A Head-to-Head Comparison of Alternative Voting Rules

Results from Mathematica's Agent-Based Modeling

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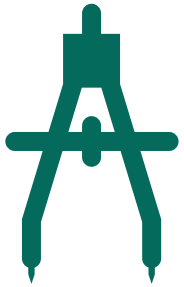
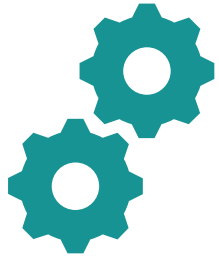
Key research questions (RQs)



RQ1: Which ranked-choice voting rules elect more moderate candidates who represent the electorate?



RQ2: Which ranked-choice voting rules are most vulnerable to voter polarization and spoiler candidates?

To answer these questions, we used agent-based models that build complex systems to simulate individual behaviors and interactions, allowing for flexible, scalable, and straightforward computations.

A team with interdisciplinary expertise

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Modeling Mechanics

Voting rules compared head to head

Current voting rule *(status quo)* **Condorcet compliant voting rule** **Other ranked-choice voting rule**

Plurality

Elect the candidate with the largest number of 1st place votes

IRV / Hare

If no majority winner, sequentially eliminate the candidate with fewest 1st place votes

Coombs

If no majority winner, sequentially eliminate the candidate ranked last on most ballots

Black

If no C winner, elect the candidate with highest Borda score

Baldwin / TVR

If no C winner, sequentially eliminate the candidate with the lowest Borda score

Nanson

If no C winner, eliminate, at once, all candidates with average or lower-than-average Borda scores

Copeland

If no C winner, elect the candidate who wins the greatest net number of pairwise comparisons

Minimax

If no C winner, elect the candidate whose single largest pairwise defeat is the smallest

An AI-enhanced literature search (105 papers; 27 sims; 39 voting rules) yielded a short list of promising RCV rules. Rules that performed well in 3+ simulation studies were assessed for distinctness. Plurality provides a baseline referent.

C = Condorcet compliant voting rule; IRV = instant runoff voting; TVR = total vote runoff; IRV = instant runoff voting.

Agent-based modeling approach

1. Sample voters + candidates

- **General election**
- **Primary election**

~10,000
Voters for Senate seat

7
Primary candidates

- 1 D, 1 R, 1 I/U candidate + 4 others randomly selected

2. Define issue space

5
Issue types

- Issue scores based on survey data from real voters
- Use issues to assess how candidates align with voters

3. Generate ballot rankings

8
Voting rules

- Spatial proximity model
- Ranks based on issue distance + noise
- Adjustments for tribalism + truncation
- Random tie-breaking (exact ties only)

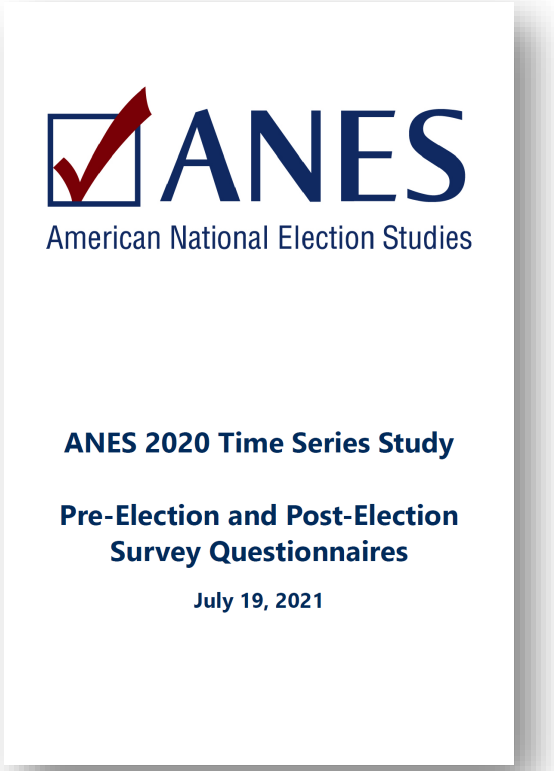
4. Assess winners + performance by voting rule

~500,000
Simulated elections

- 1,000 elections per scenario
- 512 scenario combinations
- Winner based on popular vote

D = Democrat; I/U = independent or unaffiliated; R = Republican.

Step 1: Grounding the model in voter data



Captured real voter demographics and behaviors

- ANES sample represents the U.S. electorate; used by Ko et al. 2025 to accurately forecast popular vote
- Combined two waves (2016 + 2020) with different incumbent parties to improve generalizability
- Restricted to those who voted in primary or general elections, candidates of eligible age (30+ years)

Used voters' views, ideology, and party to translate from plurality to RCV

- Modeled how straight-party voting in plurality elections related to voter features to assess how party might influence ballot rankings under RCV elections

Naturally incorporated unobserved relationships of interest

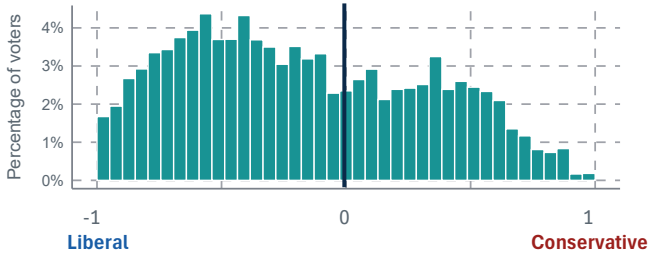
- Primary voters were older, wealthier, more educated, more engaged, and more ideologically polarized
- Senate elections drew fewer Asian, Hispanic, young, low-income, and less-educated voters

ANES = American National Election Studies; RCV = Ranked-choice voting.

Step 2: Voters' views and behaviors (50+ variables)

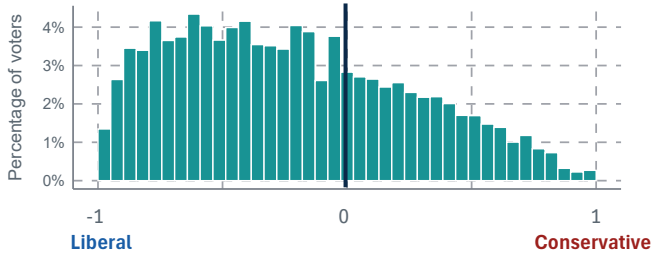
#1: Government size and services

(Government size and services; Job/wage support; Unions; Paid leave; Big business; Tax on millionaires; Spending on social security, healthcare, school, welfare, environment;)



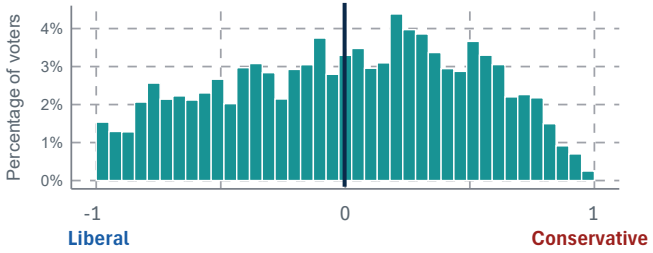
#2: Sociocultural

(Abortion, Gun rights, Church attendance, Traditional family values, Women's role in society, Protections for and rights of people who identify as gay/lesbian/transgender, Equal rights and opportunities for all)



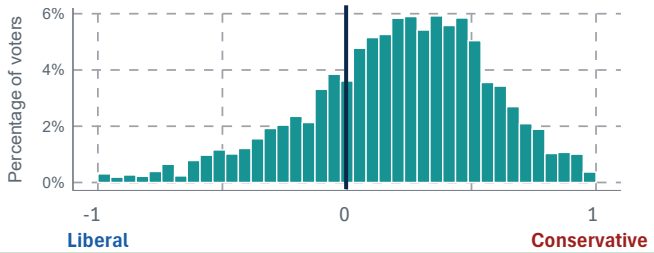
#3: Race and immigration

(Government assistance to or preferential treatment of Black people; Black Lives Matter movement; Birthright citizenship; Assimilation of racial-ethnic minority groups and immigrants)



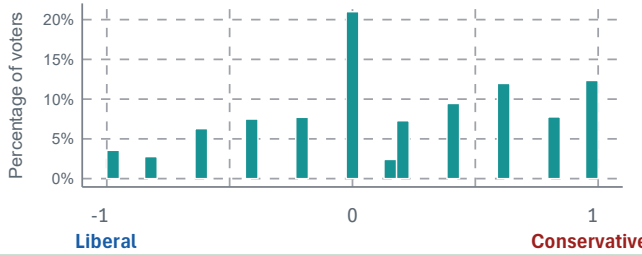
#4: Military and policing

(Spending on military and crime, Feelings about police, Use of force to solve international problems, Views toward people without legal immigration status)



#5: Ideology

(Where would you place yourself on a 10-point Left ↔ Right scale?)



	Registered Democrat	Independent	Registered Republican	Unknown	TOTAL
All ANES voters	**38%**	**28%**	**32%**	**3%**	**12,550**
Voted for senator*	40%	25%	34%	2%	4,892 (39%)
Voted for senator and in primary	47%	19%	33%	1%	2,821 (22%)

Based on voters who voted for senator and recalled which party they voted for.

ANES voters lean liberal on some issues (#1 and 2) and conservative on others (#3, 4, and 5).

Only 39% of registered voters voted for senator; Independents were underrepresented in Senate elections and primaries.

Based on 2016 + 2020 ANES variables (see Appendix for details). Issue categories align with Krasa and Polborn (2017), and scores for issues #1-4 reflect a weighted sum of variables (with weights derived from a principal components analysis). For issue #5, missing ideology values were imputed using the mean.

Step 3: Tribalism

Motivation: Political tribalism has increased dramatically in recent years

- Meta-analysis of 51 studies (19,000 people) showed voters' support for identical policies/actions differed depending on which candidate they believe enacted it (Bernstein et al. 2024).
- Tribalism can capture latent components of voting behavior, complementing issue positions.

ANES data: Most voters who voted in the Senate, House, and presidential races voted strictly along party lines (i.e., for candidates in their own party, or, in the case of I/U voters, for independent candidates).

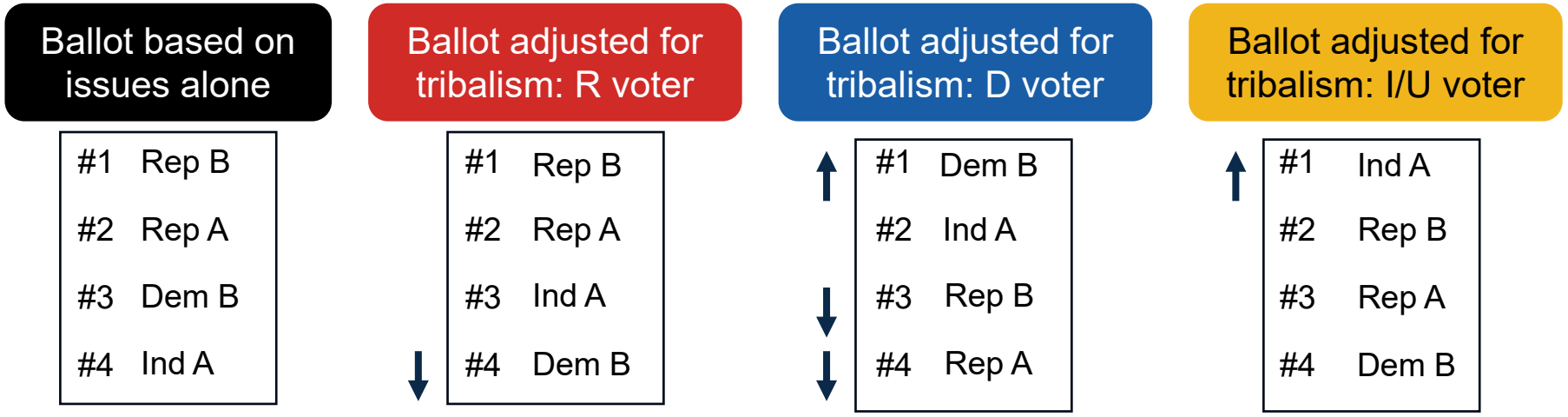
	Percentage who voted along party lines in 2016 or 2020 races		
	Registered D voters	Registered R voters	I/U voters
Senate race	87%	85%	4%
House race	84%	85%	4%
Presidential race	90%	86%	7%
More than one race	**78%**	**75%**	**<1%**

Step 3: Simulating tribalism in RCV elections

Approach

1) Modeled likelihood of straight-party vote using voters' issue views and demographics (gender, race/ethnicity, age, education, income, marital status, active-duty status, worry about finances).

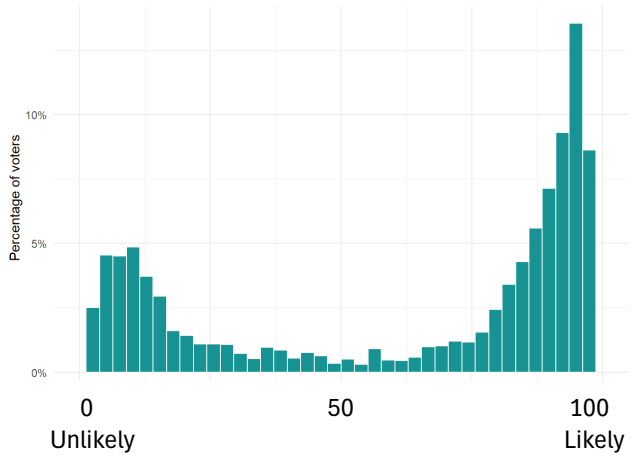
2) Used predicted probabilities from the model to weight a coin flip.
   - Generated voters' initial ballots (candidate rankings) based on issue distances + noise.
   - If the flip indicated a straight-party vote: (A) Moved candidates from voter's own party to the top of their ballot
     - and - (B) For D & R voters, moved candidates from other party to the bottom.



Impact of the tribalism mechanism

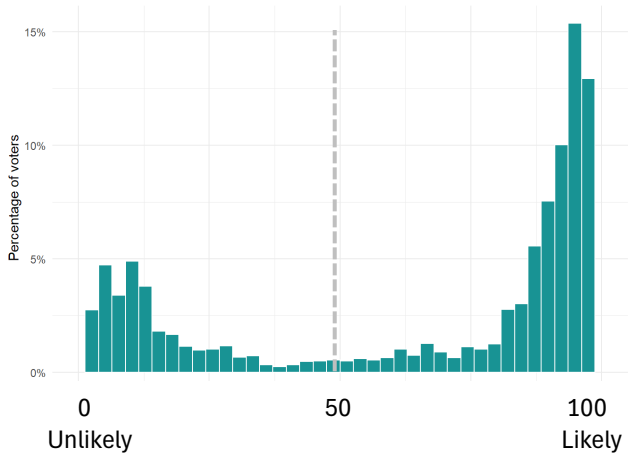
D voters
Mean = 66% with a straight-party vote

P(Straight-party vote)



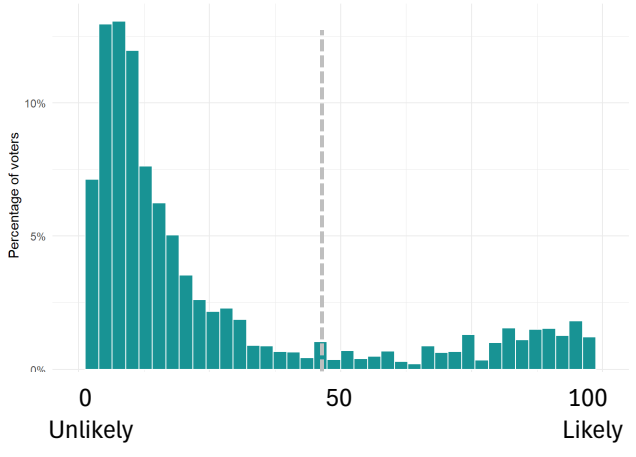
R voters
Mean = 63% with a straight-party vote

P(Straight-party vote)



I/U voters
Mean = 26% with I/U candidates prioritized

P(Straight-party vote)



Across simulated elections, 66% of D voters and 63% of R voters were identified as straight-party voters.
Though 4% of I/U ANES voters voted for I/U senate candidates, we estimated 26% would favor I/U candidates under RCV.

Step 4: Performance metrics *(0 to 100 scale)*

Identified performance metrics most relevant to the research questions at hand and most likely to differentiate the eight voting rules (based on theory).

RQ1

1) **Moderation index (based on winner)**
   Election of centrist candidates (with median ideology score)
2) **Voter satisfaction efficiency**
   Election of representative candidates (who are close to voters on issues and ideology)

RQ2

3) **Condorcet efficiency**
   Election of majority-preferred candidates (based on pairwise comparisons)
4) **Local independence of irrelevant alternatives**
   Resistance to spoiler candidates (i.e., removal of the winner or lowest-ranked candidate does not change the relative order in which the other candidates finish)

Main Results

1,000	999	326
simulated elections	*Condorcet winner existed*	*All 8 voting rules aligned on winner*

Scenarios

- Tribalism mechanism
  (without, **with**)
- Truncation rate
  (0%, **49%** of ballots)
- Number of candidates
  (n = 3, **4**, 5 in senate election)
- Primary election type
  (fully closed, **multi-party jungle**)
- Polarization level
  (**16%**, 32% at ideological poles)

*** Indicates the scenario values used in the main analyses**

Average performance and vulnerability

Best performance[a] | Next best performance | Most vulnerable[b] | Next most vulnerable

MAIN analysis	By scenario							
	Entry of new candidates	No tribalism	Truncated ballots	High voter polarization	Closed primary	More *(n=5)* candidates	Fewer *(n=3)* candidates	Legitimacy challenges[c]
Baldwin [c]	Baldwin [c]	Baldwin [c]	Baldwin [c]	Baldwin [c]	Baldwin [c]	Baldwin [c]	Baldwin [c]	Baldwin [c]
Nanson [c]	Nanson [c]	Nanson [c]	Nanson [c]	Nanson [c]	Nanson [c]	Nanson [c]	Nanson [c]	Nanson [c]
Copeland [c]	Copeland [c]	Copeland [c]	Copeland [c]	Copeland [c]	Copeland [c]	Copeland [c]	Copeland [c]	Copeland [c]
Black [c]	Black [c]	Black [c]	Black [c]	Black [c]	Black [c]	Black [c]	Black [c]	Black [c]
Minimax [c]	Minimax [c]	Minimax [c]	Minimax [c]	Minimax [c]	Minimax [c]	Minimax [c]	Minimax [c]	Minimax [c]
Coombs	Coombs	Coombs	Coombs	Coombs	Coombs	Coombs	Coombs	Coombs
IRV	IRV	IRV	IRV	IRV	IRV	IRV	IRV	IRV
Plurality	Plurality	Plurality	Plurality	Plurality	Plurality	Plurality	Plurality	Plurality

Copeland had the most robust performance followed closely by Baldwin and Nanson across most scenarios.
Plurality consistently performed worst, and IRV and Coombs were also vulnerable across several scenarios.

[a] Performance was based on average metric scores.
[b] Vulnerability was generally based on the change in average metric score from the main analysis.
[c] Legitimacy challenges may arise if the leading candidate in the first round of vote tabulation does not emerge as the ultimate election winner.

Which voting rules perform best overall?

	Moderation index	Voter satisfaction efficiency	Condorcet efficiency	Local IIA met
Baldwin [C]	94%	99%	100%	84%
Nanson [C]	94%	99%	100%	82%
Copeland [C]	94%	99%	100%	100%
Black [C]	94%	99%	100%	78%
Minimax [C]	94%	99%	100%	59%
Coombs	94%	97%	92%	72%
IRV	90%	87%	61%	23%
Plurality	78%	65%	37%	8%
% of elections with criterion possible:	*100%*	*100%*	*>99%*	*100%*

Condorcet rules performed comparably on most metrics and uniformly outperformed the other voting rules.
Local IIA best distinguished voting rules, being highest for Copeland. Among non-Condorcet rules, Coombs fared best.

IIA = independence of irrelevant alternatives.

Vote tallies and margins (first + last round leaders)

	Tabulation rounds required (mean)	Ballot exhaustion rate (mean)	Elections in which winner led in 1st place votes: First round	Leading margin: First round (winner vs. runner-up, mean)	Margin of victory: Final round (winner vs. runner-up, mean)[a]
Baldwin [C]	3.0	8%	37%	-2 pp	12 pp
Nanson [C]	2.0	7%	37%	-2 pp	10 pp
Copeland [C]	≡ 1.0	0%	37%	-2 pp	5 pp
Black [C]	≡ 1.0	0%	37%	-2 pp	5 pp
Minimax [C]	≡ 1.0	0%	37%	-2 pp	1 pp
Coombs	3.0	10%	35%	-3 pp	15 pp
IRV	2.9	8%	57%	3 pp	16 pp
Plurality	≡ 1.0	0%	100%	8 pp	8 pp

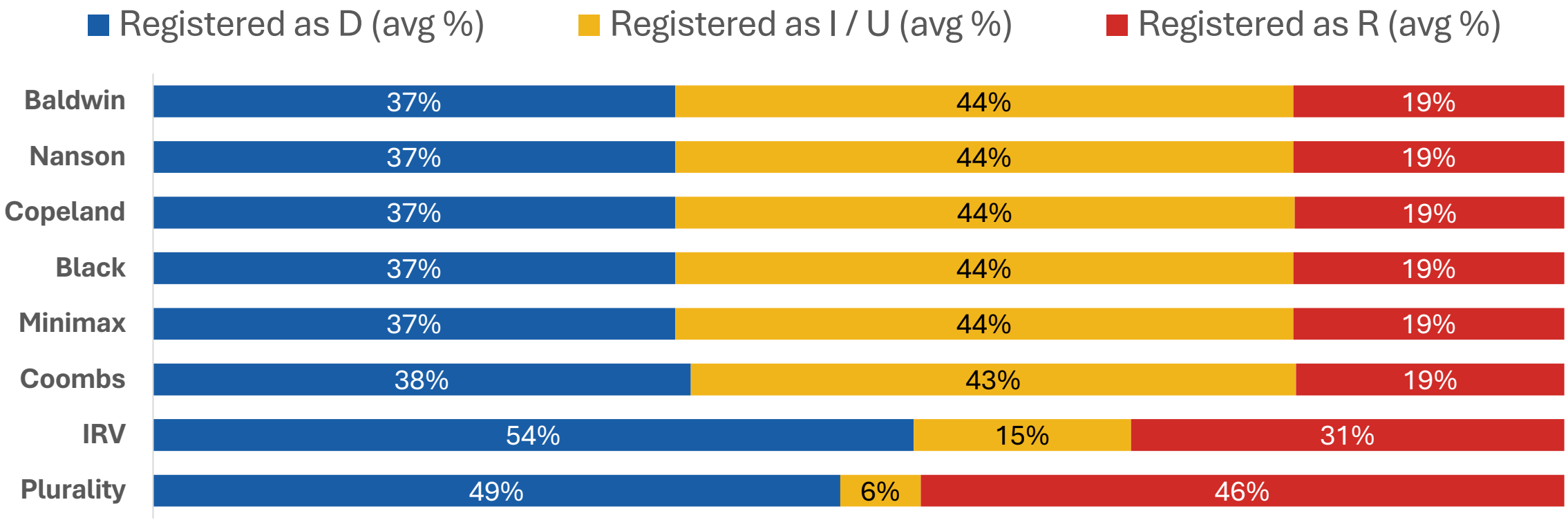
[a] For comparison, the average margin of victory was 18 pp in the most recent Senate election and ranged from <1% to 51% across states.

In most simulated elections, the winner trailed in the first round, particularly under Condorcet rules and Coombs.
In real-world elections, Condorcet rules and Coombs could be more subject to legitimacy challenges than IRV or Plurality.

pp = percentage points.

Source for Senate margins of victory: Ballotpedia (e.g., https://ballotpedia.org/United_States_Senate_elections,_2024#Margins_of_victory).

Winning candidate, by registered party



Condorcet rules and Coombs were more likely than IRV or Plurality to elect an I/U senate candidate.
Ds were elected more often than Rs under most rules, reflecting the influence of party over ideology.

Source for Senate margins of victor: Ballotpedia (e.g., https://ballotpedia.org/United_States_Senate_elections,_2024#Margins_of_victory).

Scenario Analyses

Tribalism
(Without vs. With)

Does the tribalism mechanism affect performance?

	Moderation index		Voter satisfaction efficiency		Condorcet efficiency		Local IIA met	
	Without tribalism	*With tribalism*	*Without tribalism*	*With tribalism*	*Without tribalism*	*With tribalism*	*Without tribalism*	*With tribalism*
Baldwin [C]	93%	94%	99%	99%	100%	100%	87%	84%
Nanson [C]	93%	94%	99%	99%	100%	100%	85%	82%
Copeland [C]	93%	94%	99%	99%	100%	100%	100%	100%
Black [C]	93%	94%	99%	99%	100%	100%	81%	78%
Minimax [C]	93%	94%	99%	99%	100%	100%	62%	59%
Coombs	93%	94%	98%	97%	96%	92%	85%	72%
IRV	91%	90%	95%	87%	79%	61%	34%	23%
Plurality	84%	78%	78%	65%	54%	37%	15%	8%
% of elections with criterion possible:	*100%*	*100%*	*100%*	*100%*	*100%*	*>99%*	*100%*	*100%*

The tribalism mechanism weakened the average performance score of all voting rules except Copeland.
Plurality and IRV were weakened most by tribalism; Coombs was more comparable to the Condorcet rules without tribalism.

C = Condorcet compliant voting rule; IIA = independence of irrelevant alternatives; IRV = instant runoff voting.

Ballot Truncation

(0% vs. 49%)

Ballot truncation in past elections

In past RCV elections, on average:

- **54%** of ballots were truncated (i.e., had only some candidates ranked)
- **11%** were exhausted (i.e., not counted in later rounds because all candidates on that ballot were eliminated)

- Voters who are **Asian, low income, or less educated** had higher ballot truncation rates.
- A similar share of voters ranked 1, 2, 3, 4 (of 5) candidates in NYC 2021 primary.
- Among those who ranked only 1 candidate, reasons included **preference** and lack of **familiarity** with candidates

Source	Election location and year (type)	Ballots truncated	Ballots exhausted
Kilgour et al. 2020	Santa Fe, NM, 2018 (mayor)	30%	4%
	Takoma Park, MD 2007 (municipal)	42%	0%
	Burlington, VT 2006, 2009 (mayor)	73%, 68%,	11%, 7%
Common Cause 2021	NYC, NY 2021 (mayor)	58%	NA
McCarty 2024	95 elections (municipal)	NA	10.5%
	Alaska 2022 (state senate)	NA	5%
Burnett and Kogan 2015	San Leandro, CA 2010 (mayor)	NA	10%
	Pierce County, WA 2008 (city council)	NA	10%
	Oakland, CA 2010 (mayor)	NA	12%
	San Francisco, CA 2011 (mayor)	NA	27%

NA = not available.

Data-driven approach to truncation

Step 1: We considered a voter's ballot truncated if they had lower voter engagement (i.e., a **bolded** response to any of the following ANES questions):

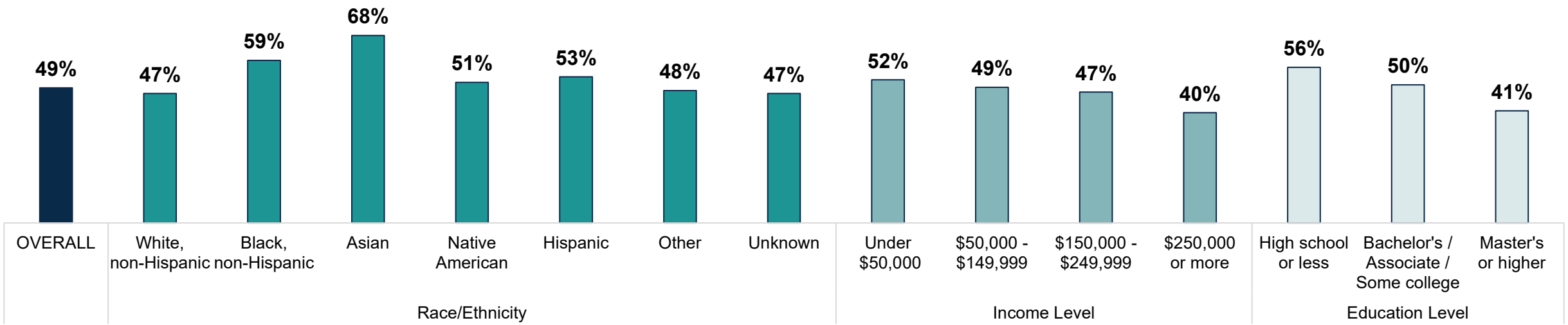
1) How often do you pay attention to what's going on in government and politics?	*2) Some people don't pay much attention to political campaigns. How about you?*	*3) How much do you care who wins the presidential election this fall?*
Always	Very much interested	A great deal
Most of the time	**Somewhat interested**	A lot
About half the time	**Not much interest**	**A moderate amount**
Some of the time		**A little**
Never		**Not at all**

Step 2: Among voters deemed to have a truncated ballot, we randomly selected the number of candidates to be ranked *(n ~ U[1, n-2])*.

Step 3: We identified unranked candidates as those at the bottom of each voter's ballot (i.e., the least preferred candidates).

Data-driven truncation rates, by group

Ballot truncation rate (among Senate election voters in 2016 + 2020 ANES data)



Using voter engagement level as a proxy for ballot truncation led to rates that align with real-world elections.
Ballot truncation rates were highest for Asian, low-income, and less-educated voters.

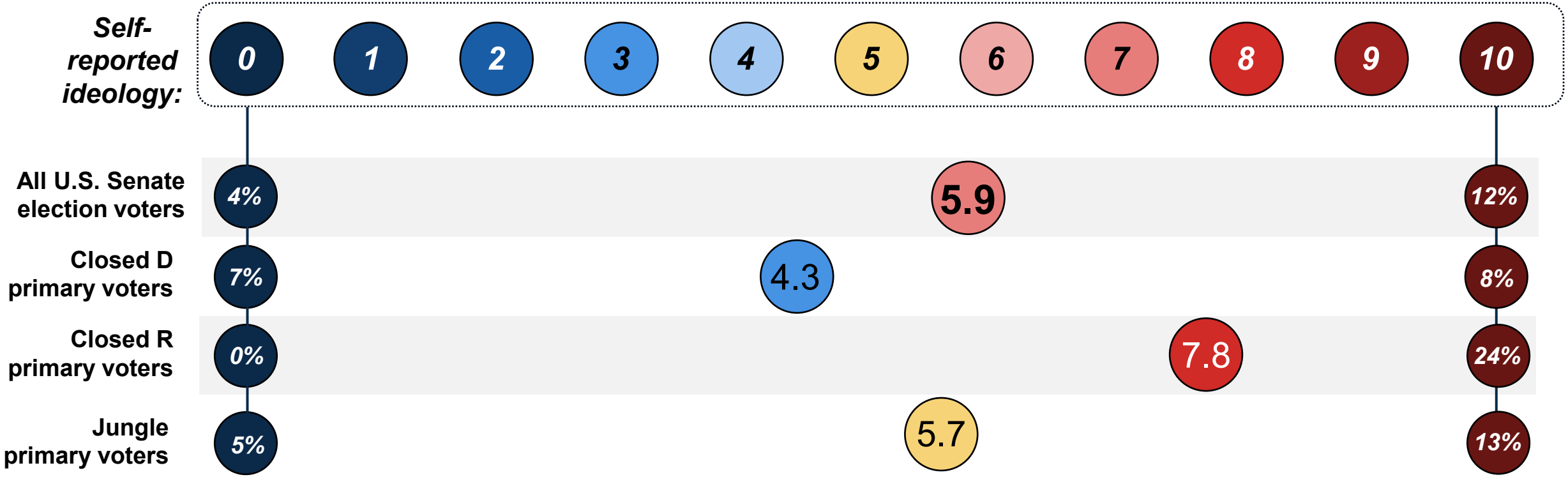
Does ballot truncation affect performance?

	Moderation index		Voter satisfaction efficiency		Condorcet efficiency		Local IIA met	
	0% truncation	*49% truncation*	*0% truncation*	*49% truncation*	*0% truncation*	*49% truncation*	*0% truncation*	*49% truncation*
Baldwin [C]	94%	94%	98%	99%	100%	100%	83%	84%
Nanson [C]	94%	94%	98%	99%	100%	100%	81%	82%
Copeland [C]	94%	94%	98%	99%	100%	100%	100%	100%
Black [C]	94%	94%	98%	99%	100%	100%	74%	78%
Minimax [C]	94%	94%	98%	99%	100%	100%	61%	59%
Coombs	94%	94%	96%	97%	93%	92%	84%	72%
IRV	91%	90%	88%	87%	53%	61%	20%	23%
Plurality	78%	78%	64%	65%	28%	37%	6%	8%
% of elections with criterion possible:	*100%*	*100%*	*100%*	*100%*	*>99%*	*>99%*	*100%*	*100%*

Ballot truncation had mixed effects on performance, with Coombs being most vulnerable because of weakened IIA.
Plurality and IRV had higher Condorcet efficiency with truncation, Black had higher IIA, and other Condorcet rules varied little.

Polarization
(16% vs. 32%)

Ideological polarization of ANES voters



ANES voters lean slightly conservative overall, and 16% sat at the ideological poles (4% at 0, 12% at 10).
Voter ideology skewed as expected when summarized separately by simulated primary election type.

Based on 2016 + 2020 ANES data, restricted to voters who voted for senators in the general election and participated in their state's primary election.

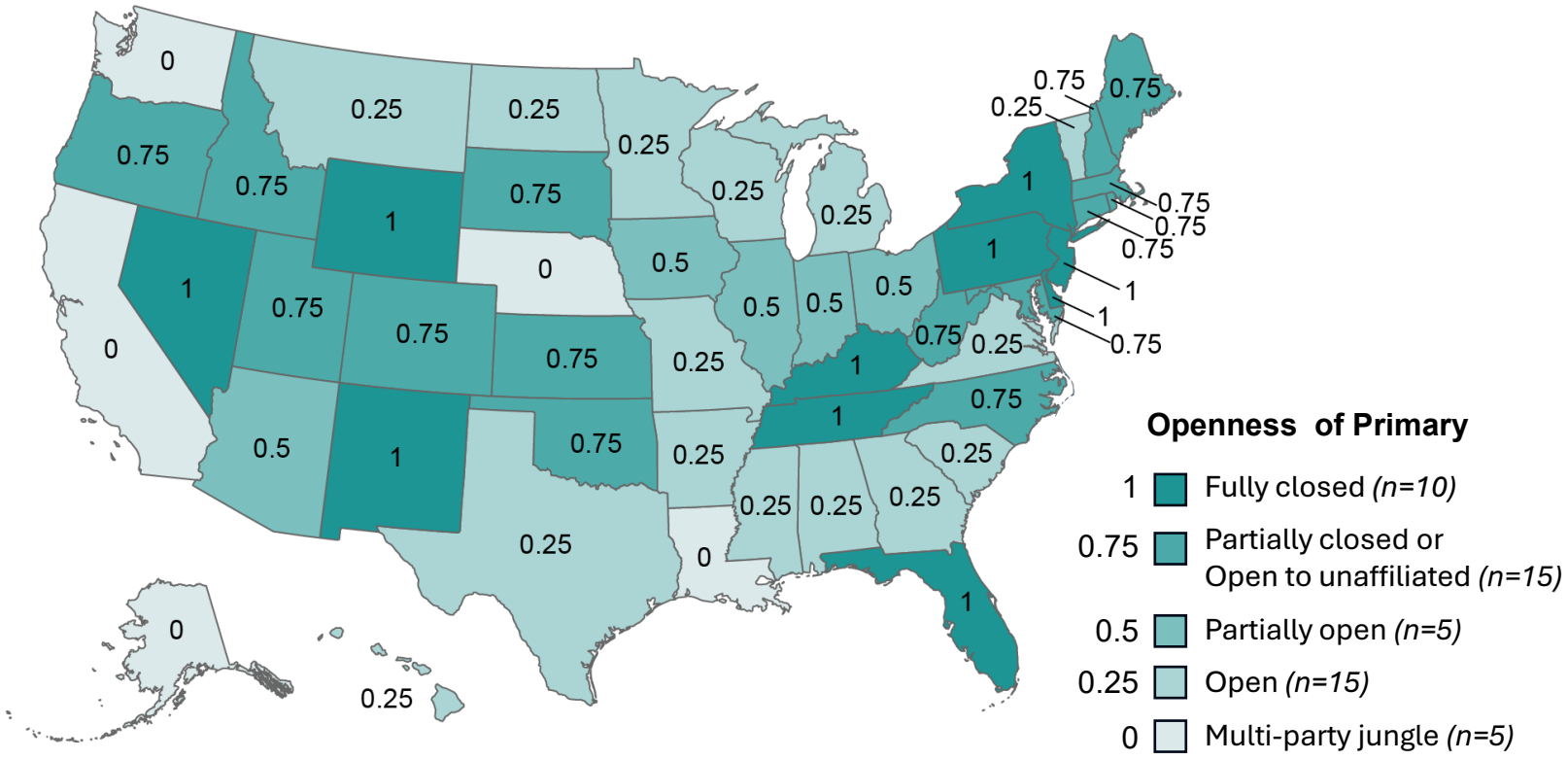
Does voter polarization level affect performance?

	Moderation index		Voter satisfaction efficiency		Condorcet efficiency		Local IIA met	
	16% at ideological poles	*32% at ideological poles*	*16% at ideological poles*	*32% at ideological poles*	*16% at ideological poles*	*32% at ideological poles*	*16% at ideological poles*	*32% at ideological poles*
Baldwin [C]	94%	89%	99%	98%	100%	100%	84%	83%
Nanson [C]	94%	89%	99%	99%	100%	100%	82%	80%
Copeland [C]	94%	89%	99%	99%	100%	100%	100%	100%
Black [C]	94%	89%	99%	99%	100%	100%	78%	73%
Minimax [C]	94%	89%	99%	99%	100%	100%	59%	58%
Coombs	94%	89%	97%	97%	92%	94%	72%	74%
IRV	90%	82%	87%	85%	61%	51%	23%	20%
Plurality	78%	61%	65%	61%	37%	30%	8%	8%
% of elections with criterion possible:	*100%*	*100%*	*100%*	*100%*	*>99%*	*99%*	*100%*	*100%*

Plurality was most vulnerable to extremism (on moderation), followed by IRV (Condorcet efficiency) and Black (IIA).
A more polarized electorate weakened moderation under all rules but had little impact on voter satisfaction.

Primary Type
(fully closed vs. multiparty jungle)

Primary election types, by state



Approach

For the single jungle primary election, selected the top 3-5 candidates to move on to the Senate election using a first-past-the-post system.

For the 3 closed partisan primaries (which included 7 candidates total), identified the winner from each primary using a first-past-the-post rule and randomly selected 1-2 others to move on.

The type of primary election held varies from state to state, from a fully closed to multiparty jungle primary.
Some primaries allow unaffiliated or non-party voters to participate so long as they are willing to register with the party.

Source: The National Conference of State Legislatures (February 2024).

Does the primary election type affect performance?

	Moderation index		Voter satisfaction efficiency		Condorcet efficiency		Local IIA met	
	Closed primary	*Jungle primary*	*Closed primary*	*Jungle primary*	*Closed primary*	*Jungle primary*	*Closed primary*	*Jungle primary*
Baldwin [C]	93%	94%	98%	99%	100%	100%	85%	84%
Nanson [C]	93%	94%	98%	99%	100%	100%	83%	82%
Copeland [C]	93%	94%	98%	99%	100%	100%	100%	100%
Black [C]	93%	94%	98%	99%	100%	100%	77%	78%
Minimax [C]	93%	94%	98%	99%	100%	100%	61%	59%
Coombs	92%	94%	97%	97%	92%	92%	67%	72%
IRV	88%	90%	87%	87%	59%	61%	21%	23%
Plurality	78%	78%	70%	65%	38%	37%	12%	8%
% of elections with criterion possible:	*100%*	*100%*	*100%*	*100%*	*>99%*	*>99%*	*100%*	*100%*

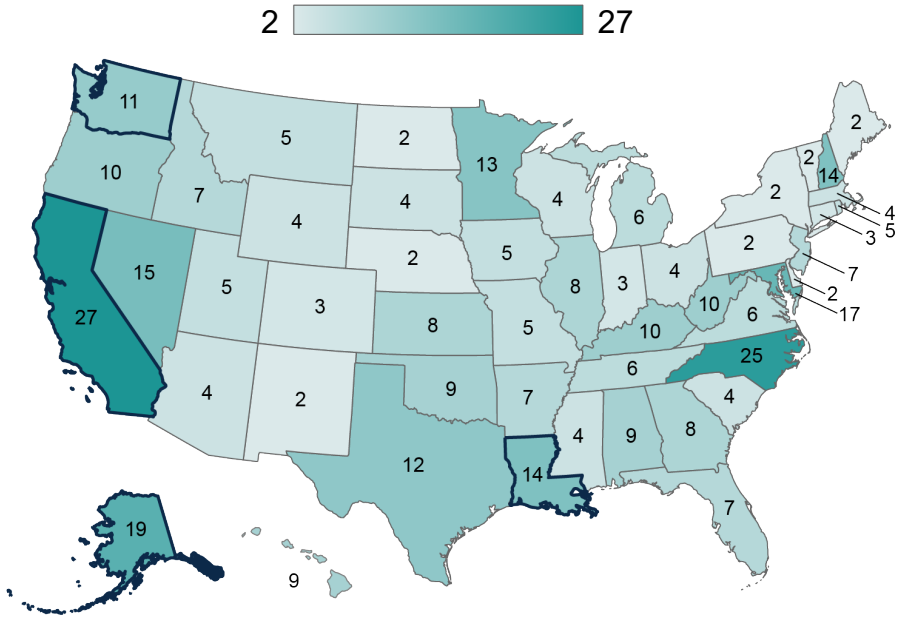
Coombs improved most (on IIA) and Plurality weakened (satisfaction) when moving from a closed to jungle primary.
Condorcet voting rules were less affected by primary type; impacts might be more pronounced with a primary that uses RCV.

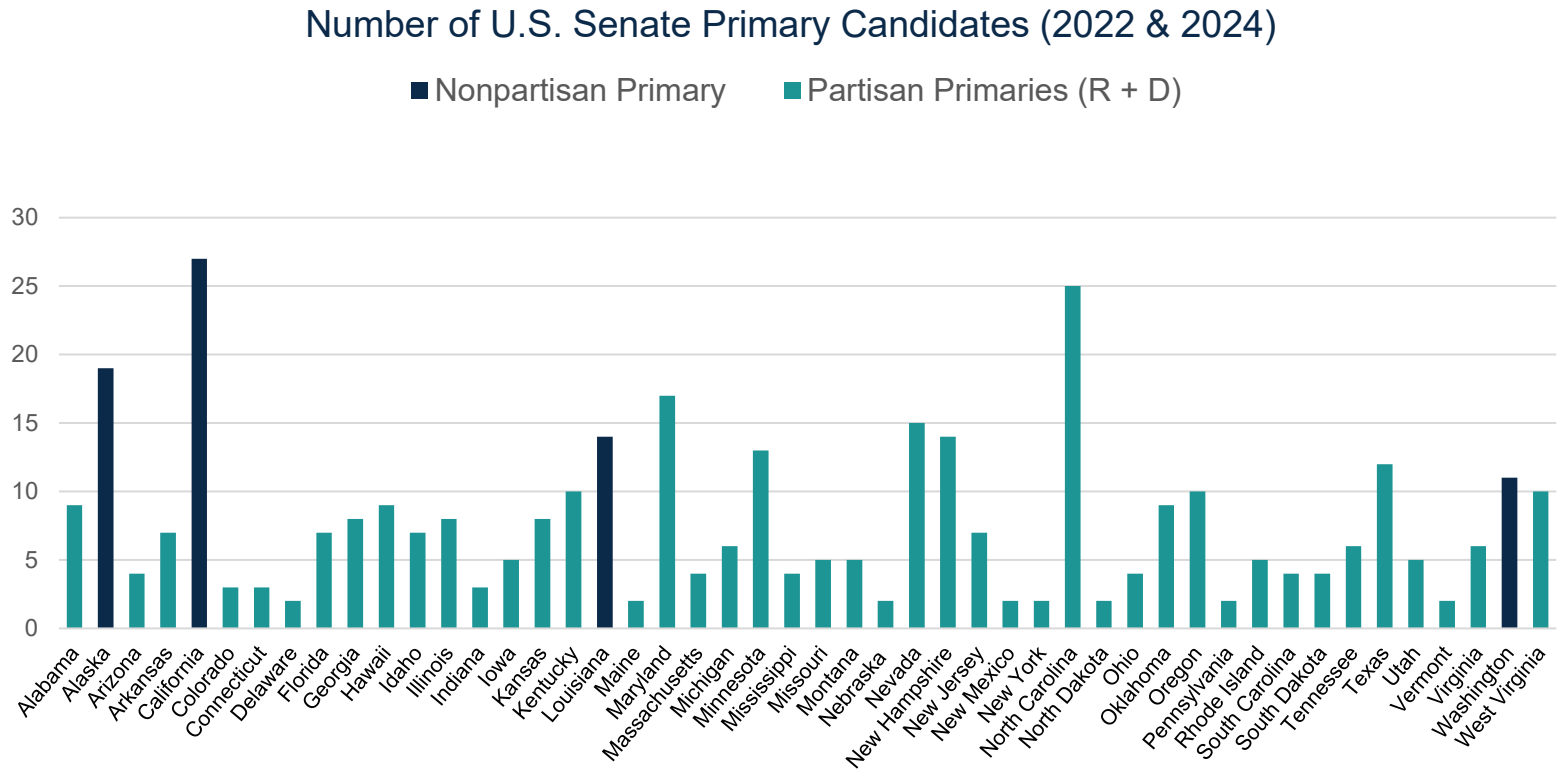
Number of Candidates

(7 primary; 3, 4, 5 in general election)

Motivation for 7-candidate primaries

☐ = **Nonpartisan primary state**





In the most recent U.S. Senate elections (2024 / 2022), states averaged 7.5 primary candidates *(excluding write-ins)*.
The average was 6.6 candidates in partisan primary states versus 17.8 in nonpartisan primary states.

Source: Ballotpedia (e.g., https://ballotpedia.org/United_States_Senate_Democratic_Party_primaries,_2024).

Does the number of Senate candidates affect performance?

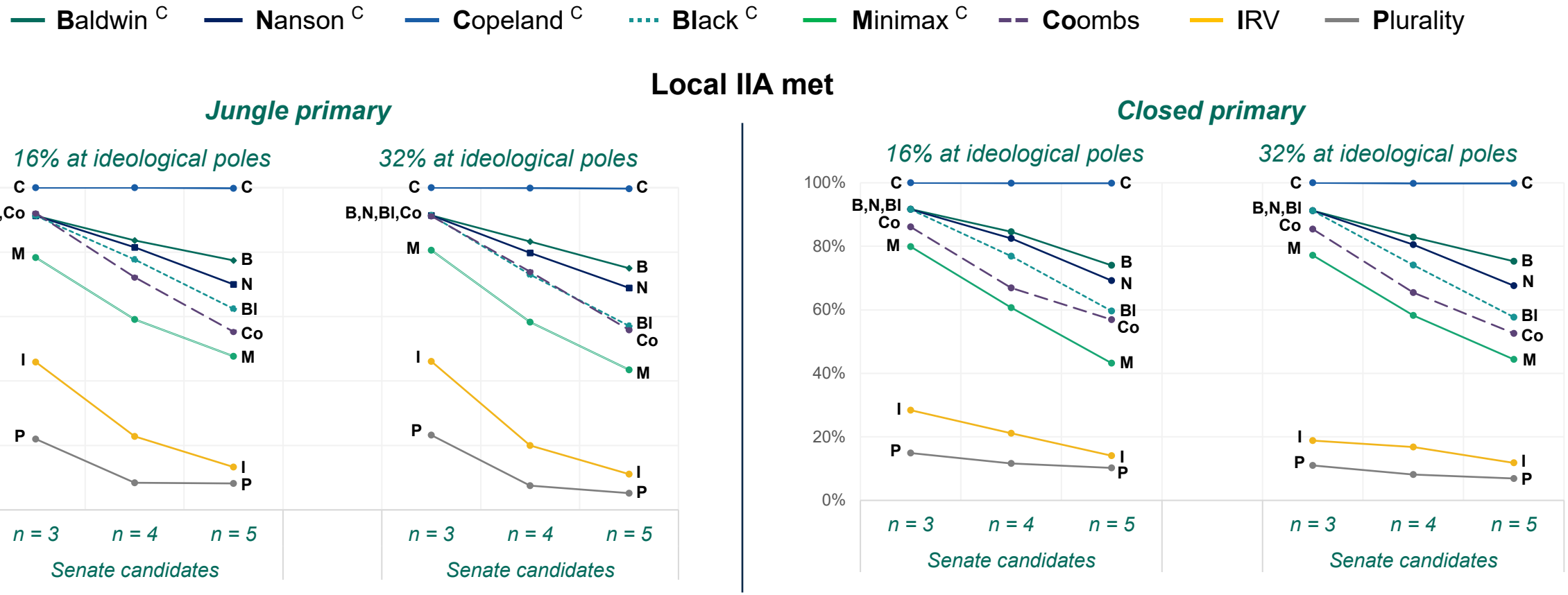
	Moderation index			Voter satisfaction efficiency			Condorcet efficiency			Local IIA met		
	n = 3	*n* = 4	*n* = 5	*n* = 3	*n* = 4	*n* = 5	*n* = 3	*n* = 4	*n* = 5	*n* = 3	*n* = 4	*n* = 5
Baldwin [C]	93%	94%	94%	99%	99%	99%	100%	100%	100%	91%	84%	77%
Nanson [C]	93%	94%	94%	99%	99%	99%	100%	100%	100%	91%	82%	70%
Copeland [C]	93%	94%	94%	99%	99%	99%	100%	100%	100%	100%	100%	100%
Black [C]	93%	94%	94%	99%	99%	99%	100%	100%	100%	91%	78%	62%
Minimax [C]	93%	94%	94%	99%	99%	99%	100%	100%	100%	78%	59%	48%
Coombs	93%	94%	93%	98%	97%	97%	98%	92%	88%	92%	72%	55%
IRV	90%	90%	90%	89%	87%	88%	75%	61%	56%	46%	23%	13%
Plurality	81%	78%	75%	69%	65%	63%	44%	37%	32%	22%	8%	8%
% of elections with criterion possible:	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*>99%*	*>99%*	*>99%*	*100%*	*100%*	*100%*

Coombs and IRV were most vulnerable to a larger field of candidates *(n = 5)*, and Copeland was most robust.
With fewer Senate candidates (*n* = *3*), Baldwin, Nanson, Black, and Coombs all performed comparably.

Interactive Effects

(two-way and three-way interactions)

Do the effects of polarization, primary, and candidate counts interact?



With only three candidates competing, IRV fared better on local IIA under a Jungle versus Closed primary.
With higher voter polarization, the decrease in Black's IIA as more candidates competed was larger under a Jungle primary.

New Candidate Entry

Assessing robustness to new candidates

1) Define MAIN candidates

Create three-candidate race with 1 D, 1 I, and 1 R

- Bedrock candidates sit at median of voters' issue positions by party
- Fringe candidates sit at extremes on each issue (-1, -0.8, 1, respectively)

2) Define NEW candidates

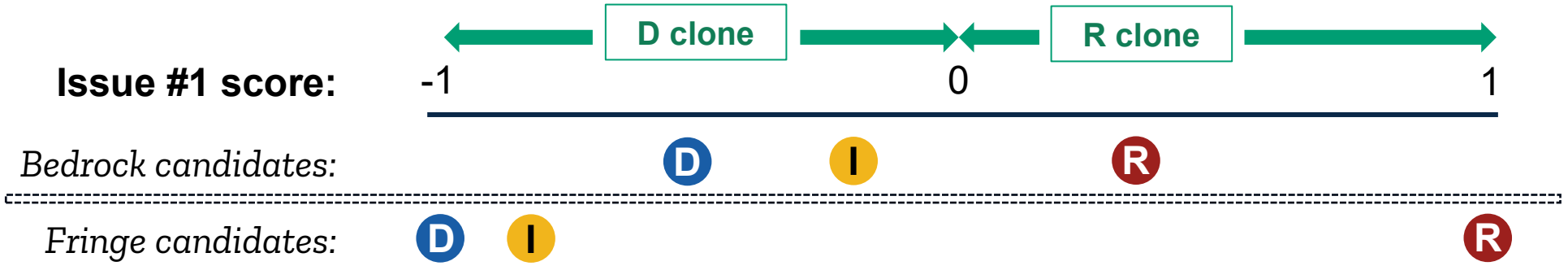
Clone D or R candidate and vary the clone's issue position(s)

- Move new D candidate across their ideological space (-1 to 0) by $\Delta = 0.02$
- Move new R candidate across their ideological space (0 to 1) by $\Delta = 0.02$

3) Assess impact

Record how results change with the new candidate entry

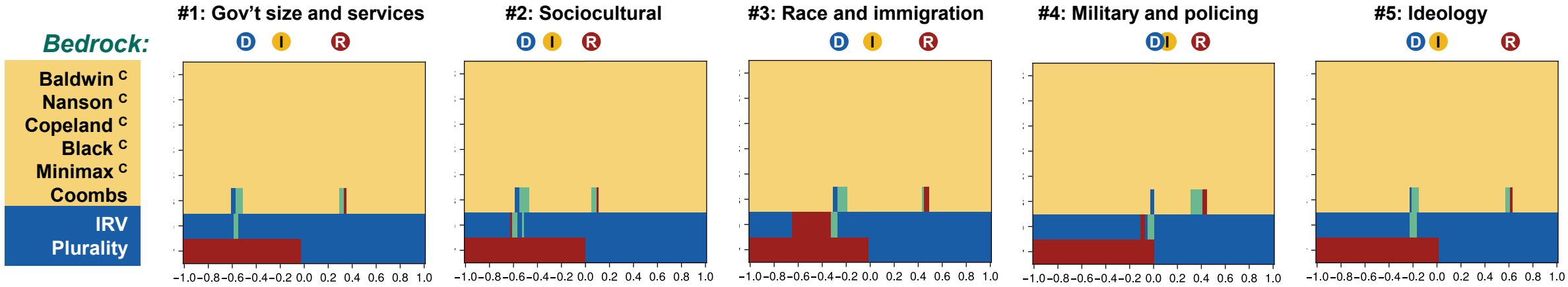
- Assess whether new candidate:
  (A) Has no impact
  (B) Wins
  (C) Flips the election
- For B and C, visualize the new candidate's position, and assess if change yielded better outcomes.



I = independent.

Does new candidate entry disrupt elections with bedrock candidates?

Winner | D I R New candidate



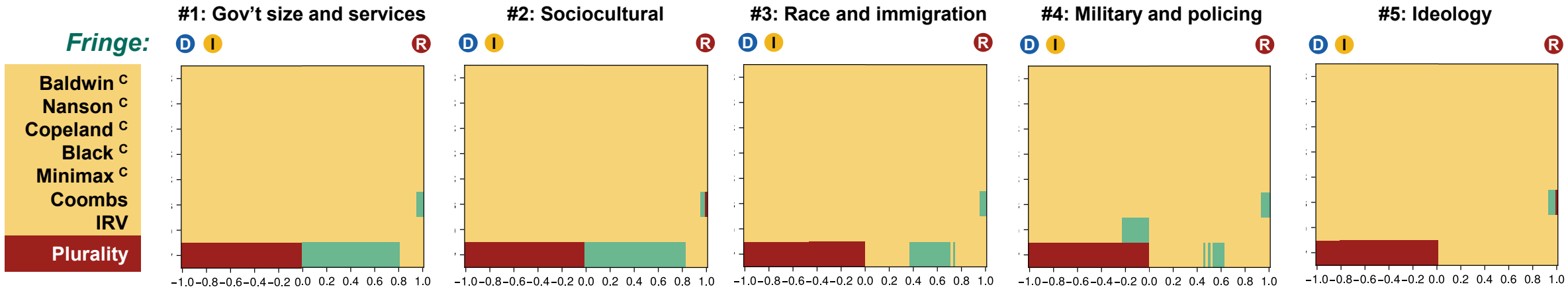
	With no new candidate (i.e., three-candidate election)				When the new candidate changed the winner			
	Moderation index (winner)	Voter satisfaction efficiency	Condorcet winner elected	Local IIA met	Moderation index worsened	Voter satisfaction efficiency worsened	Condorcet winner elected	Local IIA met
Coombs	100%	100%	Yes	Yes	100%	100%	0%	0%
IRV	96%	35%	No	No	53%	88%	0%	0%
Plurality	96%	35%	No	No	100%	78%	0%	0%

New candidates captured or flipped the three-candidate bedrock election under the non-Condorcet voting rules only.
Under Coombs, IRV, and Plurality, the flip led to worse performance metrics most of the time.

Note: The shading behind the voting rule name indicates the winner of the party of the three-candidate election winner selected under that voting rule.

Does new candidate entry disrupt elections with fringe candidates?

Winner | D I R New candidate



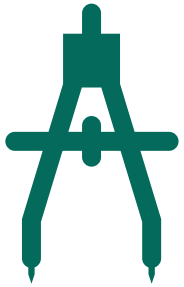
	With no new candidate (i.e., three-candidate election)				When the new candidate changed the winner			
	Moderation index (winner)	Voter satisfaction efficiency	Condorcet winner elected	Local IIA met	Moderation index improved	Voter satisfaction efficiency improved	Condorcet winner elected	Local IIA met
Coombs	36%	100%	Yes	No	0%	0%	0%	0%
IRV	36%	100%	Yes	Yes	0%	0%	0%	0%
Plurality	0%	0%	No	No	58%	100%	58%	0%

New candidates captured or flipped the three-candidate fringe election under the non-Condorcet voting rules only.
Under Plurality (but not Coombs or IRV), moderation and voter satisfaction improved most of the time.

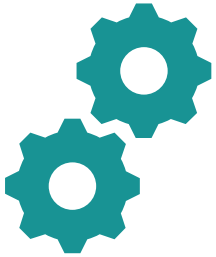
Note: The shading behind the voting rule name indicates the winner of the party of the three-candidate election winner selected under that voting rule.

Key Takeaways

Key RQs revisited



RQ1: Which RCV rules elect more moderate candidates who represent the electorate?



RQ2: Which RCV rules are most vulnerable to voter polarization and spoiler candidates?

Key insights from agent-based modeling

In simulations with no strategy, no ballot errors, and equal viability of all candidates:

1) **There was a stark, consistent performance gap between Condorcet- and non-Condorcet voting rules, but minimal differences within the class of Condorcet voting rules.**
   - Condorcet rules elected more moderate candidates and were least vulnerable to polarization and spoilers (per local IIA).
   - Among the non-Condorcet voting rules, IRV improved on Plurality, and Coombs improved on IRV.
   - The large performance gap between Condorcet and other rules points to opportunity for gains via election reform.

2) **The most widely debated rules in electoral reform discourse (Plurality + IRV) performed worst.**
   - Plurality (the most used voting rule in the United States) consistently ranked at the bottom on all metrics.
   - Plurality and IRV were by far most vulnerable to spoiler candidates, voter polarization, and tribalism stress tests.

3) **Copeland was the only voting rule not vulnerable to spoiler effects (local IIA violations).**
   - Baldwin and Nanson were also robust to IIA violations but to a lesser extent than Copeland, and only in some scenarios.
   - Local IIA violations indicate the lack of a fully consistent collective ranking of non-winning candidates.

4) **If voting rules elect winners who trail in first-place votes early on, legitimacy challenges can arise.**
   - Spoiler effects also open the door for parties and candidates to attack the legitimacy of election outcomes.

Suggested extensions to improve realism

Factor in ballot errors and strategy

RCV ballots ~10x more likely to be rejected for errors (Pettigrew and Radley 2025)

- Develop data-driven mechanism to incorporate ballot errors
- Assess robustness to strategic nomination, strategic exit, burying (Green-Armytage 2013)

Simulate systems of influence

Financing, endorsements, and media affect candidate entry and voter familiarity

- Build in effects of incumbency, fundraising, endorsements, DNC/RNC support
- Modify truncation mechanism to account for voters' distaste for candidates

Map a real-world election to our model

The 2025 NYC Democratic mayoral primary yielded unexpected results to many

- Identify candidate issue positions using candidate websites, tweets, AI
- Modify primary to use IRV and adjust issue weights using grantee survey results
- Validate results and see how they change with small tweaks *(e.g., to primary type)*

DNC / RNC = Democratic / Republican National Convention; NYC = New York City.

APPENDIX

Glossary

Borda score: Points assigned to a candidate based that candidate's ranking on a ballot (with more points for higher-ranked candidates).

Condorcet winner: A candidate who beats all other candidates in pairwise (one-on-one) comparisons.

Condorcet compliant rule: A voting rule that elects the Condorcet winner whenever one exists.

Condorcet efficiency: The share of elections in which a candidate preferred by a majority of voters in a head-to-head comparison against every other candidate wins. Calculated among elections in which a Condorcet winner exists.

Exhausted ballot: A ballot that is excluded in later tabulation rounds because all candidates on that ballot were eliminated in earlier rounds.

Local Independence of irrelevant alternatives: The share of elections in which removing the winner or the lowest-ranked candidate (e.g., from a recount, runoff, or disqualification) does not change the relative order in which other candidates finish. Adapted from Young (1995).

Majority winner: A candidate ranked first on a majority of voter ballots.

Moderation index: The squared difference between the self-reported ideology of the winning candidate and the midpoint of the ideology scale (5), transformed into an index score.

Pairwise comparisons: A method of comparing every possible pair of candidates in a head-to-head matchup to determine a winner, by counting the number of ballots on which one candidate ranks higher than another, and vice-versa.

Spoiler: A candidate who does not win the election but, by entering, draws enough support from other candidates to alter the outcome in favor of a less-preferred alternative.

Truncated ballot: A ballot that ranks some but not all candidates who are running in the election.

Voter satisfaction efficiency: Social utility of the winning candidate divided by the max social utility possible across all candidates in the election, standardized by the minimum social utility across candidates (social utility = Euclidean distance between a candidate and voters).

ANES variables analyzed

ANES 2016 / 2020 variable	ANES 2016 variable description
Variable weight	
V160102/V200010b	Post-election weight -full sample
Selection of voters and candidates	
V162046/V202087	POST: Did Respondent vote for U.S. Senate
V161021/V201020	PRE: Did Respondent vote in a Presidential primary or caucus
V161267x/V201507x	PRE: SUMMARY - Respondent age group
V162030x/V202065x	PRE-POST: SUMMARY - Party of registration
V161155/V201228	PRE: Party ID: Does R think of self as Dem, Rep, Ind or what
Ballot truncation and tribalism	
V161003/V201005	PRE: How often does Respondent pay attn to politics and elections
V161004/V201006	PRE: How interested in following campaigns
V161145/V201216	PRE: Care who wins Presidential Election revised version
V161268/V201508	PRE: Respondent marital status
V161274a/V201516	PRE: Previously served on active duty in armed forces
V162165/V201594	POST: Worry about financial situation
V161270/V201510	PRE: Highest level of Education
V161310x/V201549x	PRE: SUMMARY - Respondent self-identified race
V161342/V201549x	PRE FTF CASI / WEB: Respondent self-identified gender
V161361x/V201457x	PRE FTF CASI/WEB: Pre income summary

ANES variables analyzed (issue 1)

ANES 2016 / 2020 variable	ANES 2016 variable description
Issue dimension #1: Government size and services	
V161178 / V201246	PRE: 7pt scale spending and Services self-placement
V161184 / V201252	PRE: 7pt scale govt-private medical insurance scale: self-placement
V161189 / V201255	PRE: 7pt scale guaranteed job-income scale: self-placement
V161205 / V201300	PRE: Federal Budget Spending: Social Security
V161206 / V201303	PRE: Federal Budget Spending: public schools
V161209 / V201312	PRE: Federal Budget Spending: welfare programs
V161211 / V201318	PRE: Federal Budget Spending: aid to the poor
V161212 / V201321	PRE: Federal Budget Spending: protecting the environment
V161226x / V201405x	PRE: SUMMARY - require employers to offer paid leave to new parents
V162098 / V202162	POST: Feeling thermometer: LABOR UNIONS
V162100 / V202163	POST: Feeling thermometer: BIG BUSINESS
V162185 / V202253	POST: Less govt better OR more that govt should be doing
V162148 / V202257	POST: Does Respondent favor or oppose govt reducing income inequality
V162140 / V202325	POST: Does Respondent favor or oppose tax on millionaires
V162192 / V202377	POST: Should the minimum wage be raised
V162193x / V202380x	POST: SUMMARY- Increase/decrease gov spending for health care
V162276 / V202426	POST: Gov should take measures to reduce differences in income levels

ANES variables analyzed (issue 2)

ANES 2016 / 2020 variable	ANES 2016 variable description
Issue dimension #2: Sociocultural issues	
V161232 / V201336	PRE: STD Abortion: self-placement
V161228x / V201411x	PRE: SUMMARY - Transgender policy
V161229x / V201414x	PRE: SUMMARY - Laws to protect gays and lesbians against job discrim
V161230 / V201415	PRE: Should gay and lesbian couples be allowed to adopt
V161231 / V201416	PRE: Respondent position on gay marriage
V161244 / V201452	PRE: Ever attend church or religious services
V161245 / V201453	PRE: Attend religious services how often
V161245a / V201454	PRE: Attend church more often than once a week
V162103 / V202166	POST: Feeling thermometer: GAY MEN AND LESBIANS
V162111 / V202172	POST: Feeling thermometer: TRANSGENDER PEOPLE
V162227 / V202224	POST: How important that more women get elected
V162243 / V202260	POST: Society should make sure everyone has equal opportunity
V162245 / V202262	POST: Not a big problem if some have more chance in life
V162210 / V202265	POST: Agree/disagree: more emphasis on traditional family values
V162230x / V202290x	POST: SUMMARY- Better if man works and woman takes care of home
V161187 / V202337	PRE: Should fed govt make it more difficult to buy a gun

ANES variables analyzed (issue 3)

ANES 2016 / 2020 variable	ANES 2016 variable description
Issue dimension #3: Race and immigration	
V161198 / V201258	PRE: 7pt scale govt assistance to blacks scale: self-placement
V161194x / V201420x	PRE: SUMMARY - birthright citizenship
V162113 / V202174	POST: Feeling thermometer: BLACK LIVES MATTER
V162157 / V202232	POST: What should immigration levels be
V162238x / V202252x	POST: SUMMARY- Favor preferential hiring and promotion of blacks
V162211 / V202300	POST: Agree/disagree: blacks should work way up without special favors
V162212 / V202301	POST: Agree/disagree: past slavery make more diff for blacks
V162213 / V202302	POST: Agree/disagree: blacks have gotten less than deserve
V162214 / V202303	POST: Agree/disagree: blacks must try harder to get ahead
V162266 / V202416	POST: Minorities should adapt to customs/traditions of U.S.
V162268 / V202418	POST: Immigrants are generally good for America's economy
V162269 / V202419	POST: America's culture is generally harmed by immigrants
V162271 / V202421	POST: To be truly American important to have been born in U.S.

ANES variables analyzed (issues 4 + 5)

ANES 2016 / 2020 variable	ANES 2016 variable description
Issue dimension #4: Military and policing	
V161181 / V201249	PRE: 7pt scale defense spending self-placement
V161208 / V201309	PRE: Federal Budget Spending: dealing with crime
V161154 / V201350	PRE: Force to solve international problems
V161192 / V201417	PRE: U.S. government policy toward unauthorized immigrants
V162110 / V202171	POST: Feeling thermometer: POLICE
V162313 / V202481	POST: FTF CASI/WEB: Feeling thermometer: ILLEGAL IMMIGRANTS
Issue dimension #5: Self-reported ideology	
V162289 / V202439	POST: CSES: 10pt scale: left-right self placement