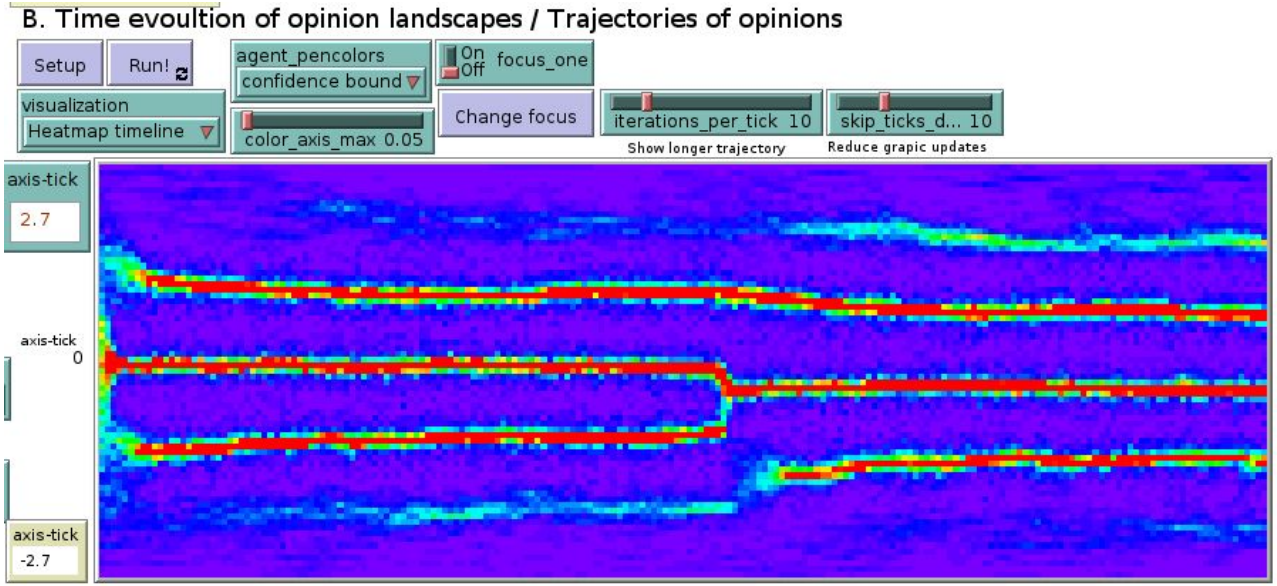


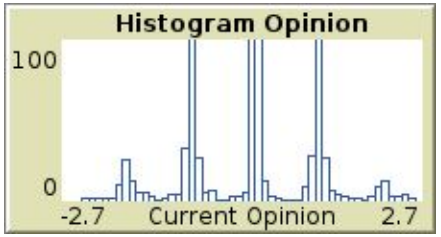
Low confidence
Median voter moderate

Intermediate confidence
Median voter not moderate!

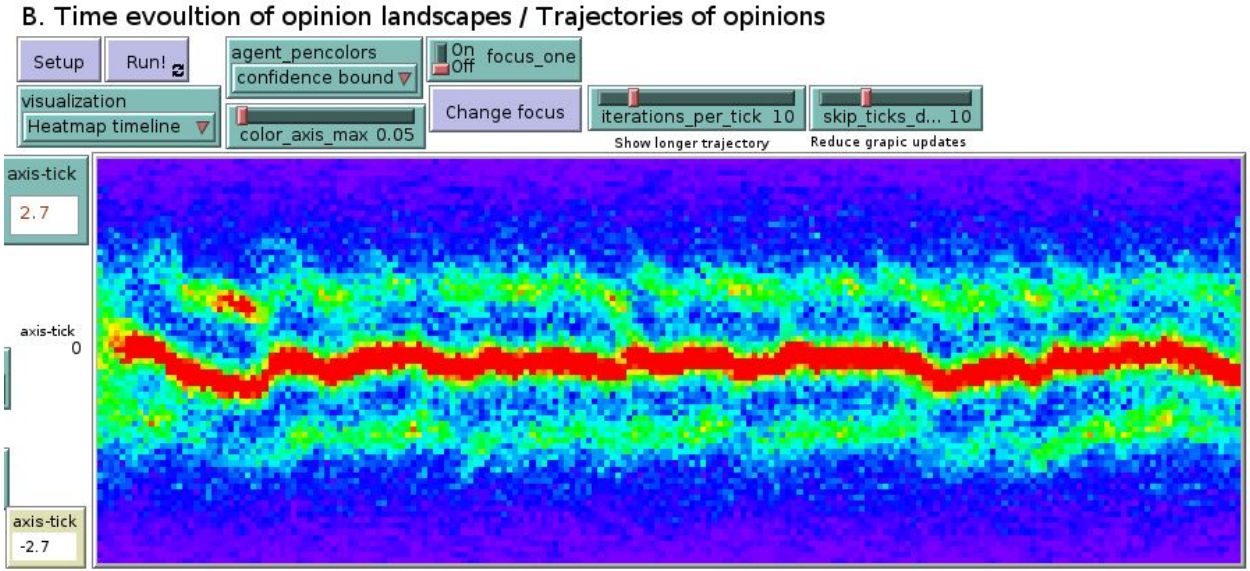
High confidence
Moderate consensus

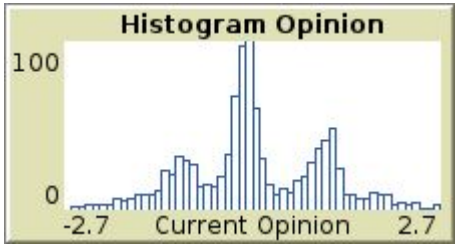
Macro Opinion Dynamics II.b:
Low fraction (1%) of idiosyncratic opinion formation with normal distribution of opinions



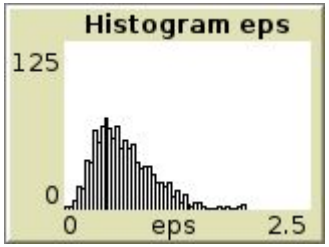


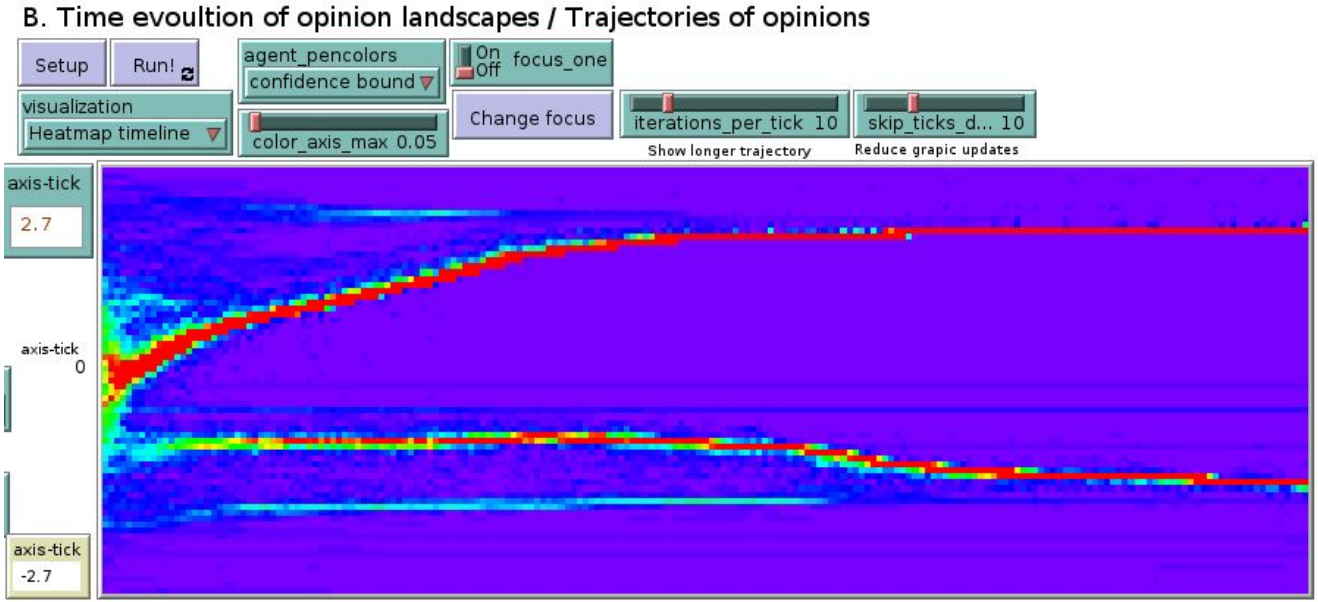
Macro Opinion Dynamics II.b:
Higher fraction (7%) of idiosyncratic opinion formation with normal distribution of opinions



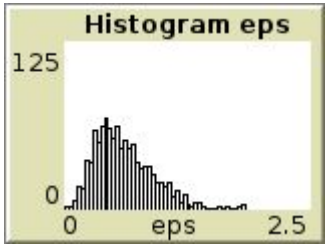


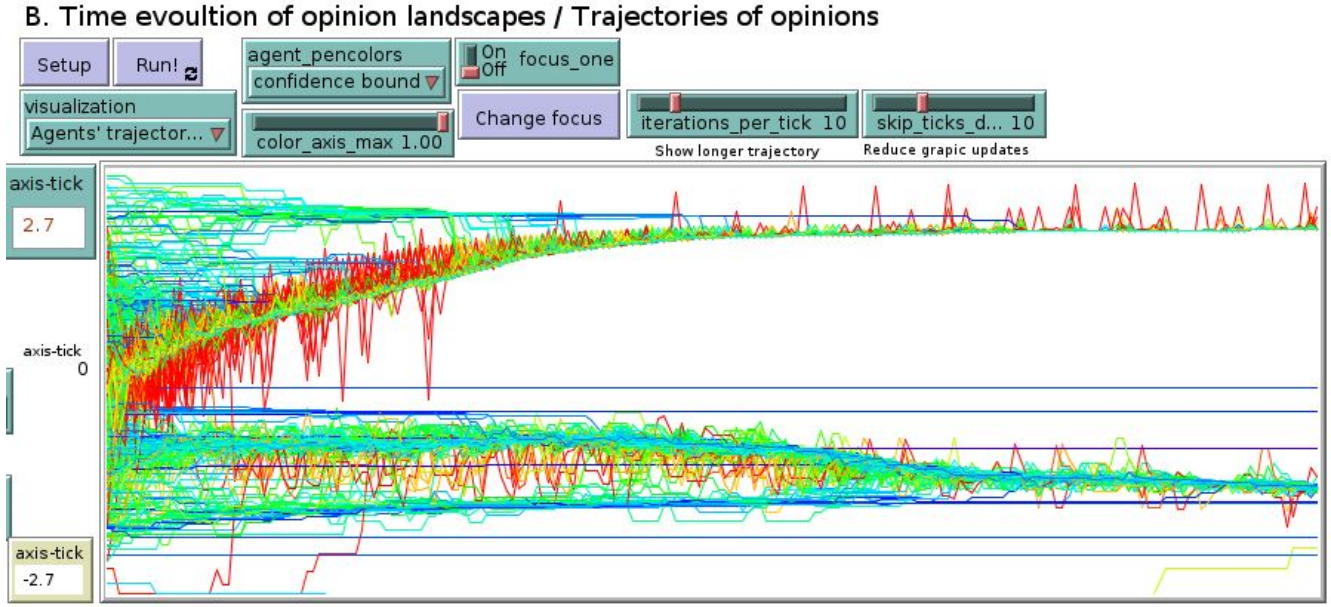
Macro Opinion Dynamics III.a:
Heterogeneous bounds of confidence
→ **Drifts of a majority cluster**





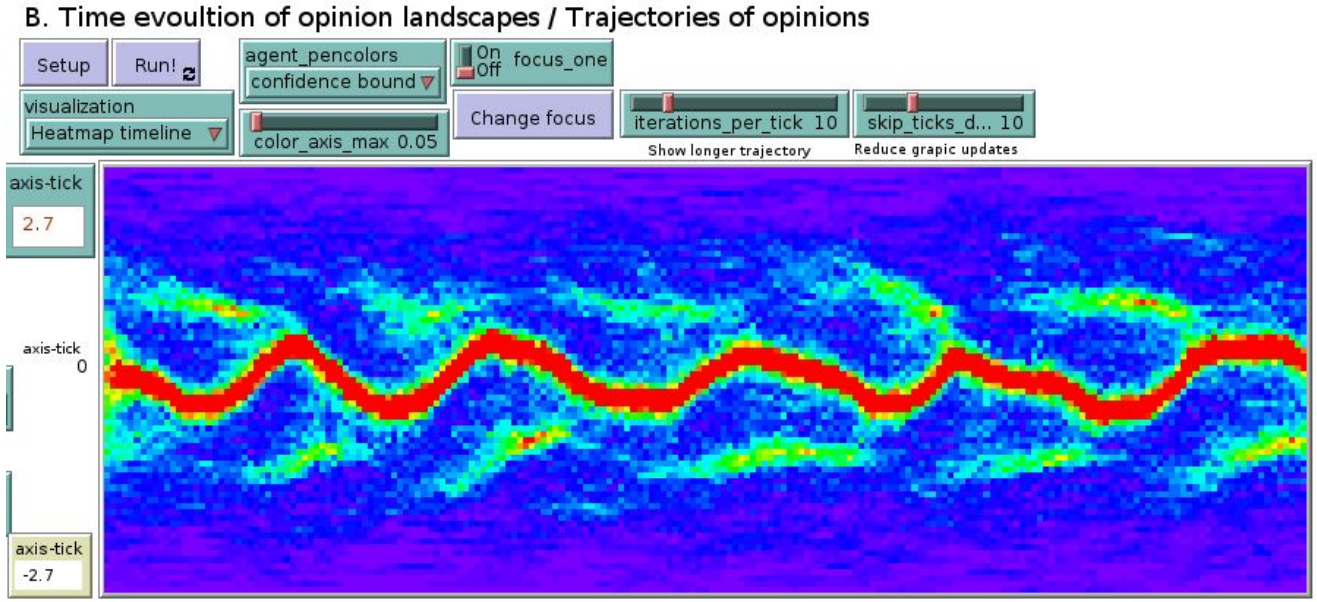
Macro Opinion Dynamics III:
Heterogeneous bounds of confidence
→ Drifts of a majority cluster





Same simulation but different visualization with individuals trajectories

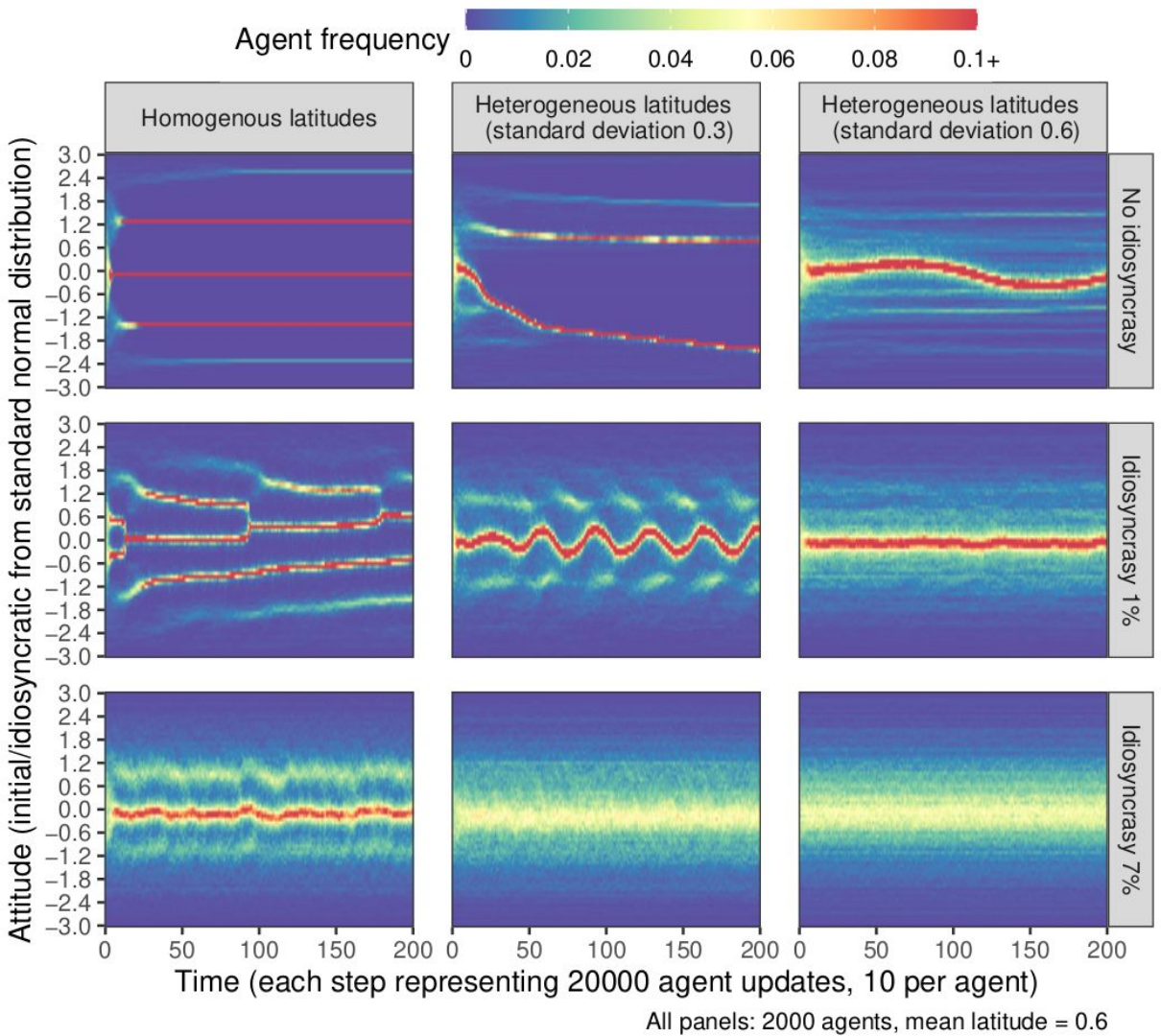
Macro Opinion Dynamics IV:
Idiosyncrasy and heterogeneous bounds → Regular oscillation



Macro Mechanism

- Open-minded form majority cluster in center
- Majority cluster drifts to one side where there are a bit more closed-minded
- Emptier space on the other side lets a small cluster evolve through come-in from turn-over
- At some point enough open-minded emerge in between to trigger a new drift

Oscillations happen with **intermediate heterogeneity** and **intermediate idiosyncrasy**

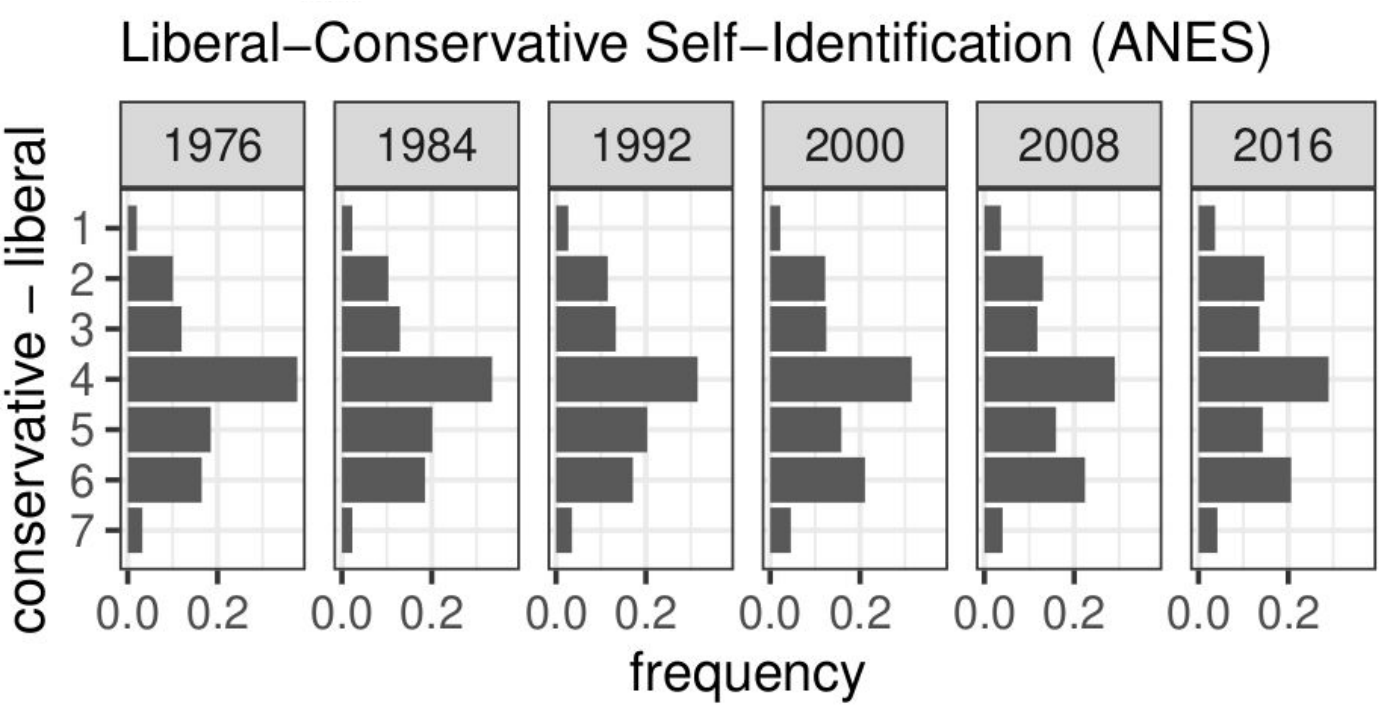


Do Polarization and Oscillations map to real political opinions?

Look at USA

- **Ideology**
  (ANES 7-point Likert scale for very conservative to very liberal)
- **Public Policy Mood**
  (Stimson's data)

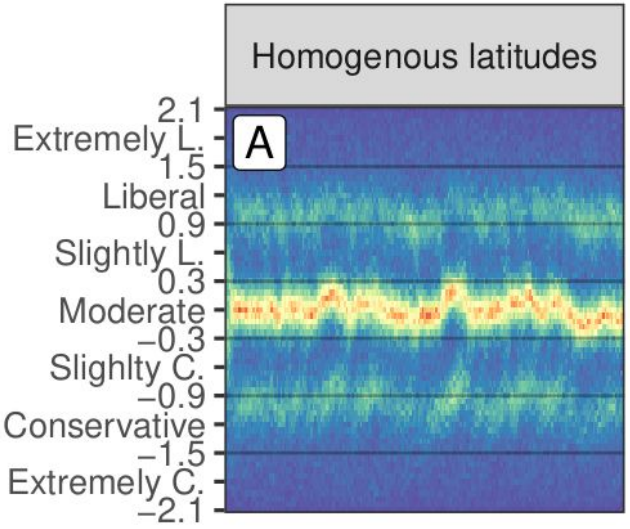
Political Ideology

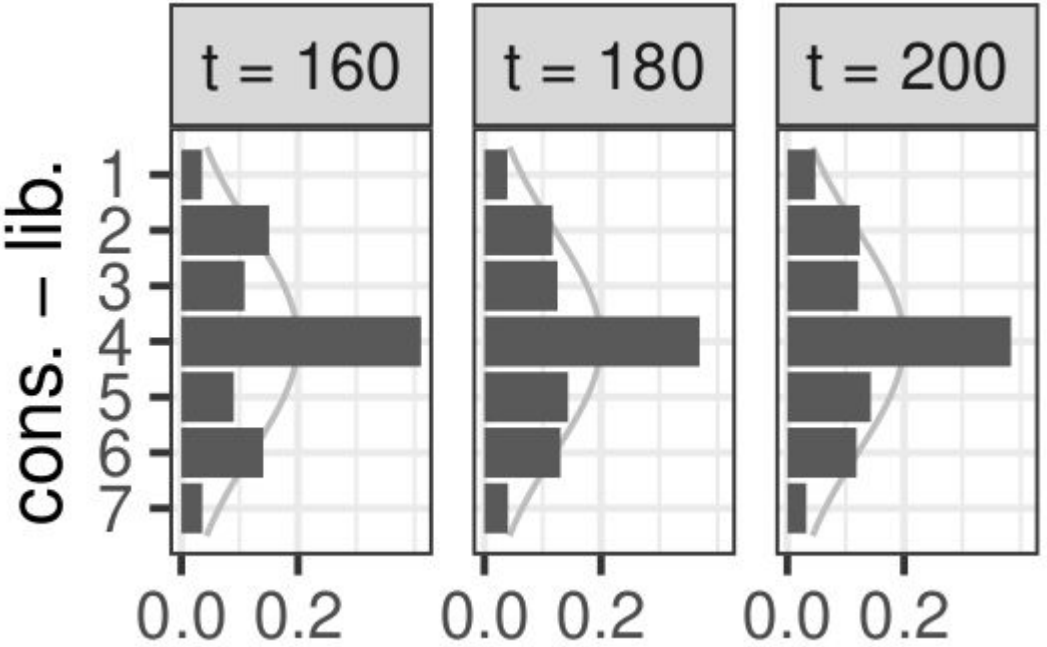


ANES = American National Elections Studies

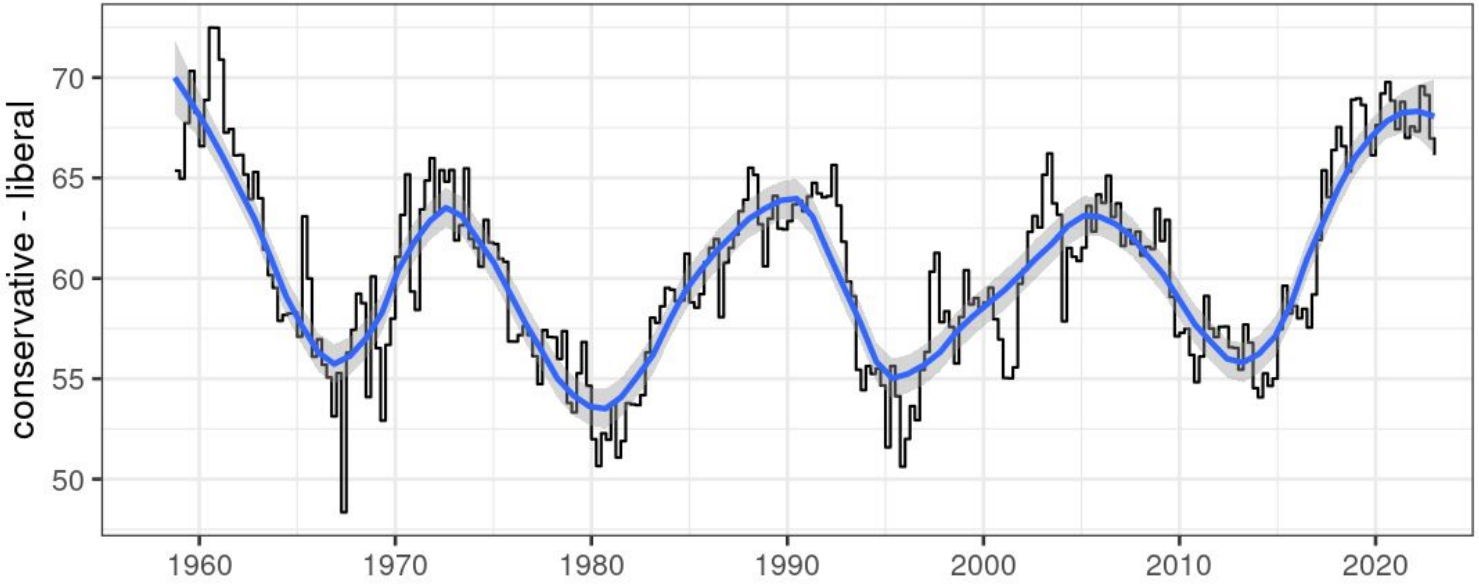
Ideology: We can come close
How: No heterogeneity, high idiosyncrasy

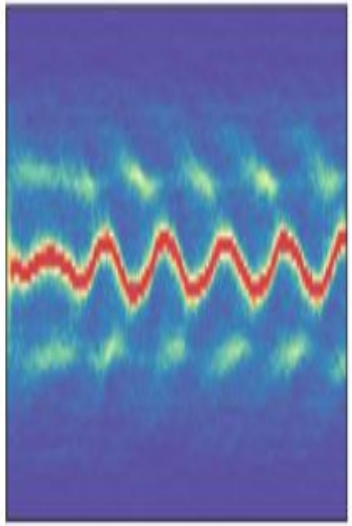
Mean latitude 0.6, standard deviation of latitudes 0
Idiosyncrasy probability 7%





Public Policy Mood: Regular oscillations
How: Intermediate Heterogeneity





Mean latitude 0.6
Standard deviation of latitudes 0.3
Idiosyncrasy probability 1%

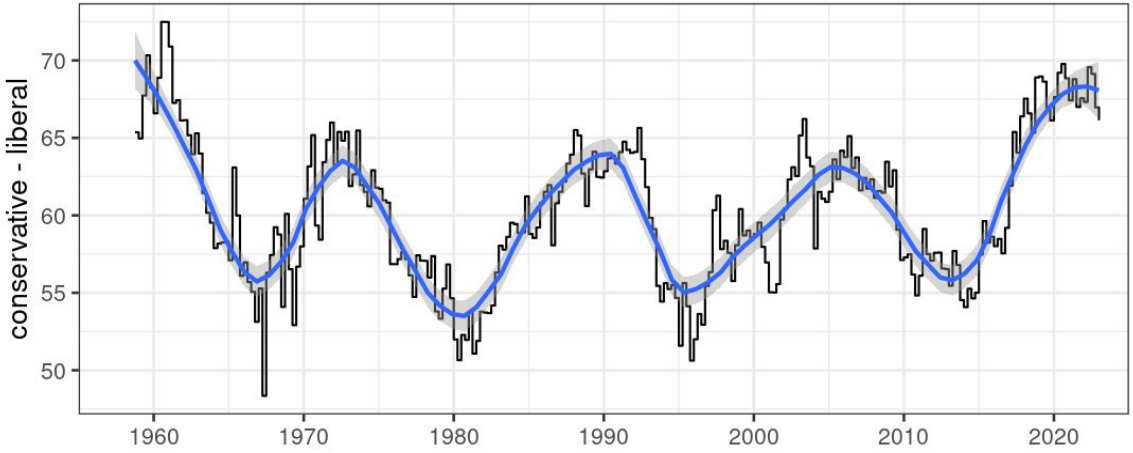
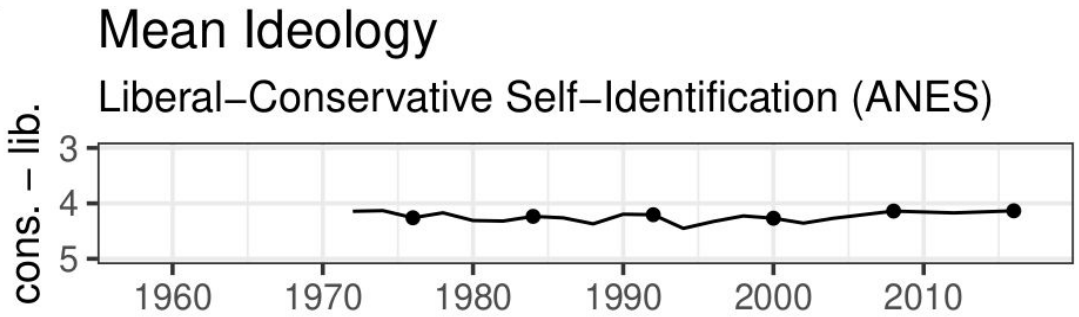
Approximate wavelength:
14.5 years ↔ 22.4 agent updates a year

Blue line from ggplot2::stat_smooth with loess method and span=0.2
Data from Stimson (2019)

Note: No mood data for individuals available.

Stimson, James. https://stimson.web.unc.edu/data/ Public Policy Mood

Takeaways

- **Mechanism 1:**
  Assimilation under Bounded Confidence as a driving force of polarization!
  - Intrinsic radicalization or repulsive forces are not a necessary mechanism
- **Mechanism 2:**
  Idiosyncrasy in opinion formation creates stochastically stable opinion distribution closer to empirical distributions of **ideology**
- **Mechanism 3:**
  Heterogeneous Bounds creates drifts of the a majority cluster
- **Mechanism 4:**
  Heterogeneous bounds and idiosyncrasy creates regular oscillations similar to **public policy mood**

Backup: Mood swings more and differently than Ideology