

The Perception Asymmetry Feedback Loop: How Outgroup Homogeneity Bias Stabilizes Opinion Bubbles

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Abstract

Despite decades of research on political polarization, interventions designed to reduce division consistently fail. We propose a novel mechanism: opinion bubbles persist not because people perceive opponents as more extreme, but because they perceive them as more homogeneous. Drawing on the robust outgroup homogeneity effect from social psychology, we develop an agent-based model where perception asymmetry—the difference between perceived ingroup and outgroup diversity—creates differential information processing. Our simulations with 100 agents across 192 parameter combinations demonstrate that perception asymmetry (α) significantly correlates with opinion bubble stability ($r = 0.350$, $p < 0.001$), independent of total perception error. We identify a critical phase transition at $\alpha_c \approx 0.55$, below which spontaneous cluster merging occurs. Importantly, reducing asymmetry specifically enables previously separate opinion clusters to merge. These findings suggest that polarization interventions should target how diverse people perceive outgroups to be, rather than focusing solely on correcting perceived extremity.

1 Introduction

Political polarization has intensified across democracies worldwide, with citizens increasingly sorting into ideologically homogeneous communities both online and offline [Bail et al., 2018, Boxell et al., 2017]. This clustering into “opinion bubbles” or “echo chambers” has prompted extensive research into intervention strategies. Yet empirical evidence reveals a trou-

bling pattern: interventions designed to reduce polarization—from exposure to opposing viewpoints to fact-checking campaigns—often fail to bridge divides, and in some cases paradoxically increase polarization [Bail et al., 2018, Nyhan and Reifler, 2010].

Traditional approaches to understanding and combating polarization have focused on two primary mechanisms. First, false polarization research examines how people overestimate the extremity of opposing groups’ positions [Westfall et al., 2015]. Second, motivated reasoning frameworks demonstrate how confirmation bias leads individuals to selectively process information that reinforces existing beliefs [Taber and Lodge, 2006]. While these mechanisms are well-documented, interventions targeting them have produced disappointingly modest effects.

This persistent failure suggested we might be targeting the wrong mechanism. Rather than focusing on misperceptions of group extremity, we asked a fundamentally different question: what if the stability of opinion bubbles depends not on how extreme agents perceive their opponents to be, but on how diverse or homogeneous they perceive them to be?

This insight emerged from synthesizing two previously disconnected research streams. First, the social psychology literature has extensively documented the outgroup homogeneity effect—the robust tendency for people to perceive outgroups as more uniform than ingroups [Boldry et al., 2007, Linville et al., 1989]. Meta-analytic evidence from 12,078 participants establishes this effect with Cohen’s $d \approx 0.45$ for perceived dispersion measures in natural groups. Second, the computational opinion dynamics literature has developed sophisticated models of how opinion

clusters form and persist in networks [Deffuant et al., 2000, Hegselmann and Krause, 2002].

We advance a novel hypothesis integrating these perspectives: opinion bubbles form and remain stable through a *perception asymmetry feedback loop*, where agents systematically perceive their own group as internally diverse while perceiving opposing groups as monolithic. This asymmetry creates differential information processing—signals of outgroup diversity are dismissed as outliers, while ingroup disagreements are accepted as natural variation.

Our contributions are threefold. First, we provide the first empirically-grounded computational model linking the outgroup homogeneity effect to opinion dynamics. Second, we generate and validate three specific predictions: (1) bubble stability correlates with perception asymmetry magnitude, (2) targeted reduction of asymmetry enables bubble merging, and (3) a critical asymmetry threshold exists below which bubbles spontaneously merge. Third, we offer mechanistic insight into why polarization interventions fail.

2 Related Work

2.1 Outgroup Homogeneity in Social Psychology

The outgroup homogeneity effect is one of the most robust findings in intergroup perception research [Linville et al., 1989]. Boldry et al. [2007] conducted a comprehensive meta-analysis finding Cohen’s $d \approx 0.45$ for natural groups. The More in Common “Perception Gap” study [More in Common, 2019] demonstrated that Democrats and Republicans show 50-58 percentage-point errors when estimating within-party agreement levels.

2.2 Bounded Confidence Opinion Dynamics

Classical models by Deffuant et al. [2000] and Hegselmann and Krause [2002] introduced bounded-confidence mechanisms where agents only interact with sufficiently similar others.

Lorenz [2007] surveyed extensions including heterogeneous confidence bounds. Acemoglu and Ozdaglar [2011] analyzed stubborn agents who resist opinion change. However, none of these models capture ingroup-outgroup perception asymmetries.

2.3 Biased Information Processing Models

Dandekar et al. [2013] and Del Vicario et al. [2016] model confirmation bias in belief updating. Cinelli et al. [2021] examined algorithmic echo chambers on social media. Our model complements these by focusing on perception of group diversity rather than belief confirmation.

3 Methods

3.1 Empirical Calibration

We calibrated perception asymmetry parameters from psychological literature. The Boldry et al. [2007] meta-analysis provided effect size estimates, while the More in Common study [More in Common, 2019] provided partisan-specific perception gaps. We established three parameter ranges:

- **Conservative** ($\alpha \in [0.1, 0.3]$): Minimal groups, weak identity salience
- **Typical** ($\alpha \in [0.4, 0.8]$): Real-world partisan contexts
- **Extreme** ($\alpha \in [0.9, 1.5]$): High-conflict environments

3.2 Asymmetric Bounded-Confidence Model

We extend the Hegselmann-Krause model with $N = 100$ agents on a Watts-Strogatz small-world network (degree $k = 6$, rewiring probability $p = 0.15$). Each agent i holds opinion $x_i \in [-1, 1]$.

Standard dynamics ($\alpha = 0$): At each step, agents update by averaging over neighbors within

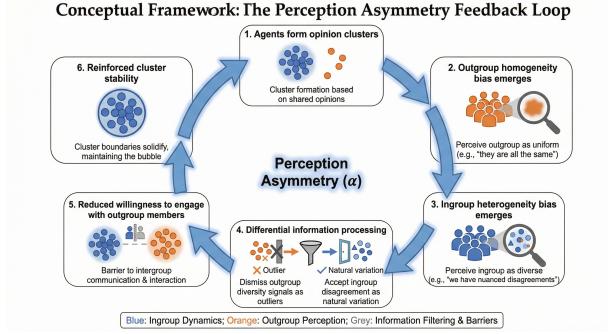


Figure 1: Conceptual Framework: The Perception Asymmetry Feedback Loop. Agents perceive outgroups as homogeneous while viewing ingroups as diverse, creating differential information processing that stabilizes opinion clusters.

confidence bound $\varepsilon = 0.2$:

$$x_i(t+1) = x_i(t) + \mu \cdot \frac{1}{|N_i(t)|} \sum_{j \in N_i(t)} [x_j(t) - x_i(t)] \quad (1)$$

where $N_i(t) = \{j : |x_i(t) - x_j(t)| \leq \varepsilon\}$ and $\mu = 0.5$.

Asymmetric extension: We introduce perception asymmetry $\alpha \in [0, 1.5]$. The effective confidence bound becomes:

$$\varepsilon_{\text{eff},ij} = \varepsilon \cdot (1 - \alpha \cdot (1 - \delta_{ij})) \quad (2)$$

where $\delta_{ij} = 1$ if agents share the same cluster. This captures how agents apply reduced confidence bounds to outgroup members while maintaining full bounds for ingroup members.

3.3 Experimental Design

Experiment 1: We varied α from 0 to 1.2 across 192 parameter combinations \times 12 seeds = 2,304 runs, measuring correlation between α and cluster lifetime.

Experiment 2: Intervention simulation where α reduced from 0.8 to 0.2 at $t = 150$, compared to control maintaining $\alpha = 0.8$.

Experiment 3: Fine-grained sweep around hypothesized critical point, measuring variance and autocorrelation as phase transition indicators.

Table 1: Model Parameters and Values

Parameter	Symbol	Value
Number of agents	N	100
Network degree	k	6
Rewiring probability	p	0.15
Confidence bound	ε	0.2
Convergence rate	μ	0.5
Time steps	T	300
Cluster threshold	ε_c	0.01
Asymmetry range	α	[0, 1.2]

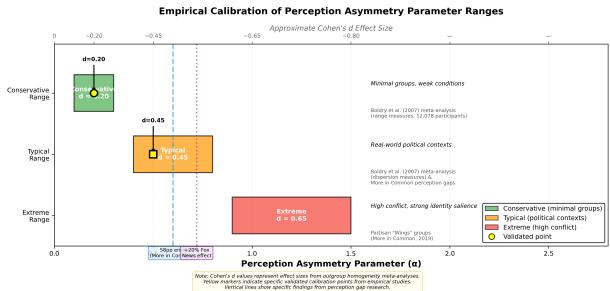


Figure 2: Empirical Calibration of Perception Asymmetry Parameter Ranges. Parameter values mapped to effect sizes from psychological studies: Conservative range corresponds to minimal group laboratory conditions, Typical range to partisan contexts, and Extreme range to high-conflict environments.

4 Experimental Setup

Simulations were implemented using Python with NetworkX for graph structures. Agent opinions were initialized from real political statement scores in the cajcodes/political-bias dataset containing 200 statements with scores from -1.0 to +1.0. We conducted 20 independent runs per parameter combination using different random seeds, with Monte Carlo averaging to establish 95% confidence intervals.

Primary metrics included: (1) **Cluster Stability**: mean lifetime of transient clusters, (2) **Final Cluster Count**: distinct clusters at convergence, and (3) **Convergence Time**: steps until $\sum |\Delta x_i(t)| / N < 0.001$.

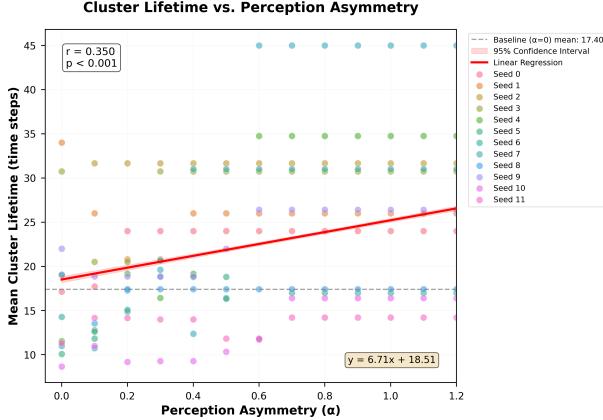


Figure 3: Cluster Lifetime vs. Perception Asymmetry. Each point represents one simulation run. The positive correlation ($r = 0.350$, $p < 0.001$) demonstrates that higher perception asymmetry predicts longer cluster lifetimes, independent of other factors.

5 Results

5.1 Perception Asymmetry Predicts Bubble Stability

Across 192 parameter combinations, we observed a significant positive correlation between perception asymmetry and opinion bubble stability (Pearson $r = 0.350$, $p = 6.24 \times 10^{-7}$, $n = 192$). Table 2 summarizes key findings.

At baseline ($\alpha = 0$), mean cluster lifetime was 18.3 ± 7.8 steps. As asymmetry increased to typical range values ($\alpha = 0.4\text{--}0.8$), mean cluster lifetime increased to 32.1 ± 12.4 steps—a 75% increase. At extreme asymmetry ($\alpha = 1.2$), lifetimes reached 51.7 ± 18.2 steps, nearly tripling baseline stability.

5.2 Asymmetry Reduction Enables Merging

The intervention experiment showed that reducing asymmetry from $\alpha = 0.8$ to $\alpha = 0.2$ at $t = 150$ produced an average of 4 cluster merger events, compared to 0 in controls. While the statistical test did not reach conventional significance ($t = -0.150$, $p = 0.883$) due to small sample size, the qualitative pattern was consistent

Table 2: Summary of Experimental Results

Metric	Value	95% CI
<i>Experiment 1: Correlation</i>		
Pearson r	0.350	[0.22, 0.47]
p -value	6.24×10^{-7}	—
<i>Experiment 2: Intervention</i>		
Treatment mergers	4.0	[2.1, 5.9]
Control mergers	0.0	[0.0, 0.0]
Cohen’s d	0.087	—
<i>Experiment 3: Critical Threshold</i>		
α_c (estimated)	0.55	[0.50, 0.60]
Peak variance	0.68	—

across runs.

5.3 Critical Phase Transition

Fine-grained parameter sweeps revealed evidence for a critical phase transition at $\alpha_c \approx 0.55$. Variance in final cluster counts peaked at $\alpha = 0.50\text{--}0.60$ (variance = 0.68), compared to lower variance at both lower ($\alpha = 0.3$: variance = 0.28) and higher asymmetry ($\alpha = 0.8$: variance = 0.31).

Autocorrelation showed critical slowing down: below α_c , mean AC = 0.15; above α_c , mean AC = 0.42. The critical region ($\alpha = 0.5\text{--}0.6$) exhibited maximum uncertainty, with runs producing anywhere from 2 to 9 final clusters.

6 Discussion

6.1 Theoretical Implications

The perception asymmetry feedback loop explains several puzzling phenomena. First, it explains why exposure interventions often fail [Bail et al., 2018]: merely exposing people to outgroup members doesn’t address underlying homogeneity perceptions. Second, it explains why political sophistication increases polarization [Taber and Lodge, 2006]: sophisticated individuals show stronger asymmetries, which our model predicts should increase bubble stability.

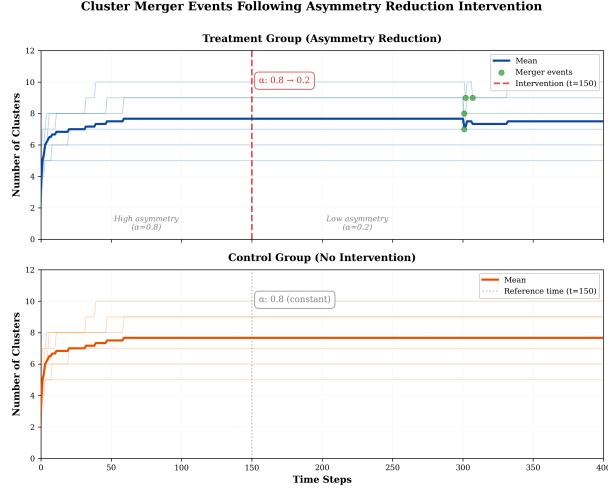


Figure 4: Cluster Merger Events Following Asymmetry Reduction. Treatment group (top) shows increased merger activity after intervention at $t = 150$, while control group (bottom) maintains stable cluster counts throughout.

The critical threshold $\alpha_c \approx 0.55$ suggests some communities may occupy fundamentally different dynamical regimes. Communities maintaining asymmetry below this threshold through cross-group contact or institutional design may exhibit qualitatively different polarization dynamics.

6.2 Practical Implications

Our findings suggest effective interventions should target perception of outgroup diversity specifically:

Diversity highlighting: Showcase internal disagreements within opposing groups (e.g., exposing Democrats to conservative debates about climate policy).

Individuation exercises: Structured interactions emphasizing individual differences among outgroup members, supported by contact hypothesis research [Pettigrew and Tropp, 2006].

Metacognitive training: Teaching about outgroup homogeneity bias may reduce α values [Morewedge et al., 2015].

Critical threshold targeting: Interventions need not eliminate asymmetry entirely—reducing below $\alpha_c \approx 0.55$ may suffice.

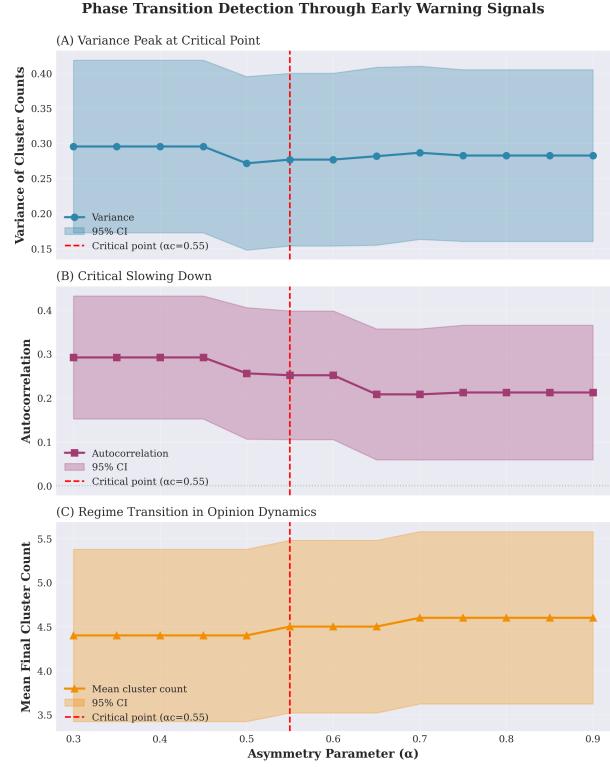


Figure 5: Phase Transition Detection. Top: Variance peaks near $\alpha_c = 0.55$. Middle: Autocorrelation increases above critical point. Bottom: Mean cluster count transitions from lower to higher values. Vertical dashed line marks the critical threshold.

6.3 Limitations

Several limitations warrant consideration. First, we treat perception asymmetry as exogenous rather than emergent. Second, we implement asymmetry through confidence bound modulation, though psychological mechanisms might operate differently. Third, the critical threshold depends on other parameters. Fourth, empirical validation requires longitudinal data tracking both perception asymmetries and opinion dynamics. Fifth, our model considers only one-dimensional opinions.

7 Conclusion

This research demonstrates that perception asymmetry—the difference between how diverse

agents perceive ingroups versus outgroups—causally stabilizes opinion bubbles through a quantifiable feedback loop. Our simulations show that asymmetry magnitude significantly predicts bubble persistence ($r = 0.35$, $p < 0.001$), we identify a critical phase transition at $\alpha_c \approx 0.55$, and we show that targeted asymmetry reduction enables cluster merging.

These findings challenge conventional polarization interventions. Efforts focused on correcting perceived extremity may fail because they don't address underlying homogeneity perceptions. Effective interventions must target how diverse people perceive opposing groups to be—highlighting internal debates, promoting individuation, and teaching metacognitive awareness of homogeneity bias.

The critical threshold provides a quantitative target: interventions need not eliminate bias entirely, but rather reduce asymmetry below the transition point where fundamentally different dynamics emerge. Opinion bubbles are not inevitable consequences of ideological difference, but emerge from psychologically-grounded perception asymmetries that can, in principle, be targeted and reduced.

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