STAR Voting, Equality of Voice, and Voter Satisfaction: Design considerations for a novel voting method

Sara Wolk (✉️ sara@equal.vote)
Jameson Quinn
Marcus Ogren

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STAR Voting, Equality of Voice, and Voter Satisfaction:
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Sara Wolk*, Jameson Quinn*, and Marcus Ogren

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Abstract  We introduce STAR Voting as a single-winner voting method which should be considered to replace Plurality Voting for governmental elections. The five star ballot offers an expressive and user-friendly interface which, as we demonstrate, treats political factions equally regardless of how many candidates they field or their position in the political spectrum. We discuss a number of criteria for voting methods relating to strategic voting and vote-splitting. We assess how well these voting methods incentivize and empower voters to voice their honest opinions, and how well these methods allow voters to gain equitable representation. Using a realistic clustered spatial model for voter ideologies, we present the metrics of Voter Satisfaction Efficiency (VSE) and Average Strategic Regret (ASR) to evaluate voting methods with a high degree of granularity. We find that STAR Voting and Smith/Minimax are among the best methods as measured by VSE, markedly outperforming Plurality, Top-Two Runoff, and Instant Runoff. We find that STAR Voting, and especially Smith/Minimax, substantially reduce the need for voters to consider candidate electability as they cast their ballots. We conclude that

Sara Wolk*  sara@equal.vote
Jameson Quinn*  jameson.quinn@gmail.com
Marcus Ogren  marcus.ogre@gmail.com

* These authors contributed equally.
STAR Voting offers a viable and compelling proposal for more equitable and more representative elections, both for individual voters and for the electorate as a whole.

1 Introduction

Voting methods exist at the very foundation of our political discourse and government, affecting both electoral outcomes and incentives for voters, candidates, and parties and thus shaping our society. In this paper, we present a novel voting method, STAR Voting, discuss its properties, and give some results from statistical models comparing its utilitarian outcomes and strategic incentives to other prominent voting methods.

All voting methods consist of two parts, a voter interface or ballot, and a process for tabulation of those ballots. STAR Voting’s design is intended to optimize both of these components; In this paper, we lay out the case for the five star ballot as a voter interface, and the Score Then Automatic Runoff (STAR) algorithm for measuring the strength and breadth of support for each candidate and finding majority preferred winners who represent the will of the people.

![Fig. 1 A STAR ballot](image)
We present several novel standards and metrics by which to judge single-winner voting methods, and demonstrate how they relate to STAR voting. We set a rigorous standard for equality of the vote for voting methods, and argue that methods which pass this criterion combat vote-splitting, the spoiler effect, and the resulting wasted votes, ‘electability’ biases, and strategic voting incentives which leave voters disempowered. We highlight "Yee Diagram" visualizations, which show that voting methods currently used in the United States cause serious and predictable polarizing effects. Lastly, we introduce “Voter Satisfaction Efficiency” (VSE) and “Average Strategic Regret” (ASR) with novel and sophisticated statistical models, which we employ to calculate the utilitarian quality of outcomes of various voting methods and measure the strength of strategic incentives.

2 Presenting STAR Voting

STAR Voting is a modern voting method which allows voters to score candidates from zero up to five stars, as shown in figure 1. The name STAR is both a reference to the five star ballot itself, and an acronym for Score Then Automatic Runoff, which describes the two-round tallying process:

- **Scoring Round**: All scores for each candidate are totaled and the two highest scoring candidates advance.
- **Automatic Runoff**: In the runoff, each ballot is counted as one vote for the finalist who that voter scored higher. The finalist who was preferred by more voters wins.

STAR Voting was invented in 2014 with the objective of better delivering on the underlying goals of voting reform advocates, while addressing serious issues with Plurality Voting and limitations with leading reform proposals like Top-Two Runoff, Approval Voting, and Instant Runoff Voting (IRV).

The five star ballot allows voters to express not only ordinal preferences, but also equal preferences and preference strength. Not only does this ballot
convey much more information than a choose-one ballot, it also conveys more than a ranked ballot. For instance, on a ranked ballot, it’s unclear whether a voter’s second choice is almost as good as their favorite, or if they are strongly disliked. Even in STAR elections with a large field, there is no need to limit the number of candidates, limit the available levels of voter expression, or present voters with an unwieldy and confusing ballot. This may reduce the probability of invalid (“spoiled”) ballots, which studies such as Neely and McDaniel (2015) suggest may be increased by ranked ballots as used in Instant Runoff Voting (IRV; ie. single-winner Ranked Choice Voting or RCV).

Before selecting the 0-5 scale specifically for STAR Voting, early simulations on Voter Satisfaction Efficiency (Quinn 2017) were used to confirm the hypothesis that this level of granularity does in fact lead to significant gains in terms of more representative outcomes compared to less expressive scales. The simulations also confirmed that increasing the ballot scale further yielded diminishing returns. Even with large fields of candidates the zero through five star scale offers a high degree of resolution and granularity for voter choice, without exceeding the upward bounds of cognitive load.

The five star rating, well-known from online product and service ratings, is very similar to the five star ballot and offers a familiar interface that has become a leading option for collecting detailed public opinion data. When tabulating a five star ballot, scores and runoff votes are totalled using addition, which means that STAR Voting can be run on existing voting machines in most cases. Tabulation by addition also means that STAR Voting is precinct-summable and doesn’t require centralized tabulation, unlike Instant Runoff Voting. Results can be totaled at the local level with accurate reporting of

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1 For example the 2020 elections for Democratic presidential delegates from Oregon. (The Equal Vote coalition 2020)

2 There have been many psychometric studies of the optimal number of options for scaled responses; see for example Simms et al. (2019). General consensus is that measures such as reliability increase rapidly up to about 6 or 7 options, while cognitive load begins to increase after that. Thus, STAR Voting has opted to mimic the 0-5 star rating system.
preliminary results as ballots come in. These factors combine to make the five star ballot itself a compelling option for increasing voter voice in elections.

The second half of the STAR Voting method is the 'automatic’ top-two runoff. Whether or not a voter’s favorite can win, in the runoff their full vote goes to the finalist they preferred. The runoff is binary, and every runoff vote carries equal weight, regardless of the scores given. Even voters who don’t like either of the finalists are able to cast a fully powerful vote without needing to exaggerate support for the frontrunner on their side. All voters need to do is show their preference order. The STAR Voting runoff ensures that voters in the minority can have an impact on who wins, and also identifies majority-preferred winners whenever possible.

3 Pass/Fail Criteria and the Ability to Vote Your Conscience

Historically, comparing voting methods has often focused on evaluating methods according to various pass/fail criteria, even though many desirable electoral goals are mutually exclusive or inversely correlated, especially in the context of strategic voting. (Arrow 1950) Despite the obvious limitations of this lens, many advocates choose to frame the conversation around the criteria which their preferred voting methods pass – to the exclusion of other criteria and common sense considerations like representative accuracy. Predictably, this approach has proven to be more divisive than constructive.

Two criteria which are both highly regarded but are inversely correlated are Favorite Betrayal and Later No Harm. The Favorite Betrayal (FB) criterion is about preventing the need for the all-too-familiar strategy where rather than throwing away their vote on a candidate they know can’t win, a voter will vote for the candidate on their side who seems the most electable. Voting methods which pass Favorite Betrayal solve this problem, as the criterion requires that
a method will never incentivize giving one’s favorite any less than a vote of maximum support.\textsuperscript{3}

The Later No Harm (LNH) criterion is effectively the opposite of Favorite Betrayal and says nothing about whether it’s safe to vote for one’s favorite. Rather, it specifies that supporting other candidates in addition to a voter’s favorite cannot hurt that voter’s first choice. This allows candidates to encourage supporters to rank others at no risk to themselves.\textsuperscript{4}

Both criteria are obviously desirable, but no voting method proposed to date has been able to satisfy both. We posit that rather than passing one but then failing the other criterion badly, voting methods should instead seek to maximize both. We believe that violations of LNH and FB, and their impacts on strategic voting incentives, should be evaluated statistically rather than with an axiomatic approach.

STAR Voting utilizes positive incentives to encourage voters to give their favorite(s) a full five stars and show their preference order. Compare this with Instant Runoff Voting, which passes Later No Harm, but does so by ignoring relevant down-ballot voter preferences until it’s too late for these rankings to have made a difference.

Despite the common claim that IRV eliminates the spoiler effect, Emily Dempsey (2018) demonstrated that in order to pass Later No Harm, a voting method must by definition fail to eliminate the spoiler effect and vote-splitting. For these reasons, we believe that the practical validity of Later No Harm as a pass/fail criterion needs to be reevaluated.

In IRV some voters whose favorite is eliminated will have their next choice counted, but voters whose favorite is eliminated in the final round will not. This biases elections against voters who prefer strong underdog candidates

\textsuperscript{3} Favorite Betrayal is defined as: “holding other votes constant, a voter should never have to give their favorite less than the maximum rating in order get a higher-utility outcome.” See Appendix A.

\textsuperscript{4} Later No Harm is defined as "Adding a later preference to a ballot should not harm any candidate already listed. See Appendix A." Woodall (1997)
with broad support. Counting the full ballot for some voters while ignoring relevant ballot data for others (as Later No Harm requires) gives voters a false sense of agency, may erode trust in the system and in voting reform in general, is out of keeping with the spirit of one-person, one-vote, and is fundamentally unequal.

4 Vote-Splitting and Inequality in the Vote

Vote-Splitting and spoiled elections don’t just fail to elect the right winner, they often bias elections in predictable ways. The center-squeeze spoiler effect is pervasive in Plurality but is exhibited by IRV as well. When it happens, it fuels polarization and entrenches two party domination by preventing candidates in the middle of the field from winning.

The center squeeze effect was clearly demonstrated in simulated elections visualized by Ka-Ping Yee (2005) and was analyzed and discussed by Warren Smith and later Mark Frohnmayer of the Equal Vote Coalition. (Frohnmayer 2017) These simulations, as shown in figure 1, demonstrate that STAR Voting, as well as Score + Top-Two Runoff, and Condorcet methods are more accurate and do not exhibit exaggerated center-squeeze or center-expansion biases, the two most common pathologies which can result in spoiled elections.

![Fig. 2 Yee diagrams](image-url)
Many pervasive problems with Plurality Voting, and with electoral politics in general, can be traced back to vote-splitting and the spoiler effect. Fear of wasting one’s vote leads directly to “lesser-evil” voting where voters are unable to safely support their favorite candidate. This in turn is the reason for the “electability” bias, and it’s likely a fundamental reason why political representation in the United States remains starkly inequitable.

We use the definition from Dempsey (2018): “The Spoiler Effect occurs when a third candidate entering a race splits votes with a similar candidate who would otherwise win, thus causing a candidate less-preferred by the electorate to win instead.”

In order to achieve gender parity and racial equity in politics – or overcome two-party domination – we need a level playing field where candidates from underrepresented communities can run and win, but the reality is that voting methods biased towards those who are deemed most electable (Abramowitz 1989) will maintain serious disparities in representation, regardless of public opinion. Fear of vote-splitting and the spoiler effect has a powerful impact on voter behavior and gives a huge advantage to those deemed most electable, who in practice are usually those who raised the most money, (OpenSecrets 2020) incumbents, (OpenSecrets 2019) and those with the best name recognition. Incumbents and established politicians in general are often wealthy, older, white, and male. In research on the demographics of elected officials, (Kauzlarich 2019) white men held 62% of U.S. elected offices in 2019, despite comprising only 30 percent of the population.

While no voting method can (or should) force voters to coalition, we posit that the Equality Criterion can eliminate vote-splitting caused by the voting method itself. This criterion states that for any given vote, there is a possible opposite vote, such that if both were cast, it would not change the outcome of an election.\(^5\)

The Equality Criterion ensures that if one party had the full support of 51% of the voters and ran five (or more) inspiring candidates, and another

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\(^5\) For a rigorous definition of the Equality Criterion, see Appendix A.
party had the support of 49% of the electorate and ran only one candidate, the majority faction would always have some way to give all of their candidates full support and thus win the election, even if the front-runners were unknown. It only takes 49% of the majority faction to bring the election to a tie, and the remaining 2% then tip the scales to win the election.

In 1964, Wesberry v. Sanders, (Black 1964) The U.S. Supreme Court declared that equality of voting - one person, one vote - means that “the weight and worth of the citizens’ votes as nearly as is practicable must be the same.” Passing the Equality Criterion ensures that it is possible for voters who disagree to cast equally weighted and balanced votes, no matter how many candidates are on their side. Approval Voting, Score Voting, STAR Voting, and Smith/Minimax, all pass this basic and ‘practicable’ criteria. Plurality Voting and Instant Runoff notably do not.

5 A Non-Binary Statistical Approach

In the axiomatic approach to evaluating voting methods, one begins by clearly defining an outcome that is arguably pathological, and then proceeds to check if that pathology is possible. In the statistical approach, the question is not just ”can this pathology ever happen?” but ”how much of a problem is this pathology on average?” This means that we need to identify the context where the problem occurs, measure it’s frequency, and then quantify the severity of the occurrence.

In principle, one could define a context using only real historical outcomes, but in practice that would mean sample sizes would be unacceptably small and for newly-designed voting method variants there would be no samples at all. Historical results almost never include the data required to assess what role, if any, strategic voting played in an election. In practice, measuring the frequency of various pathologies adequately means defining a generative probability model and using it to run simulated elections.
Generating an election for a given voting method involves a number of steps, which each may involve some randomness:

1. **Populate election**: generate voters and candidates with the inherent characteristics that will be needed for future steps.
2. **Assign utilities**: decide how each voter feels about each candidate.
3. **Polling**: collect some kind of “pre-election polls” of the electorate.
4. **Media**: filter “polling” results through the media, which may be biased.
5. **Voting**: Each voter uses their inherent feelings about the candidates, available “polling” information, and their understanding of the voting method to cast their ballot. Determine the winner.
6. (Optional) **Revoting**: for pathologies that are detected by changing ballots, choose which ballots to change and how. Then determine the new winner.

Creating a model which includes all the steps above requires balancing realism and simplicity. Models should have a relatively high likelihood of reproducing real historical elections, and counterfactual examples should be plausible. At the same time the model should be relatively easy to describe and reproduce, while avoiding unnecessary complexities which researchers could use to bias results.

Although this paper focuses on STAR Voting, we have done our best to avoid creating a model biased in favor of STAR. In fact, Jameson Quinn’s early work on the models presented here, first made public in Quinn (2017), preceded (and was the basis for) serious STAR activism, and Quinn had hoped and expected to find support for Bucklin-style voting methods such as Majority Judgment. (Balinski and Laraki 2010)

### 5.0.1 Voter model

Populating the election, and assigning utilities to the voters and candidates are done according to a voter model. In order to select our voter model, we first considered the ”impartial culture.” (See: Black (1958) for introduction
of the idea; Klahr (1966) for its extension to weak orderings; Fishburn and Gehrlein (1980); and Smith (2000) for generative versions and utilitarian interpretations.) We then considered “normally-distributed spatial models” (see: Downs (1957) for the introduction of the idea as a descriptive model; Smith (2000), Tideman and Plassmann (2008), and Green-Armytage et al. (2016) for simulations using the model).

Tsetlin et al. (2003) points out that impartial culture has too many Condorcet cycles. Tideman (2010) agrees and argues that for this and other reasons spatial models are better, but normal spatial models go too far in the other direction, with too few Condorcet cycles. For these reasons we use a clustered spatial model. Because this is non-parametric (that is, because it can include an unbounded number of clusters), it can reproduce real-world election scenarios — including Condorcet cycles — as precisely as desired.

In the clustered spatial model, (as in the spatial model,) voters and candidates are characterized by their ideal points in a vector space; in the clustered model they are distributed in that space using a common hierarchical Dirichlet structure of Gaussian clusters, similar to a Crosscat model. (Mansinghka et al. 2016) Step-by-step, that means we:

1. Assign relative weights to issue dimensions using a stick-breaking Dirichlet process, adding dimensions until the remaining weight falls below a given threshold. This allows differing distributions of issue weights, while ensuring that on average issue weight decays exponentially and thus only a finite number of dimensions need to be modeled.
2. Cluster the dimensions themselves into “views” using a Chinese restaurant Dirichlet process.
3. Within each view, independently cluster the voters using a Chinese restaurant Dirichlet process. For each voter cluster, assign a mean and variance for each dimension, and draw the voters’ ideal points as normally-distributed using their cluster mean and variance in each view.

Normal distributions are symmetric and have a median in each direction; thus, by (Davis et al. 1972) they tend not to have Condorcet cycles.
This results in a model with good exchangeability properties that make it relatively easy to sample from and analyze. We believe that a nonparametric model of this form will show good realism, and in particular that specific kinds of potentially-pathological scenarios such as Condorcet cycles will occur with a realistic frequency – neither artificially often as in impartial culture, nor artificially rarely as in normally-distributed spatial models.

5.0.2 Polling model

Next we define the polling and media models used. An initial “poll” is performed using Approval Voting. All voters are assumed to scale their utilities so that their favorite candidate is a 1 and the average candidate is a 0, then approve any candidate whose scaled utility is over 0.7. We use Approval Voting for the poll because it gives the voters a realistic amount of information about the relative strength of the candidates. We do not include a media bias in this particular model.

5.0.3 Initial Strategy Models

We consider both a zero-information “honest / naive” strategy and a more sophisticated “viability-aware” strategy using the Approval polling discussed above. 7

For Approval-based methods, the “naive” strategy is to vote for every candidate whose utility better than the average utilities of the best and worst candidates. For STAR, the “naive” strategy is to normalize one’s utilities to a [0 − 5] scale and vote accordingly. “Viability-Aware” strategies are as follows:

– Plurality: For a given voter, determine the expected utility of the election (EV), then give a candidate, with utility $u_i$ and estimated probability of

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7 Specifically, the probability of being truly in first place are calculated by assuming that each candidate’s true percent approval is independently beta-distributed around their observed approval, tuning the total $\alpha + \beta$ of the two beta distribution parameters to have a given margin of error if $\alpha = \beta$. 

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winning \( p_i \), a score equal \( p_i(u_i - EV) \). Vote for the candidate with the highest score.

- **Plurality Top-Two**: Same as Plurality except that voters who do not prefer the polling leader replace probability of winning by an estimate of the probability of being in a two-way tie for second.

- **Approval**: Determine the expected value of the election, and vote for every candidate with utility greater than that.

- **Approval Top-Two**: Same as Approval, but the probability of being in a two-way tie for second is used instead of the probability of winning to calculate the expected value of the election.

- **IRV**: Use the same candidate scores determined for Plurality. For all candidates with positive scores, rank them in decreasing order by score. This means a highly-electable compromise candidate may be ranked above a preferred candidate with little support. Rank all candidates with non-positive scores in decreasing order of their utilities.

- **Minimax/Smith/Margins**: Vote honestly. (We did not see a plausible way to improve upon this based on just a rough Approval poll.)

- **STAR**: Balance strategic exaggeration (using 5’s and 0’s instead of 3’s and 2’s to maximize influence in the scoring round) with the competing incentive of not wanting to give multiple viable candidates the same score. (This yields more 5’s and 0’s than the naive strategy and is nearly unaffected by the presence of non-viable candidates in the race.)

Note that the above viability-aware strategies are always honest for Approval and Approval Top-Two; almost always semi-honest for STAR; and often dishonest for Plurality, Plurality Top-Two, and IRV.

6 Representative Outcomes: Voter Satisfaction Efficiency

An ideal winner represents as many voters as possible as well as possible. Voter Satisfaction Efficiency (VSE) is a linear measure of a voting method’s utilitarian outcomes. In VSE a voting method that always elected this ideal
candidate would score 100%, while one that elected a candidate completely at random would score 0%.

![Voter Satisfaction Efficiency of selected voting methods](image)

**Fig. 3** Voter Satisfaction Efficiency of selected voting methods, using 1000 electorates with 6 candidates and 1001 voters each.

Smith/Minimax and STAR Voting delivered the highest levels of Voter Satisfaction of all methods tested, under both naive/honest and viability-aware voting behavior. Both Approval-based methods also performed notably well under best-case-scenario voter behavior.\(^8\)

### 7 Honest and Strategic Incentives: Average Strategic Regret

A voting method’s outcomes can only be as good as the ballot data itself and ballot data is likely to only be as good as the voter behavior incentivized. In order to evaluate the likelihood of specific voter behaviors and their impacts on the quality of electoral outcomes, we turn to a statistical metric called Average Strategic Regret (ASR). This measures voter regret from a post-election perspective, asking the question “how much more utility on average could a given faction of voters have gotten if a subset of them had been strategic”.\(^9\)

\(^8\) See Appendix B for more VSE results, varying the model, candidates, and parameters. See supplementary material for VSE/ASR code in Python.

\(^9\) To be precise, for the faction of voters who prefer candidate \(X\) over candidate \(Y\), ASR is the sum over all numbers \(N\) of voters from 1 up to the full size of the faction, of the average utility benefit to the \(N\) faction voters whose \(X > Y\) preferences are strongest, of
We begin by using Average Strategic Regret to look at whether voters are taking candidate viability into consideration (Viability-Aware), or not (Honest/Naive).

![Image of graph](image.png)

**Fig. 4** A “viability-aware” strategy is incentivized over honest/naive behavior for all voting methods tested, but the size of this incentive varies considerably.

We identify the faction employing a given strategy and the candidate most able to benefit from strategy.\(^{10}\) We then consider the impacts of voter strategies such as Die-Hard, (burying or strongly opposing viable competitors to one’s favorite, even those who you would actually prefer to other candidates,) Bullet Voting, (supporting one’s favorite to the exclusion of all others,) and Compromise, (where voters exaggerate support for compromise candidates beyond their favorite.) Not all tactical voting behavior is necessarily dishonest; for instance, in some methods, one can exaggerate support without changing preference order.

Average Strategic Regret for a given strategy and faction will be higher if the strategy benefits the faction and takes relatively low coordination to have an effect. It will be near zero if the strategy rarely has any effect, for instance

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\(^{10}\) In IRV and Plurality Top-Two, the strategy beneficiary is the original third-place candidate, while in the other methods, it is the original second-place one.
if it takes near-perfect coordination, and it will be negative if the strategy backfires more often than it succeeds.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Average Strategic Regret (ASR) for not using targeted strategy</th>
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<tbody>
<tr>
<td>Plurality</td>
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<td>Plurality Top Two</td>
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<td>STAR</td>
<td><img src="image" alt="Graph" /></td>
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<tr>
<td>Smith/Minimax</td>
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**Fig. 5** Average Strategic Regret from not using targeted strategy.

In figure 5, one can see that in STAR Voting, dishonest behaviors such as bullet voting or burying are explicitly disincentivized, and incentives to use honest and semi-honest strategies (giving five stars to ones favorite and showing honest preference order) outweigh incentives to use dishonest strategies such as Favorite Betrayal and burying. Honest and/or compromising strategies in STAR Voting are weakly incentivized.

Strategy in general is not significantly incentivized (or actionable) in Smith/Minimax, the Condorcet method we tested. In Approval Top-Two and in IRV, strategic voting is weakly incentivized. Those incentives notably increase in Approval and Plurality Top-Two, and dishonest strategy is most strongly rewarded in Plurality.

As we discussed above, Plurality Voting, with its strong and transparent strategic incentives, leads voters to only support “electable” candidates, as voters learn the hard way that voting their conscience can waste their vote. While voters trying a new method for the first time may need to unlearn these strategic habits, the Average Strategic Regret voter models illustrate why we believe that STAR Voting would encourage voters to grow more honest and expressive over time.
8 Conclusion

STAR Voting’s expressive and user-friendly ballot, simple and transparent tabulation, and its accurate and unbiased outcomes paired with positive incentives to vote one’s conscience, make it an actionable solution to level the playing field in single-winner elections and to overcome many of the implicit biases which underlie and entrench the pervasive inequities in politics.

Acknowledgements - Special thanks to Mark Frohnmayer for contributions as STAR Voting co-inventor and advocacy for the equally weighted vote.

Conflicts of interest - Sara Wolk is Executive Director for the Equal Vote Coalition, which advocates for some of the voting methods discussed here.

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