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COMPARING APPROVAL VOTING AND RANKED CHOICE VOTING

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INTRODUCTION

This paper is about better ways to vote.

Americans have become so accustomed to our voting system we forget how strange it is. Many countries admire our Constitution to the point of imitation, and have adopted our system of checks and balances by dividing government into executive, legislative and judicial branches. Yet absolutely none of them elect candidates to political office the way we do. That's because democracies want to avoid precisely those problems besetting America today: citizen apathy, low voter turnout, bitter partisanship, a lack of political competition, the lack of a political center, and the resulting division of the country into two warring factions that see each other as the enemy. To name a few.

The Framers were exceptionally well-read and intelligent men, perched at the right point in history to create an exceptional system of government for an exceptional nation. We are right to consider significant changes to their legacy institutions only with great reluctance and deliberation. Experiments should be tried at the local level first, then the states, and only then at the level of national government.

On the other hand, we should also note that our present conundrum is exactly what the Framers warned against over two hundred years ago. Their writings in this regard seem downright prophetic.

Consider this excerpt from George Washington's Farewell Address:

> *"[We must be wary of] the alternate domination of one faction over another, sharpened by the spirit of revenge, natural to party dissension, which in different ages and countries has perpetrated the most horrid enormities."*[1]

Or this from his successor:

> *"There is nothing I dread So much, as a Division of the Republick into two great Parties, each arranged under its Leader, and concerting Measures in opposition to each other. This, in my humble Apprehension is to be dreaded as the greatest political Evil, under our Constitution."*[2]

James Madison's concerns about parties rooted in geography are eerily accurate today (bolding is mine).

> *"Should a state of parties arise founded on geographical boundaries and other* ***physical and permanent distinctions*** *which happen to coincide with them, what is to control these great repulsive Masses from awful shocks against each other?"*[3]

This could have been written yesterday, about urban Democrats vs. rural Republicans.

If we're honest with ourselves, we must conclude that we are now in the very situation the Framers worked so hard to avoid. We need to look at how we got here, and to experiment with other ideas that might help move us forward. Let us not forget that experimentation with alternative voting systems at the state level, as for example Maine and Alaska have done, is a great example of Federalism, and completely consistent with both conservatism and the Framers' vision of distinct states united into a democratic republic.

Many countries admire our Constitution to the point of imitation, and have adopted our system of checks and balances by dividing government into executive, legislative and judicial branches. Yet absolutely none of them elect candidates to political office the way we do.

SOMETHING IMPORTANT ABOUT VOTING SYSTEMS

Voting stinks.

I'm paraphrasing here. It's more accurate to say that no voting system is perfect. Turns out that's not an opinion, but a mathematically proven fact.

In 1951, the economist Kenneth Arrow showed that given reasonable assumptions about how voting systems work, and given some fairly obvious desirable properties that any voting system should have (all votes are equal, for example), it's impossible to design a system that satisfies them all. This became known as the Arrow Impossibility Theorem. Arrow was awarded the Nobel Prize in 1972.

...when you're comparing voting systems (as this report does) it is vital to *not let the perfect be the enemy of the good*.

What does Arrow's Theorem mean in practice? It means that every voting system is going to have problems. So when you're comparing voting systems (as this report does) it is vital to *not let the perfect be the enemy of the good*. The right question is not, "Does this system have problems?" The right questions are:

- What are the problems of the current system?
- What are the problems of the system we want to replace it with?
- How do they compare?
- For a given problem with a given system, what are the chances of it happening?
- How hard is it to solve a specific problem?
- Are all the problems equally bad, or are some worse than others?

Similarly, the right criticism is not, "This system has problems so we should reject it." Right criticisms would be, "This system has more problems than the present one," or, "This system's problems are worse than those we have now," and so on.

This paper will look at two alternative voting systems: *approval voting (AV)* and *ranked choice voting (RCV)*. Before we do that, it will help to understand how voting systems can be classified.

WAYS TO DESCRIBE VOTING SYSTEMS

There are many possible voting systems in both the academic literature and in the real world; we can explore only a few. However, it will be useful for us to know the different ways voting systems can be classified, so we'll know how to think about our present system and some of the alternatives. Here are some questions we might ask about a voting system:

How many winners are there? Partisan elections at the state and federal level have only one winner; you vote for one candidate and they win or lose. But most of us are also familiar with elections that have more than one winner. For example, you might be asked to vote for a few candidates for city council or school board if there are multiple positions available.

How is the winner chosen? The most common method in the US is whoever gets the most votes. This is known as a *plurality* system, also called *first-past-the-post* or *winner-take-all*. Note that this does not guarantee a majority winner if more than two candidates are on the ballot. Note as well that this is not the only way to choose a winner. More on this shortly.

How many candidates can you vote for? This may seem nonsensical for

elections with a single winner. How and why would you vote for more than one candidate in that case? In fact, there are numerous advantages to allowing voters to vote for multiple parties and/or candidates in single-winner elections. I will discuss this shortly.

Can you express preferences among candidates? For those elections in which you can vote for more than one candidate, are you allowed to rank order your choices or not?

How many parties are there? In the US, two is the most common answer, unusual among democracies. Zero can also be an answer in elections for non-partisan posts, local government boards, judgeships, and so on. One is the answer if the election in question is a primary, whose purpose is to choose a party representative to run in a later partisan election. One is also the answer for "elections" in totalitarian regimes, and are the reason why the Communist Party was so successful at winning elections in the former Soviet Union. In multiparty democracies like those in Europe, voters will typically have the option of choosing between three or more parties come election time.

Can you vote for a party only, individual candidates from different parties, or a combination of both? Ireland has a system that permits both.

If a majority of votes is required for a winner and only a plurality is achieved, how is the winner decided? This is typically not an issue in the US election when a plurality determines the winner and there are only two major parties. But for a party primary, or elections with a single winner and multiple primaries, or an election where a strong third-party or independent outsider is running, some procedure must be invoked for those cases where a majority is not obtained on the first ballot. The simplest and most common technique is a runoff election between the top two vote getters, adding considerable cost to the electoral process. Fortunately, as we shall see, there are other possibilities.

There are many other questions that could be asked, and many other ways to classify voting systems. The above list should be adequate for the purpose of this paper.

...there are numerous advantages to allowing voters to vote for multiple parties and/or candidates in single-winner elections.

PROBLEMS WITH VOTING SYSTEMS

I have already mentioned that no voting system is perfect. Here are a few of the problems they can suffer from:

Non-majority representation. A majority of voters may not translate to a majority in government. This happens quite often, not always through the intentional manipulation of districts known as "gerrymandering." It is an inherent flaw in any winner-take-all system of representational government.

Non-majority outcomes. A candidate with higher preferences by a majority of voters can still lose.

Tactical voting. This occurs when it is rational for a voter to vote against their personal preferences because, due to quirks of the system, such votes could actually improve the chances of getting the outcome they want. This possibility may seem surprising to Americans, because elections with two choices do not have this problem. However, all

elections with more than two choices are vulnerable to tactical voting.[4]

Wasted votes. I use this term in the sense of any vote that does not contribute to the final result. This includes not just votes for the losing candidate, but votes for the winner beyond the minimum needed. For example, given a 60%-40% result in a two-candidate election, approximately 49% of the votes were wasted: 40% that supported the losing candidate, plus the 9% "extra" beyond the 51% needed to elect the winner.[5] Various systems exist to reduce the number of wasted votes. Wasted votes are also a good measure of the partisan nature of a given district map, since the objective of the party in power is to minimize the number of their wasted votes while maximizing those of the party out of power.

Surprisingly, when more than two candidates are involved, there is no one universally accepted definition of who the winner of an election should be.

Disproportional representation. The opposite of non-majority representation, a voting system can magnify the influence of majorities and minimize the influence of minorities,[6] to the point where even large minority voting populations can wind up with zero representation.

They pick different kinds of winners. Surprisingly, when more than two candidates are involved, there is no one universally accepted definition of who the winner of an election should be. The two main contenders, both from France, argued this in the 18th century. Jean-Charles de Borda thought that in an election with more than two candidates, the winner should be whomever gets the most points in a rank-ordered system. The higher a voter ranks you, the more points you get (for example, 2 points for a first place vote, 1 point for a second place vote, 0 points for a third). This type of system is a *Borda count*. A winner in this system can always be determined, the *Borda winner*.

A few years later, Borda's fellow countryman, the Marquis de Condorcet, published a counterargument. Condorcet believed that if a candidate existed who would beat all others in separate head-to-head contests, a fair system should be able to find such a candidate and declare that candidate the winner. This is known as the *Condorcet criterion*. Note that Condorcet himself understood that such a victor, the *Condorcet winner*, may not exist. Voting systems that are guaranteed to find a *Condorcet winner* if one exists are said to *satisfy* the Condorcet criterion.

Other potential problems include lack of political competition, excessive partisanship, inadequate expression of voter preferences, and voter apathy.

Now that we understand some of the distinguishing features of voting systems and some of the problems they can have, we consider the two most popular alternatives: approval voting (AV) and ranked choice voting (RCV).

APPROVAL VOTING

When it comes to simplicity, approval voting wins hands down. Voters mark their ballots for all candidates (and only those candidates) they approve of. Each mark counts for one vote; the candidate with the most votes wins (for now, we will assume one-winner elections).

For example, suppose candidates A, B, C and D are running for office and 100

people vote in the election. Each column of the chart below represents how many people cast a ballot of a particular type:

	30	20	30	10	5	5	
A	X				X	X	40
B			X	X			40
C		X	X	X	X		65
D		X	X		X	X	60

So 30 voters approved of A only, 20 voters would be happy with C or D, and so forth. C received the most votes with 65, so C would be declared the winner.

How many wasted votes were there? C needed 61 ballots to win, and received 65, so four of the ballots that approved of C were wasted. A total of 35 ballots did not approve of C, so those all were wasted as well. Thus we have a total of 39 wasted votes.

Notice that approval voting in this election actually produced two majority winners. This can happen with approval voting. It can also produce a plurality winner. For example:

	40	30	15	5	5	5	
A	X			X			45
B		X		X		X	40
C		X		X	X		40
D			X	X	X	X	30

A wins with 45 votes, even though over half the voters did not approve of her. On the other hand, 60% of the voters didn't want B or C, and 70% didn't want D. In scenarios like this, approval voting picks the "least hated" candidate. The number of wasted votes in the above election is 4+55=59.

Similar to other voting systems, a majority winner can be found with approval voting by holding a runoff between the top two finishers. Runoffs are a popular and effective way to determine a majority winner from a plurality outcome. Unfortunately, they are time-consuming and costly. Approval voting advocates, however, note the ability of voters to approve multiple candidates makes the need for a runoff less likely.

Approval voting is popular with academic political scientists because you can prove theorems about it. For example, among voting systems where voters cannot rank candidates, approval voting is the one where voters can most authentically present their preferences, and is most resistant to tactical voting.[7]

We may characterize approval voting in this way:

How many winners are there?	Arbitrary
How is the winner chosen?	Whoever gets the most votes
How many candidates can you vote for?	As many as you like
Can you express preferences among candidates you vote for?	No
How many parties are there?	As many as voters demand
Can you vote for a party only, individual candidates from different parties, or a combination of both?	Yes
If a majority of votes is required for a winner and only a plurality is achieved, how is the winner decided?	Additional runoff election

Approval voting is popular with academic political scientists because you can prove theorems about it.

RANKED CHOICE VOTING

Ranked choice voting, or RCV, is more complex than both our current system and approval voting. Its complexity is the price we pay for eliminating the need for runoffs in plurality scenarios, and for reducing the number of wasted votes. It also is easily adapted to proportional representation, as I will show in a separate paper.

RCV is like approval voting in that voters can select (approve of) more than one candidate. It differs in that voters add additional information: a rank ordering of their preferences. Voters are asked to rank their first choice, their second choice, and so on up to some predefined limit. This allows elections that more accurately reflect voter preferences, and eliminates the need for runoff elections in plurality scenarios. We will see this shortly.

Ranked choice voting, or RCV, is more complex than both our current system and approval voting.

Consider the first example we looked at with approval voting. Suppose all the ballots were exactly the same, but this time voters were allowed to rank their preferences. Suppose their preferences were expressed as follows:

	30	20	30	10	5	5	1st Choice Votes
A	1				2	1	35
B			2	2			0
C		2	3	1	3		10
D		1	1		1	2	55

Each column is a distinct ballot type. Reading the columns from left to right, 30 voters ranked A as their first (and only) choice, 20 approved C and D but preferred D to C, and so on. The rightmost column is the total number of first-choice votes for each candidate.

The first step in RCV is to count the number of first-choice votes to see if a majority winner exists. D was the first choice of 55 voters,[8] so D is declared the winner. Note the difference in outcome from approval voting. This is due to the more detailed preferences expressed by voters. In this case, we may regard the RCV results as a better expression of voters' will.

What about the plurality scenario? Consider a four-candidate election again, this time with the following results:

	40	30	15	5	5	5	1st Choice Votes
A	1		2	2	3	3	40
B		1	3	1		2	35
C		2		3	1		5
D			1	4	2	1	20

No candidate has a majority of first-choice votes, so we have a plurality scenario. This is where RCV's distinctiveness comes into play. It uses an algorithm that eliminates the need for a runoff.

When no majority winner is found after the counting of first-choice votes, the candidate with the least number of first-choice votes is eliminated, and ballots that ranked that candidate first choice will have their votes re-assigned to their second choice. This process repeats until a majority winner is obtained.

In the example above, candidate C received the lowest number of first-choice votes, so he is eliminated from contention. This does not affect ballots in the first four columns, all of whom ranked other candidates higher than C and are therefore still in the running. Looking at the fifth column, five votes were cast with

C as their first choice and D as second, so those votes get reassigned to D with A getting moved up to their second-choice spot. This gives:

	40	30	15	5	5	5	1st Choice Votes
A	1		2	2	2*	3	40
B		1	3	1		2	35
C		2		3	1		~~5~~ 0
D			1	4	1*	1	~~20~~ 25

(Asterisks denote rankings that were increased due to C's elimination. Strikethroughs denote updated first-choice vote totals.).

There is still no majority first-choice winner, and D has the smallest number of first-choice votes, so D is eliminated. The 15 votes in the third column go to A, along with the five votes in the fifth column, while the five votes in the sixth column go to B. This gives:

	40	30	15	5	5	5	1st Choice Votes
A	1		1*	2	1*	2*	~~40~~ 60
B		1	2*	1		1*	~~35~~ 40
C		2		3	1		~~5~~ 0
D			1	4	1*	1	~~25~~ 0

Therefore, A is declared the winner. Note that a second ballot/runoff is not required, because voters' relative preferences among candidates are already known. One of the cost-benefit tradeoffs of RCV is asking voters to supply more information up front (cost), in return for eliminating the need for a possible runoff in the future (benefit). In fact, all the retallying rounds above happen "instantly," or at least as quickly as computers can perform the calculation.

Note as well that all ballots in this election that ranked A ahead of B still contributed to the election of A, even if they did not rank A first.

We may characterize RCV in this way:

How many winners are there?	One (but adaptable to multiple)
How is the winner chosen?	Whoever gets the most votes
How many candidates can you vote for?	As many as you like
Can you express preferences among candidates you vote for?	Yes
How many parties are there?	As many as voters demand
Can you vote for a party only, individual candidates from different parties, or a combination of both?	Yes
If a majority of votes is required for a winner and only a plurality is achieved, how is the winner decided?	Instant algorithmic runoff using existing ballot information

Note that RCV can have ballots that are *exhausted*: eliminated from further tallies because none of the candidates they rank are in contention. For example, any ballots that only ranked C would be discarded after the first round, since they had no other candidates as backup choices. Similarly, any ballots that ranked only C and D would be discarded after the second round. This is often regarded as a problem with RCV, but is in fact an inevitable consequence of RCV's instant runoff features. Exhausted ballots are best viewed as simply the votes for losing candidates in successive runoff elections.

How should AV and RCV be compared? Who benefits most from each? There are many factors to consider: cost, simplicity, accurate expression of voter preferences, ease of adaptation to multiple winners and proportional representation, support for third parties and independent candidates, resistance to tactical voting, whether or not they find a Condorcet winner, how they handle wasted votes, and other criteria from the academic literature we have yet to consider. Let's take a look.

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SIMPLICITY

Simplicity is a desirable trait of voting systems for obvious reasons. Simpler ballots reduce the amount of *ballot spoilage:* the number of ballots that must be discarded because they were filled out incorrectly. Simple voting systems are easier to understand, which increases both voter turnout and confidence in the outcome. Simple voting systems also have fewer possible ballots and are easier to count by hand. The more complex a voting system is, the easier it is to deface ballots and the more likely computers will be required to determine a winner.

Simple voting systems are easier to understand, which increases both voter turnout and confidence in the outcome.

Ballot appearance

AV ballots are no more complex than our existing winner-take-all ballots. They both consist of a list of candidates with a checkbox next to each. The difference is that with winner-take-all, only one box may be checked, while with AV multiple boxes may be checked. By contrast, RCV ballots must replace a single checkbox for each candidate with multiple boxes, each in a column representing the voter's ranked choice for each candidate. Simple ballots for a four-candidate election with AV and RCV are shown below:

Vote for one or more candidates	
Alice Anderson	
Bill Baxter	
Cindy Crandall	
Douglas Dawson	

4-candidate AV ballot

Rank up to four candidates. Check at most one box for each candidate. Check at most one box in each column.				
	1st	2nd	3rd	4th
Alice Anderson				
Bill Baxter				
Cindy Crandall				
Douglas Dawson				

4-candidate RCV ballot

AV ballots, while more complex than winner-take-all, are far simpler than RCV. This is as expected. Since RCV allows voters to supply more information through finer-grained preferences, its ballot must be more complex.

Number of possible ballots

Another way of measuring the complexity of a voting system is by the number of different ballots that could be cast. With winner-take-all and two candidates on the ballot, only two valid ballots exist. By this criterion, winner-take-all is the simplest. For a detailed comparison with specific numbers and mathematical derivation, see Appendix A.

Ballot spoilage in theory

Under AV, assuming voter information is filled out correctly, there is only one possible invalid ballot: One where no approval votes are cast. (Even that exception could be counted as a valid "protest" vote, it would simply have no effect on the outcome.) Thus we would expect ballot spoilage under AV to be minimal.

By contrast, as large as the number of valid ballots can be in RCV, it pales in comparison to the number of ways to cast an invalid ballot. Ballots with the same candidate ranked more than once must

be considered invalid, since there is no way to discern the voter's true preference. Similarly, ballots which assign more than one candidate the same ranking must also be discarded. If we assume our standard matrix ballot of *n* candidates and *m* rankings, there are a total of 2^{nm} possible ways a voter could complete a ballot in an RCV election. We may subtract our previously calculated value of valid ballots to identify the total number of ways a voter could submit an invalid ballot.

This number runs into the millions very quickly for even the small values of *n* and *m* we consider here, easily dwarfing the number of possible valid ballots. Fortunately, voters do not fill out ballots at random. That said, an understanding of this calculation underscores the nature of the problem and the importance of accurate instructions for an RCV election, particularly during any sort of transition period should RCV become more frequently adopted.

The number of ways to fill out an invalid ballot under RCV for smaller values of *n* and *m* are shown below.

Ballot spoilage in practice

Critics of RCV have pointed out, correctly, that ballot spoilage rates are higher with RCV than both winner-take-all and AV.[9] The numbers vary widely, but a factor of up to 10 in some cases does not seem out of the question. However, while relative comparisons are important, it is also important to know the absolute numbers. For example, the spoilage rate in a 2009 Minnesota election using RCV was four times higher than the previous non-RCV election in 2005. But the actual numbers were 4% versus 1%, which could be an acceptable tradeoff given the other advantages of RCV. The same site critical of RCV pointed out a spoilage rate 7x higher for an RCV election in San Francisco compared to winner-take-all races. But the actual numbers were .60% to .08%, very small numbers to begin with.

Finally, we should remember that there will be a learning curve for voters with the transition to any new voting system. With proper instruction, well-designed ballots, and practice, we should expect spoilage rates for any system to decline over time, including RCV.

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How Many Candidates on the Ballot							
		1	2	3	4	5	6
Maximum number of candidates you can rank	1	1	2	5	12	27	58
	2		12	55	240	999	4,060
	3			497	4,056	32,683	261,988
	4				65,472	1,048,371	16,776,700
	5					33,554,107	1,073,740,588
	6						68,719,474,780

Total number possible invalid ballots for RCV

TACTICAL VOTING

Recall that all voting systems with more than two candidates are vulnerable to *tactical voting*. Tactical voting occurs when a voter expresses a dishonest preference in order to achieve the result of his true preferences.

AV and tactical voting

Because voter preferences are restricted to very coarse granularity (yes or no), the effectiveness of tactical voting is limited in AV. It can occur when more than one candidate makes it above a voter's approval threshold, but there is a large difference in how that voter feels among those candidates. For example, a voter may be satisfied with both candidate A and candidate B, but candidate A might be far and away the voter's preferred choice. Because relative rankings are not permitted in approval voting, it may be worth it for a voter to drop B and approve only A, even if the voter finds B an acceptable alternative, because a vote in AV helps all choices equally and a voter may not wish to do this. This is known as *bullet voting:* Voting for a single alternative when multiple alternatives are possible.

Tactical voting occurs when a voter expresses a dishonest preference in order to achieve the result of his true preferences.

In fact, there is good evidence this is what happens in AV elections.[10] In 2016, in an AV presidential poll by the Independent Party of Oregon, fully 70% of the votes cast were bullet votes and no majority winner was found. Similarly, AV has been used for alumni and/or trustee elections at both Dartmouth College and the University of Colorado at Boulder. In both those elections, the vast majority of votes were bullet voted, and only plurality winners were obtained (one with only 30% approval). Based on the limited cases where AV has been tried, it appears to degenerate into plurality voting due to the tactical behavior of voters.[11] This appears to be a factor in the Dartmouth College Alumni Association abandoning approval voting in 2009.[12]

RCV and tactical voting

Because RCV increases the possibilities of preference expression, it also increases the possibilities of tactical voting. One way to do this is to exploit the *non-monotonicity* of RCV.

With RCV, it is theoretically possible that, in close elections with more than two candidates, ranking a candidate higher could actually make them worse off, depending on the alternate preference orderings of the other candidates. To see how this is possible, we'll use the example from the "monotonicity criterion" Wikipedia page.[13]

Suppose there are three candidates in an RCV election called Right, Center and Left. Suppose voters are allowed to rank two choices, and their preferences come out like this:

Preference		Voters
1st	2nd	
Right	Center	28
Right	Left	5
Left	Center	30
Left	Right	5
Center	Left	16
Center	Right	16

Left has 35 first-place votes, Right has 33, and Center has 32. No candidate has a majority, so Center is eliminated. 16 votes transfer to Left and 16 to Right, so Left wins 51-49.

Suppose, however, that two voters in the second row (Right 1st, Left 2nd) had

ranked Left higher instead. That would change the results to:

Preference		Voters
1st	2nd	
Right	Center	28
Right	Left	5 3
Left	Center	30
Left	Right	5 7
Center	Left	16
Center	Right	16

Left now has even more first-place votes at 37, so it seems like these new votes have only helped Left. But they have also now caused Right to be eliminated. This throws most of Right's votes to Center, causing Center to win by a 60-40 majority. Thus voters who ranked Left higher actually contributed to Left losing an election she would have won had those voters ranked Left lower.

Tactical voters thus could conceivably target a candidate they want to lose by ranking them higher than a candidate who they hope will be eliminated, but whose alternate preferences will be sufficient to defeat the target in a runoff.

If this seems confusing, that's because it is. While non-monotonic results are indeed possible in RCV, their deliberate exploitation requires tactical voters to have information about the backup preferences of other voters that is difficult to acquire and never completely known. Thus tactical voters are taking a risk their strategy won't backfire. For example, if Right voters' second choices had broken 17-16 for Center instead of 28-5, Left still wins 51-49, this time by defeating Right, the candidate the tactical voters ostensibly preferred.

If non-monotonicity is not deliberately exploited by tactical voters, but instead simply happens as a consequence of voter preference, then whether this is a flaw in RCV is debatable. Examining the first scenario from the Wikipedia page, Left was the most popular plurality candidate, followed by Right. It was close, but since the runoff is for the top candidates to ensure a majority winner, Center is rightly eliminated. Voters who couldn't have Center were evenly split on who they liked next, so those votes were evenly distributed between the top two candidates. This made Left the winner.

In the second scenario, Right was (barely) the least popular. But this time voters whose first choice (Right) was eliminated overwhelmingly preferred Center to Left, so much so that Center won with a solid majority. Looking at the overall distribution of ballots and the overall preference for a centrist candidate among those who lost their first choice, it is hard to argue this is anything other than the right outcome.

Tactical voters thus could conceivably target a candidate they want to lose by ranking them higher than a candidate who they hope will be eliminated, but whose alternate preferences will be sufficient to defeat the target in a runoff.

MISCELLANEOUS CRITERIA

There are a variety of criteria from the academic literature that may be applied to determine the fairness of an election. Some of them are contradictory, and no electoral system can satisfy them all. I examine some of them for AV and RCV voting in this section.

Majority rule

I state the majority rule criterion as, "If a candidate is the first choice of a majority of voters, a good voting system should find that candidate and declare her the winner." AV does not satisfy this criterion

because it has no way of identifying the first choice of any voter. RCV, by contrast, does satisfy this criterion. If there is a candidate who is the first choice of a majority of voters, he would be found on the first ballot.

Condorcet criterion

As described previously, a Condorcet winner is a candidate who would defeat all other candidates in separate head-to-head contests. AV is known to find the Condorcet winner in the case that voter preferences are *dichotomous:* divided into a group they support and a group they do not.[14] RCV, by contrast, is not guaranteed to find a Condorcet winner.

One problem with the Condorcet criterion is that it permits candidates to win who are no one's first choice. It disproportionally favors moderates even when the electorate desires otherwise. For example, in an election between a right-of-center Republican, a left-of-center Democrat, and a moderate with enough support to affect the balance of power, the moderate would defeat both the other two candidates in head-to-head contests by virtue of being the least disliked. In a contest between the moderate and the Democrat, presumably all the Republicans would prefer the moderate, and their votes would be enough to make him the winner. The same would be true between the moderate and the Republican. If the Condorcet criterion were the only one to be considered, it would allow candidates to win who were no one's first choice, despite not having a broad base of core support.

One problem with the Condorcet criterion is that it permits candidates to win who are no one's first choice.

That said, RCV *as a matter of practice* is highly likely to find the Condorcet winner if one exists. For example, in all of the more than one hundred RCV elections held in the San Francisco Bay Area since 2004, all found the Condorcet winner.[15] The difference is that RCV finds Condorcet winners only when they have a strong base of core support.

Later-no-harm criterion

This criterion requires that a vote for a lower-ranked choice (the "later" choice) cannot hurt ("harm") the chances that your higher-ranked choice will be elected. AV does not satisfy the criterion. RCV does.

Monotonicity

As explained in the tactical voting section, AV is guaranteed to satisfy the monotonicity criterion. RCV is not.

Precinct summation

The Center for Election Science has noted that, unlike RCV, winner-take-all and AV ballots can be counted in the precincts where they were cast. Aggregate totals can then be sent to city or state election headquarters.

RCV ballots cannot be counted in this way. The current strategy in RCV elections has been to send all ballots to a central location where they are first counted to determine if a majority winner has been found. If not, the first round of instant runoff occurs, then if necessary, the second, and so on. This centralization has caused delays in some RCV elections.[16]

Fortunately, physical transportation of ballots to election headquarters, followed by centralized counting, is not the only possibility. Communication between the precincts and the central headquarters can occur with each runoff round. In the first round, precincts calculate their first-choice vote totals and send those to election headquarters. While those are being tabulated, precincts can calculate the results that will be needed in the event of a runoff by producing multiple

second-round totals based on the possible scenarios. That is, while first-choice vote totals are being calculated, precincts can calculate hypothetical second-round totals if candidate A is eliminated, if candidate B is eliminated, and so forth. Should central headquarters determine that a majority was not obtained, they inform precincts of the last place candidate and then ask precincts to send their corresponding second-round totals. While those are being centrally tabulated, precincts calculate the possible third-round totals, etc.

With the use of computers, this is very easy to do, employing a standard technique in algorithm development in the presence of unknown or delayed information. Each individual aggregation operation is very simple, the equivalent of plurality voting or AV. These operations can all be cascaded, from precincts to city headquarters, to county, to state.

Favorite betrayal criterion

An election system that meets the favorite betrayal criterion guarantees that voters will never have an incentive to support their favorite candidate less than others. AV satisfies this criterion, albeit vacuously, since it forbids distinctions among candidates beyond "yes" or "no." Only you know who your favorite candidate is, and you cannot support any candidate less than any other beyond "approve" or "disapprove," so given these constraints, approval voting satisfies this criterion trivially.

Our current system of plurality voting, as well as RCV, do not satisfy the favorite betrayal criterion. The former's deficit is manifest in the well-known "spoiler effect," where voters know that voting for a third-party candidate with no chance of winning risks the election of the worse of the two remaining evils. Thus voters are incentivized to vote for a candidate other than the one they really want.

The reasons for RCV's violation of this criterion are a little more subtle. RCV does, in fact, satisfy the favorite betrayal criterion in two special cases: when the voter's favorite candidate is likely to win, or likely to be eliminated in the first round. The larger either of these probabilities are, the more likely the criterion will be satisfied. Both these cases should be intuitively clear. If your favorite is likely to win, then you have no reason to vote for anyone else. If your favorite is likely to be the first one eliminated, you risk nothing by ranking them first, since that is effectively a vote for your second choice.

Things become more subtle in the middle range of your favorite's popularity. In a three-way race, the more popular your favorite becomes, the greater the risk that a) your second choice will be eliminated, and then b) the resulting reallocation of votes will be enough to tip the election to your third choice. In a three-way race, this would be the worst outcome for you, so depending on how you assess that risk, it may be rational to rank your second choice above your true favorite.

This risk would continue to increase until your candidate's popularity reaches a certain threshold, at which point either your third choice will be more likely to be eliminated first, or else the vote reallocation from your second choice's elimination will not be enough to prevent your first choice from winning.

Knowing that threshold is, however, quite problematic. It requires a great deal of information about how voters will express their preferences, information which, if already known, would negate the purpose of the election in the first place. Betraying favorites in the absence of complete

If your favorite is likely to win, then you have no reason to vote for anyone else. If your favorite is likely to be the first one eliminated, you risk nothing by ranking them first since that is effectively a vote for your second choice.

information is very brittle. It can easily backfire, particularly if small margins are involved. I show an example of this in Appendix B.

Given all this, I believe RCV's handling of this criterion represents an improvement over plurality voting and AV. Plurality voting doesn't handle it at all, whereas RCV addresses it on a continuum, satisfying it in cases at either end of a probability distribution. AV "satisfies" it by simply not allowing you to have a favorite. Satisfying a criterion in this way seems to me rather, well, unsatisfying.

I also note that voters who wish to see support for their favorite candidate or party grow may be willing to lose an election or two to get there; there is more to politics than simply winning the next election. They may also regard a strong showing of their dark horse as a hopeful portent for still more growth (to cross over the critical midrange region where spoiler effects are more likely) or to influence the major parties to adopt policies they find attractive. RCV gives them that chance.

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SECURITY

I have noted that AV is significantly simpler than RCV. This makes AV elections easier to secure. Ballot counting can be done by hand in an emergency, and because the ballots are so simple, it is difficult to disfigure or invalidate them.

By contrast, the complexity of RCV dictates both that ballots are easier to disfigure or malevolently invalidate them. Their complexity also demands that computers be involved in the counting process, which in turn brings up the possibility of hacking. A single misplaced checkmark can invalidate a ballot, and the multiple communication rounds from precincts to headquarters proposed previously, presumably over the internet, provide plenty of opportunities for mischief. The complexity of RCV also means that recounts and audits are significantly harder, and provide further opportunities for hostile parties to sow mistrust in the outcome.

Solutions exist for secure internet communications and election software, but they need to be implemented properly. Such implementation is vital for any voting system, but it is especially crucial for RCV. See the section on cost below.

COST

It seems reasonable to expect the costs of implementing AV to be lower, because AV requires minimal changes to existing plurality winner-take-all voting systems. RCV, by contrast, permits voters to cast a wide variety of possible ballots and uses a non-trivial algorithm to count them. RCV allows voters to express a significantly wider range of preferences and supplies considerably more information. That extra information must be paid for.

A detailed quantitative cost comparison of AV and RCV is beyond the scope of this paper. I do, however, have a recent data point from my home state: Colorado House Bill 21-1071.[17] HB 21-1071 was introduced and approved

in the House State Affairs Committee in this year's Colorado legislative session. It permits local municipalities to use RCV for non-partisan elections. The Fiscal Note prepared by the Colorado Legislative Council estimates its first year implementation cost at a little over one million dollars, mostly due to software updates, reprogramming, and licensing costs.[18] If passed, it will be made revenue neutral through business filing fees.

While this is only one data point, it seems clear that depending on where and how RCV is implemented, it will require one or more of software upgrades, hardware upgrades, training of election officials, and a significant public awareness campaign to help with voter confidence in the outcome and to keep ballot spoilage to a minimum.

On the other hand, we should not forget the cost savings RCV provides through the elimination of runoff elections. Should plurality or AV balloting fail to find a majority winner, as will become increasingly likely with multiple-winner elections (see below), costly runoff elections between the top two finishers will be required. By asking voters for backup preference information up front, RCV eliminates runoffs entirely. More accurately, the runoff happens "instantly," in the sense that it requires only a different type of ballot count performed with the same set of ballots. This is why RCV is often called "Instant Runoff Voting." It is referred to by that name in HB-1071, and is often described that way in similar bills around the country.

Given the historically lower turnouts that accompany runoffs and the associated costs of holding an additional election, instant runoff is a significant advantage of RCV.

According the University of Chicago Booth School of Business, the supporters of RCV over plurality voting outnumber its detractors by more than 8 to 1.

CONCLUSIONS

AV offers better security and it satisfies the favorite betrayal and monotonicity criteria. Its most important advantage is its simplicity. The process is very easy to understand, ballots are very easy to complete, and counting them comparable to our present system.

However, I believe RCV is the better choice. It is comparable to AV in terms of the number of fairness criteria it satisfies, its cost savings in avoiding runoffs are far greater, it produces a majority winner and involves more voters in that result, it is adaptable to proportional representation (as I show in another paper), and it has already been used successfully in municipal and state elections. Most importantly, it provides voters with a much richer set of options that more accurately represent their views.

This is one reason why support for RCV is so strong among economists, who keenly understand the importance of information. According the University of Chicago Booth School of Business, the supporters of RCV over plurality voting outnumber its detractors by more than 8 to 1.[19]

RCV has been put into practice in approximately 40 cities across 17 states. At the state level, Maine and Alaska now use RCV for state and federal elections. The Republican Party of Utah and the Democratic Party of Virginia use RCV for their primaries. Alaska, Hawaii, Kansas,

Wyoming and Nevada used RCV in last year's Democratic Party primaries. While not every RCV implementation has been smooth, and it has been repealed in a small number of instances, often for reasons having little to do with its merits, none of the doom-and-gloom predictions of RCV opponents (excessive security risks, chronic ballot spoilage, exploitations of subtle vulnerabilities to tactical voting) have come to pass.

It should be noted as well that, as emphasized in earlier sections, no electoral system is perfect. RCV does not have to be perfect to be a significant improvement over AV and the status quo. It simply has to be better, perhaps a lot better, in order to justify such a significant change to such an important civic function. I believe it passes that bar.

I believe RCV's challenges will be overcome as more voters and election workers become familiar with it. Most importantly, by providing more options to voters compared to our current system, RCV improves political competition, provides more information to candidates and parties, reduces negative campaigning, and in general makes democracies work better. For an expansion of these and other advantages of RCV, I refer the reader to my companion paper "The Conservative Case for Ranked Choice Voting," to follow this one.

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APPENDIX A:

CALCULATING THE NUMBER OF BALLOTS IN APPROVAL VOTING AND RANKED CHOICE VOTING

Because AV permits voting for multiple candidates, considerably more types of valid ballots are possible. In particular, if there are *n* candidates on the ballot, and we assume that ballots with no approving votes are invalid (since there is no point in casting them), then there are a total of 2^n-1 ways a voter might complete a valid ballot. This is just the number of possible subsets of a set of *n* items, minus the empty set.

The number of possible valid ballots in an AV election for small numbers of candidates is shown below:

Number of candidates	2	3	4	5	6	7	8
Possible valid ballots	3	7	15	31	63	127	255

For example, in a two-candidate election between A and B, a voter could approve of A only, B only, or both, giving three valid possible ballots. In a three-candidate election, the possible approval combinations are [A], [B], [C], [A,B], [A,C], [B,C], and [A,B,C], for a total of seven. And so forth.

There are even more possible ballots for RCV. Let *B(n,m)* be the number of valid ballots in an RCV election with *n* candidates where voters are permitted to rank up to *m* of them, $m \le n$. "!" denotes the factorial operation.

If voters are permitted to rank only one candidate out of *n,* there are *n* possible ballots. Permitting the ranking of one more candidate to an existing RCV ballot increases the total by the number of possible sets of *m+1* candidates, multiplied by the number of ways to rank them. This additional total is:

$$\binom{n}{m+1}(m+1)! = \frac{n}{(n-(m+1))!\,(m+1)!}(m+1)! = \frac{n!}{(n-m-1)!}$$

Thus *B(n,m)* is given by the recurrence relation:

$$B(n,1) = n$$
$$B(n,m+1) = B(n,m) + \frac{n!}{(n-m-1)!}$$

Alternatively, by summing the number of ways to rank one candidate, two candidates, etc, we obtain the closed formula solution:

$$\sum_{(j=1)}^{m} \frac{n!}{(n-j)!}$$

Both formulae give the same answer. Values of this number for small *n* and *m* are shown in the table below.

For example, in an RCV election with three candidates on the ballot where voters can rank all three, the table says there are fifteen possible ballots. Let "[A>B]" denote a ballot where A is ranked higher than B. Possible ballots are:

[A 1st] [B 1st] [C 1st] – 3 ballots
[A > B] [B > A] [A > C] [C > A] [B > C] [C > B] – 6 ballots
[A > B > C] [A > C > B] [B > A > C] [B > C > A] [C > A > B] [C > B > A] – 6 ballots

	How Many Candidates on the Ballot							
Maximum number of candidates you can rank	1	2	3	4	5	6	7	8
1	1	2	3	4	5	6	7	8
2		4	9	16	25	36	49	64
3			15	40	85	156	259	400
4				64	205	516	1,099	2,080
5					325	1,236	3,619	8,800
6						1,956	8,659	28,960
7							13,699	109,600

Total number unique ballots for RCV

As the table on the previous page shows, there are a large number of possible ballots for RCV, even more than for AV. One way to address this problem is to limit the maximum number of candidates voters can rank (for example, providing space for no more than their top three choices). This has the effect of cutting off the lower, larger entries for a given column. While reducing the complexity of the ballot and simplifying vote tallying, setting the threshold too low runs the risk of *ballot exhaustion:* The possibility that a majority winner will not be found even after one or more runoff rounds.

Another way to reduce the number of possible ballots is to require voters to rank m choices out of n candidates in order for their ballot to be valid. In this case the formula for $B(n,m)$ is simply the last term of the closed formula summation:

$$B(n,m) = \frac{n!}{(n-m)!}$$

where again "!" denotes the factorial operation and $m \leq n$. Values of this number are shown below:

How Many Candidates on the Ballot									
Number of candidates you MUST rank		1	2	3	4	5	6	7	8
	1	1	2	3	4	5	6	7	8
	2		2	6	12	20	30	42	56
	3			6	24	60	120	210	336
	4				24	120	360	840	1,680
	5					120	720	2,520	6,720
	6						720	5,040	20,160
	7							5,040	40,320
	8								40,320

Total number unique ballots for RCV

APPENDIX B:
A FAVORITE BETRAYAL SCENARIO IN RCV[20]

(For this section, we will use the RCV balloting notation from Ranked Choice Voting section)

Suppose we have a four-way race between candidates A, B, C, and D, with 41 votes cast in the following way:

	10	6	5	20	1st Choice Votes
A	1	2	3	2	10
B	2	1	2	4	6
C	3	3	2	3	5
D	4	4	4	1	20

Note that the 10 voters in the second column have marked A as their favorite. This will be important later.

Candidate C has the fewest first-choice votes and is therefore eliminated, with her five first-choice votes going to candidate B. This gives the following second-round totals:

	10	6	5	20	1st Choice Votes
A	1	2	2*	2	10
B	2	1	1*	4	~~6~~ 11
C	3	3	2	3	~~5~~ 0
D	4	4	3*	1	20

Candidate A is eliminated next, with his 10 first-choice votes going to candidate B.[21] This is enough to give B a majority and hand her the election:

	10	6	5	20	1st Choice Votes
A	1	2	2*	2	~~10~~ 0
B	1*	1	1*	4	~~11~~ 21
C	3	3	2	3	~~5~~ 0
D	2*	4	3*	1	20

Suppose that two voters in the second column have somehow foreseen this possibility and decide to "betray their favorite" by ranking him second to candidate C.

These two ballots are reflected in the new leftmost column and the changed first-choice totals are highlighted below:

	2	8	6	5	20	1st Choice Votes
A	2	1	2	3	2	8
B	3	2	1	2	4	6
C	1	3	3	1	3	7
D	4	4	4	4	1	20

The new vote totals are enough to eliminate B first and reallocate her votes to A:

	2	8	6	5	20	1st Choice Votes
A	2	1	1*	3	2	~~8~~ 14
B	3	2	1	2	4	~~6~~ 0
C	1	3	2*	1	3	7
D	4	4	3*	4	1	20

Now C is eliminated as before:

	2	8	6	5	20	1st Choice Votes
A	1*	1	1*	1*	2	~~14~~ 21
B	3	2	1	2	4	~~6~~ 0
C	1	3	2*	1	3	~~7~~ 0
D	2*	4	3*	2*	1	20

But this time her votes go to candidate A, giving him a majority and the election. This is because the two tactical voters correctly guessed that:

1) If C were eliminated first, enough redistributed votes might go to B to hurt their favorite candidate A.

2) If B were eliminated first, enough redistributed votes could go to A to help him.

In other words, they had some suspicions about the second choices of voters who ranked B first and voters who ranked C first. In this case, they guessed right.

Failing to rank their favorite candidate A first ("betraying their favorite"), and instead working to eliminate B first, resulted in A winning the election.

This is possible because A's popularity was in the risky middle range I discussed in the section on favorite betrayal criterion: popular enough to have a significant effect on the election, but not so popular as to guarantee victory.

Note as well that things could have easily gone awry. Suppose that instead of two voters betraying their favorite, five voters decided to. This gives:

	5	5	6	5	20	1st Choice Votes
A	2	1	2	3	2	5
B	3	2	1	2	4	6
C	1	3	3	1	3	10
D	4	4	4	4	1	20

This tips the balance too far, with the unintended result of eliminating their favorite A immediately:

	5	5	6	5	20	1st Choice Votes
A	2	1	2	3	2	~~5~~ 0
B	3	1*	1	2	4	~~6~~ 11
C	1	2*	2*	1	3	10
D	4	3*	3*	4	1	20

Next, C is eliminated, and B wins:

	5	5	6	5	20	1st Choice Votes
A	2	1	2	3	2	~~5~~ 0
B	1*	1	1	1*	4	~~11~~ 21
C	1	2	2	1	3	~~10~~ 0
D	2	3	3	2	1	20

B was the tactical voters' original second choice, so perhaps they thought the risk was worth taking. On the other hand, it resulting in their favorite being eliminated first, giving the electorate an inaccurate perception of the depth of his base. Without knowing voter preferences of other voters or the number of betrayals among their own voting group, the outcome of attempted favorite betrayal can be what mathematicians call *chaotic*, where the outcome is highly sensitive to specific initial conditions. In layman's terms, it is highly unpredictable, where small changes in voting can have large changes in the results.

ENDNOTES

[1] For example, https://www.digitalhistory.uh.edu/disp_textbook.cfm?smtID=3&psid=160.

[2] Drutman, Lee "Breaking the Two-Party Doom Loop", cited originally as https://founders.archives.gov/documents/Adams/06-10-02-0113.

[3] Drutman, originally cited as https://press-pubs.uchicago.edu/founders/documents/a1_9_1s20.html.

[4] Gibbard, Allan (1973). "Manipulation of voting schemes: A general result" (PDF). Econometrica. 41 (4): 587–601. doi:10.2307/1914083. JSTOR 1914083.

[5] "Approximately" because technically every vote beyond 50%+1 is beyond the minimum needed.

[6] I use the term "minority" here to describe any voting population that did not support the winning candidate.

[7] Brams, Steven and Fishburn, Peter, "Approval Voting", The American Political Science. Review, Sep 1978 Vol n72 No 3 pp 831-847. Online at https://www.jstor.org/stable/1955105.

[8] The 20 votes in the 3rd column, the 30 votes in the 4th column, and the 5 votes in the 6th column.

[9] https://www.rangevoting.org/SPRates.html.

[10] https://www.fairvote.org/new_lessons_from_problems_with_approval_voting_in_practice.

[11] AV advocates have argued this effect would disappear, or at least be reduced, if *approval polling* were the norm [https://electionscience.org/library/approval-voting-tactics/]. At the very least, this presents a rather tricky chicken-and-egg problem. More importantly, based on the author's reading of the above, it would seem to require that voters not even access to plurality polling information. This seems both unrealistic and undesirable.

[12] https://alumni.dartmouth.edu/content/dartmouth-alumni-association-election-results-new-executive-committee-elected-constitutional.

[13] https://en.wikipedia.org/wiki/Monotonicity_criterion.

[14] Brams and Fishburn, *op cit.*

[15] https://www.fairvote.org/every_rcv_election_in_the_bay_area_so_far_has_produced_condorcet_winners.

[16] https://electionscience.org/library/approval-voting-versus-irv/.

[17] https://leg.colorado.gov/sites/default/files/documents/2021A/bills/2021a_1071_01.pdf.

[18] https://leg.colorado.gov/sites/default/files/documents/2021A/bills/fn/2021a_hb1071_00.pdf.

[19] https://www.igmchicago.org/surveys/ranked-choice-voting/. 60% agreed or strongly agreed in their support of RCV, compared to 7% who disagreed. The rest were either uncertain (16%), had no opinion (5%), or did not answer (12%). No economist polled strongly disagreed.

[20] This section is based on https://electowiki.org/wiki/Favorite_betrayal_criterion#Instant-runoff_voting, with some extensions by the author.

[21] Note that candidate A is in fact a Condorcet winner. Based on the first ballot count, in a head-to-head contest with B,C and D, A would win 30 to 11, 36 to 5, and 21 to 20 respectively. As noted in section 9.2, RCV is not guaranteed to find Condorcet winners, particularly if they do not have a broad base of support.

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