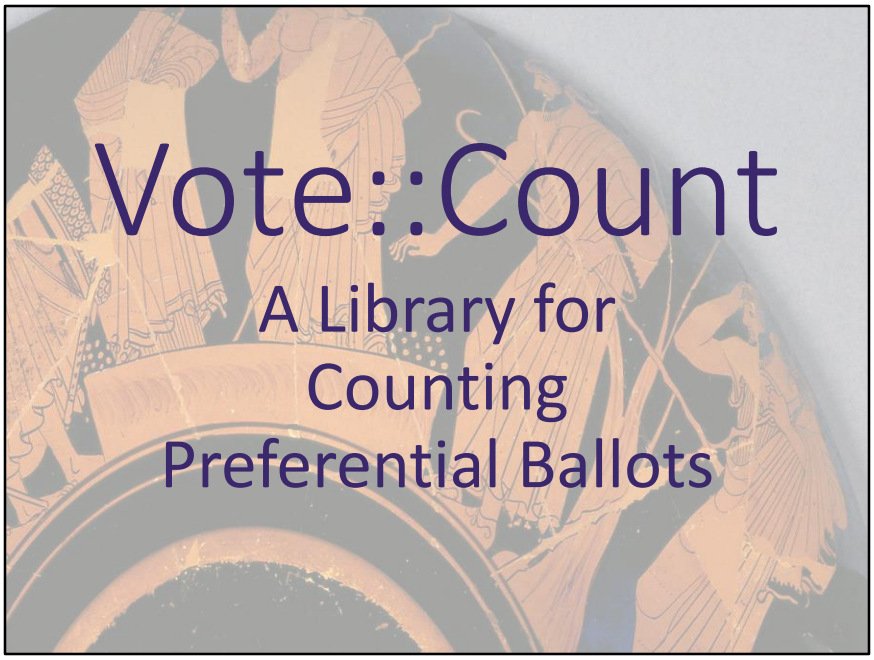
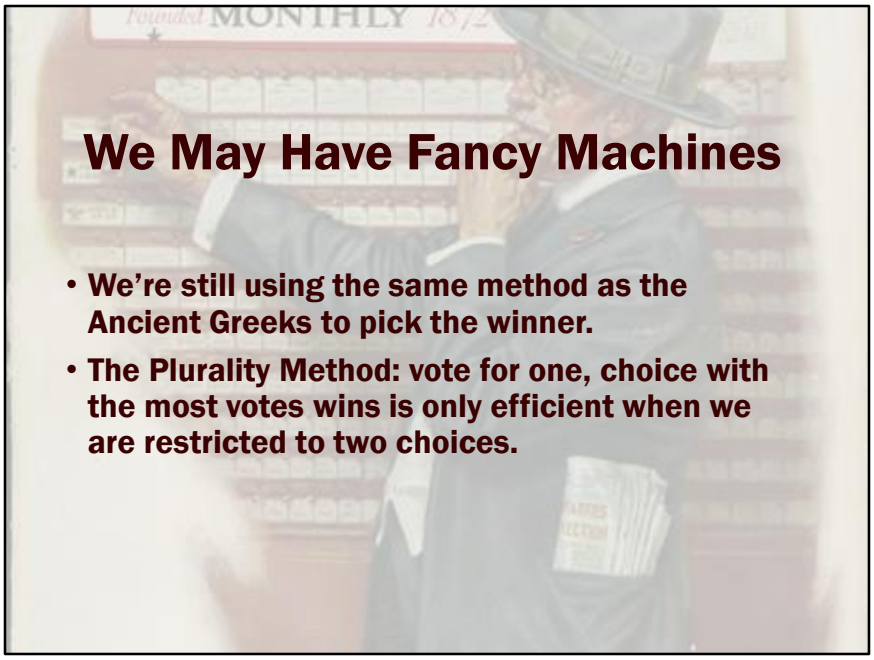
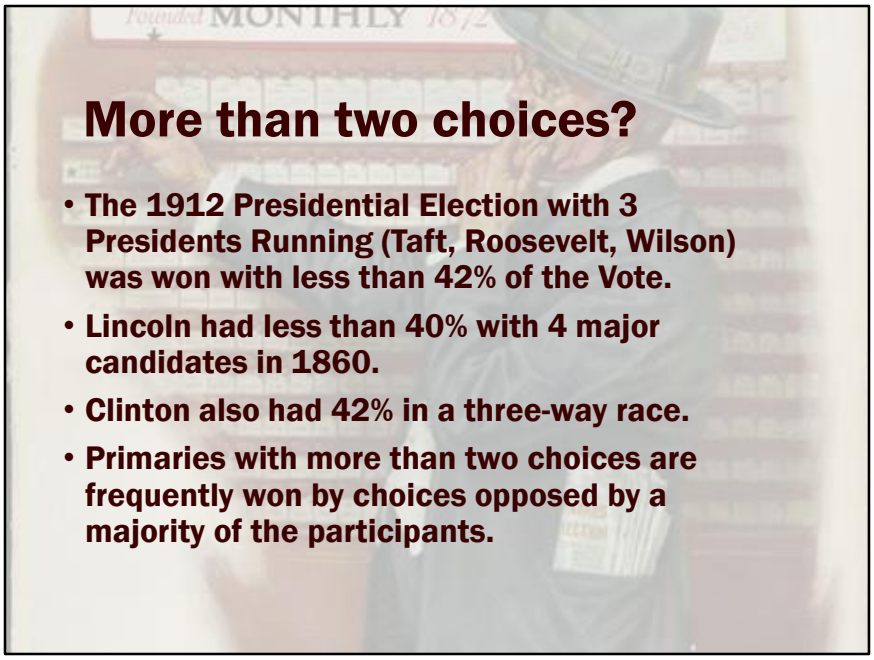


Background: Casting Ballots with Pebbles in Ancient Greece

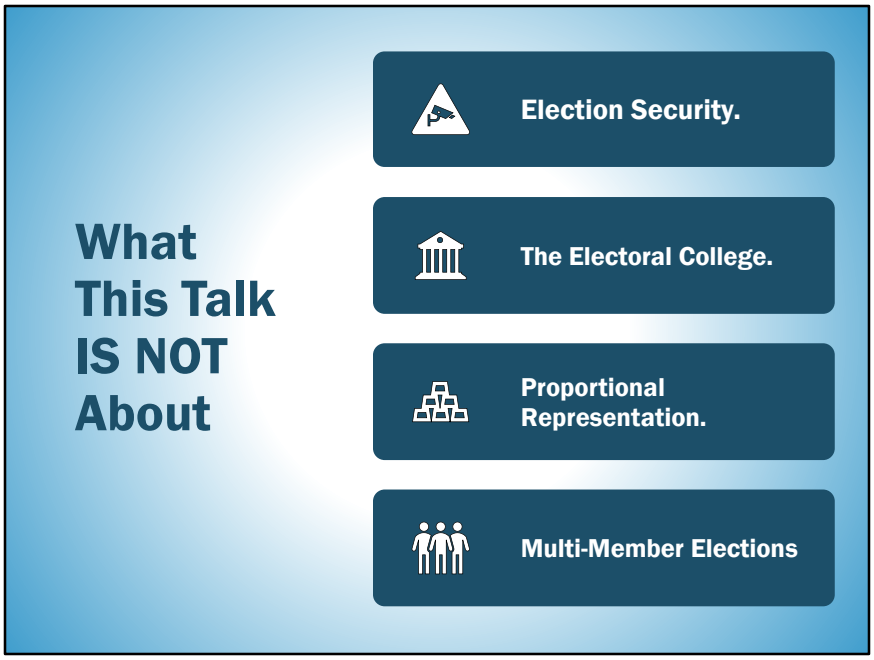


We May Have Fancy Machines

- We're still using the same method as the Ancient Greeks to pick the winner.
- The Plurality Method: vote for one, choice with the most votes wins is only efficient when we are restricted to two choices.



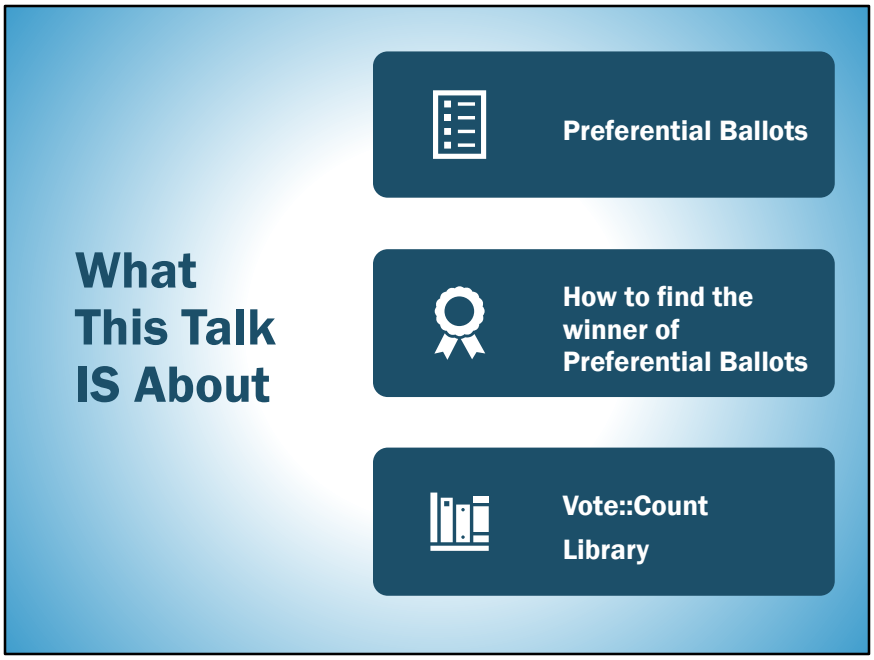
In the Presidential Elections:
Perot voters were nearly evenly split between Republican and Democrat Leaning, Clinton probably won.
Lincoln had a majority in enough states to win the Electoral College, but with preferential ballots and no electoral college, Douglas might have won it.
Without the Republican Taft acting as a spoiler the Independent Roosevelt would have defeated Wilson.
In Philadelphia's single party system, where it is common to have the party organization back a choice opposed by most of the voters, the opposition splitting to multiple alternatives usually results in the selection of the machine candidate.



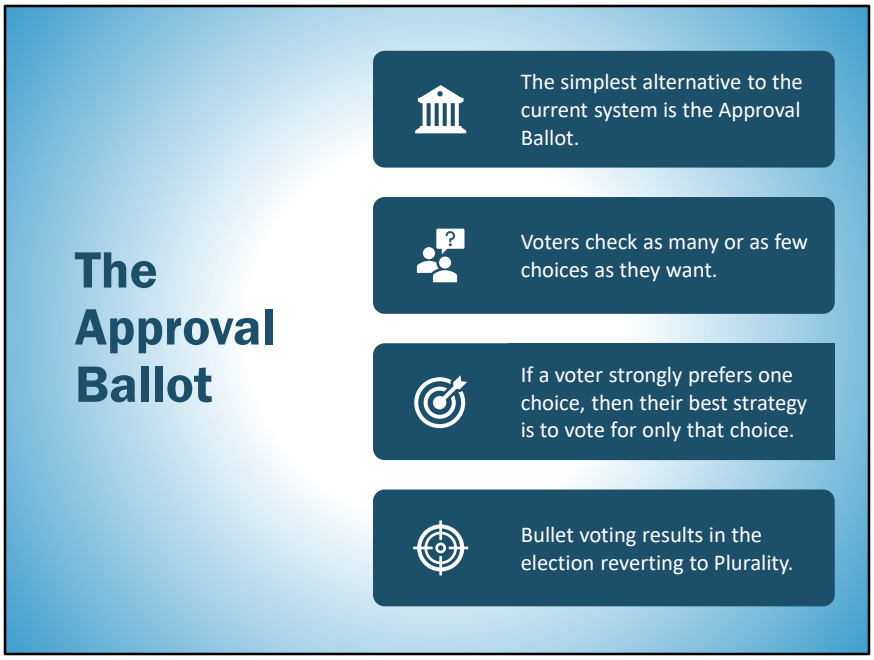
This talk is about vote count and single member preferential ballot elections. There isn't time to talk about security issues which are completely outside the scope of Vote:::Count. A library can't fix poor choice of voting equipment and poor procedure!

The Electoral College is a uniquely American issue. It will be impossible to amend the constitution to scap the system completely. It is more likely that we could amend the constitution to allocate electors proportionately within each state.

Proportional Representation and multi-member elections are interesting topics that we won't have time for today.



Vote::Count is a programmer's library for resolving preferential elections.

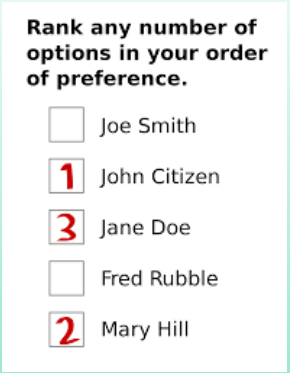


Supporters of Approval Voting for public elections are in denial of how people think and behave.

While Approval is simple, it only works a little bit better because the best strategy for voters is often to vote for only one choice, effectively reverting to plurality.

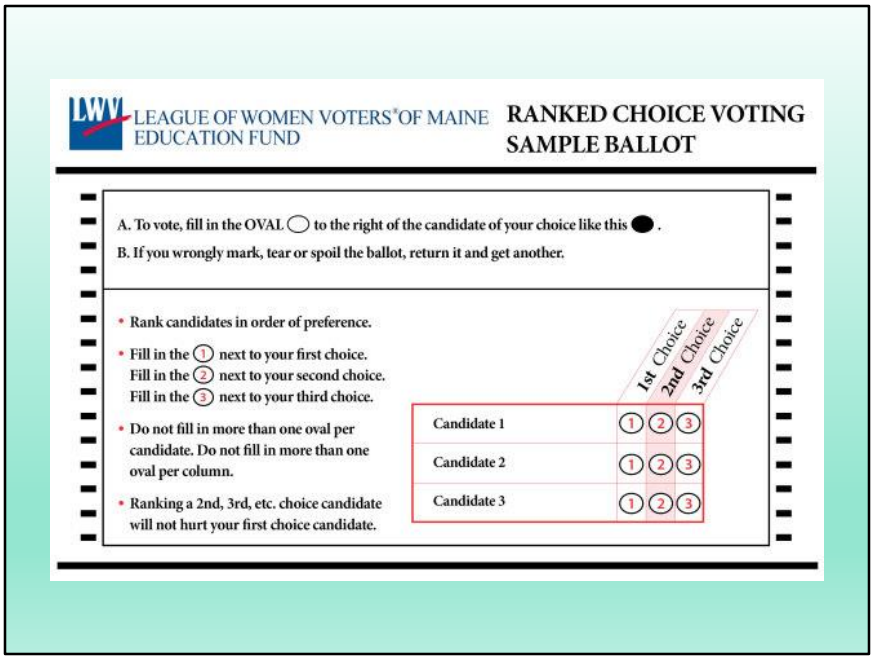
Preferential Ballot Types

- **Voters indicate multiple choices with a preference.**
- **Ranked Choice Ballot: voters rank choices.**
- **Range (Score) Ballot: voters assign scores.**
- **Ranked Ballots are also referred to as Ordinal and Range Ballots as Cardinal.**

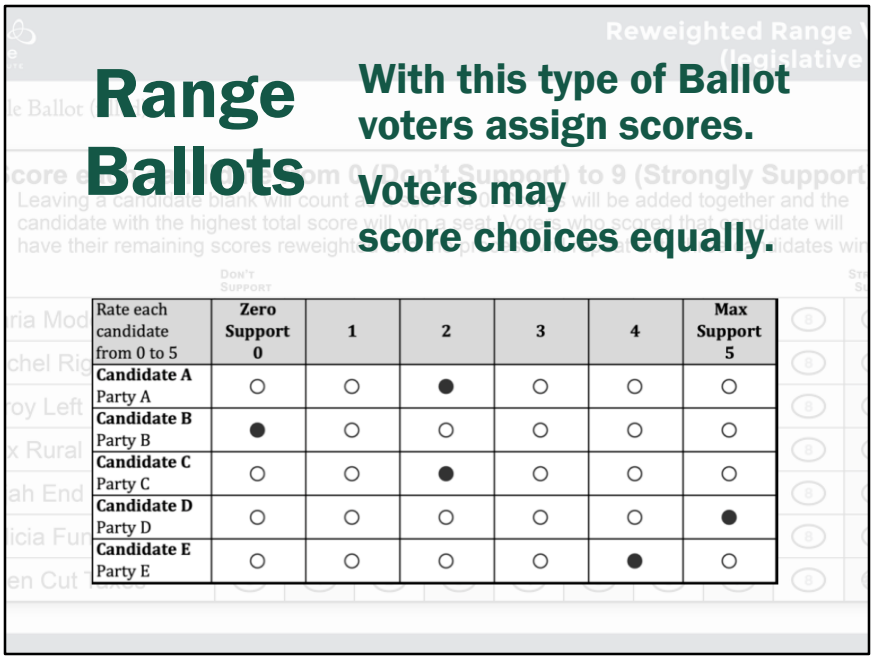


Range Voting is often referred to as Score voting by its proponents.

A third type the combines both, by restricting voters from scoring choices equally on a range ballot allowing the ballot to be interpreted as either an ordinal or cardinal ballot.



Maine uses Ranked Choice Ballots, here is an example from the League of Women Voters.



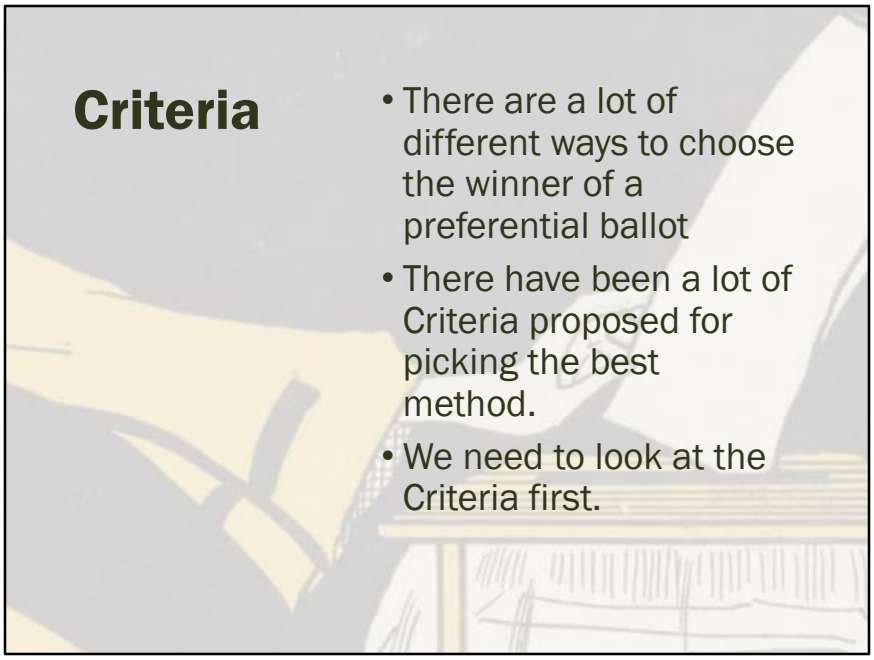
An example of a standard Range Ballot, notice that the voter has scored A and D the same. The watermark is also a range ballot.

Ordinal Range Ballots

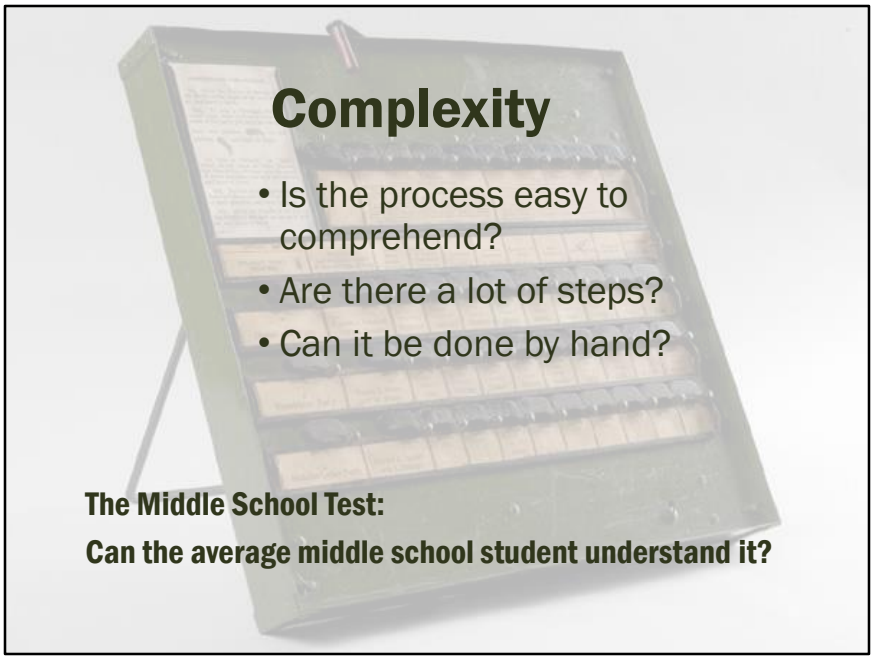
- A variant of the Range Ballot that does not Permit Equal Scores.
- This variant may be evaluated as a Cardinal (Range) or Ordinal (Ranked) Ballot.
- Because it is in the form of a Range Ballot but is also Ordinal, Vote::Count refers to it as Ordinal Range.

If the score depth is 10 or greater the loss of expression is minimal.

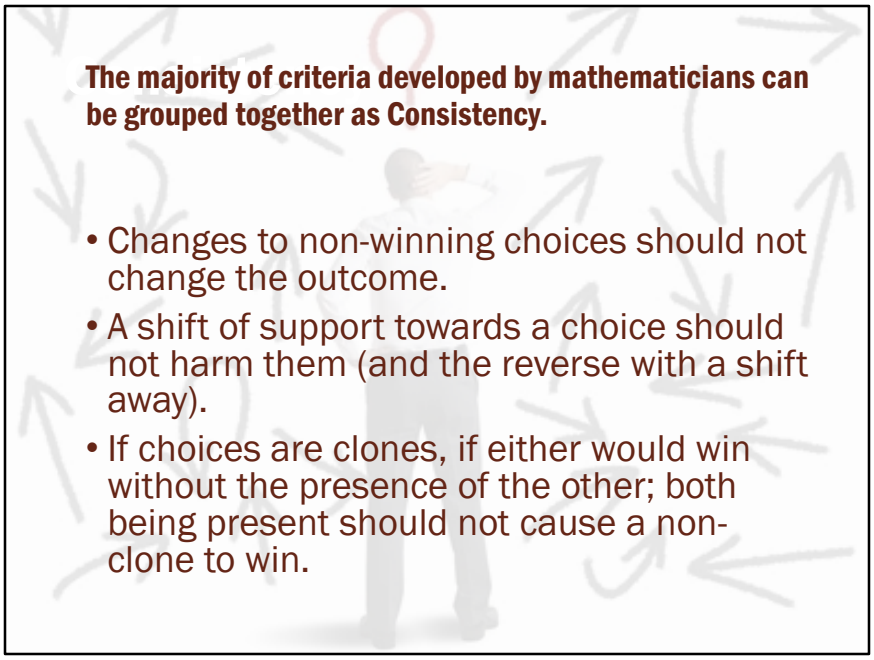
In voting terms Ordinal means ordered preferences, while Cardinal means assigned a value. So these terms are effectively synonyms for ranked and range. The Ordinal Range ballot takes the form of a range ballot but can be interpreted as an Ordinal Ballot.



Before I can talk about methods I need to talk about Criteria.



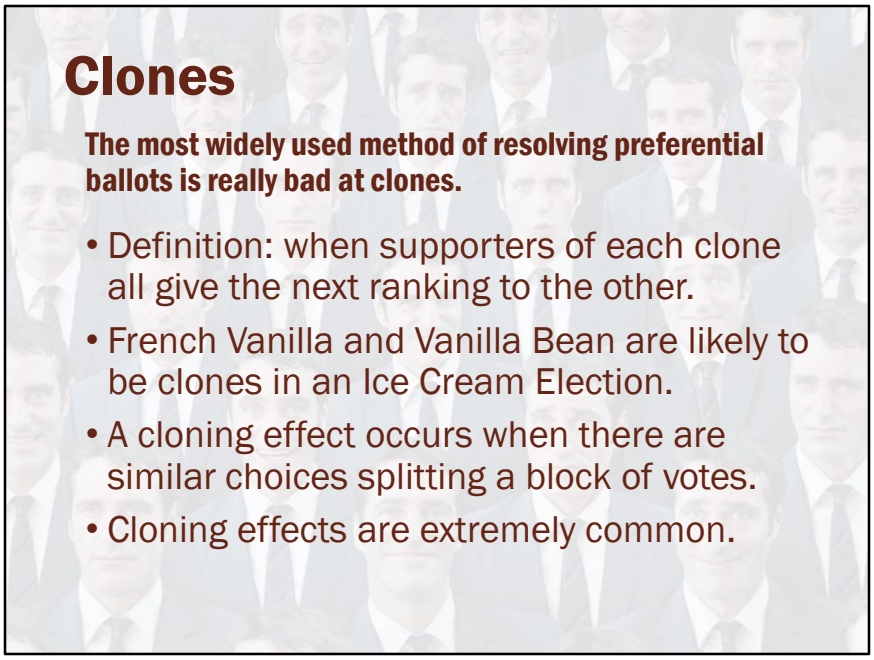
This criteria is subjective, and generally overlooked in discussions by Mathematicians. The middle school test is a policy test and somewhat hypothetical. The methods currently most favored by the Mathematicians, SSD and Kemeny-Young generally require being past introductory level college math to understand and considered a very hard fail on Complexity.



There is a criteria that Mathematicians call consistency, which isn't very important from a policy perspective.

Imagine we hold the same election every day, and the same choice always wins. One morning the 4 people who always cast first preference for Rocky Road and second for Chocolate, simply vote for Chocolate, on that day for the first time Vanilla wins instead of Chocolate. This is both a shift of support towards the normal winner and the dropping of a weakly supported choice, neither of which should rationally change the winner.

The next slide is about clones.



Democratic Voters tend to like both Elizabeth Warren and Bernie Sanders or not like them. The majority of their supporters would also rank the other one high on a preferential ballot. It is also possible to have a clone group of more than two, consider a hypothetical 2020 democratic primary featuring AOC, Bernie Sanders and Elizabeth Warren pitted against Joe Biden. The election would easily divide between voters who ranked all of the other 3 above Biden and those who preferred Biden.

Condorcet's Criteria

- **Condorcet Winner**

  A choice which defeats all others in Pairwise Comparison should always Win.

- **Condorcet Loser**

  A choice defeated by all others should never win.

Democratic Voters tend to like both Elizabeth Warren and Bernie Sanders or not like them. The majority of their supporters would also rank the other one high on a preferential ballot. It is also possible to have a clone group of more than two, consider a hypothetical 2020 democratic primary featuring AOC, Bernie Sanders and Elizabeth Warren pitted against Joe Biden. The election would easily divide between voters who ranked all of the other 3 above Biden and those who preferred Biden.

Marie Jean Antoine Nicolas de Caritat, Marquis de Condorcet

- Mathematician, Philosopher, Politician
- Friend of Benjamin Franklin
- Victim of the French Revolution
- Started the study of Choice Theory

Smith Criteria
The third Condorcet Criteria

- **Smith Set (Dominant Set)**

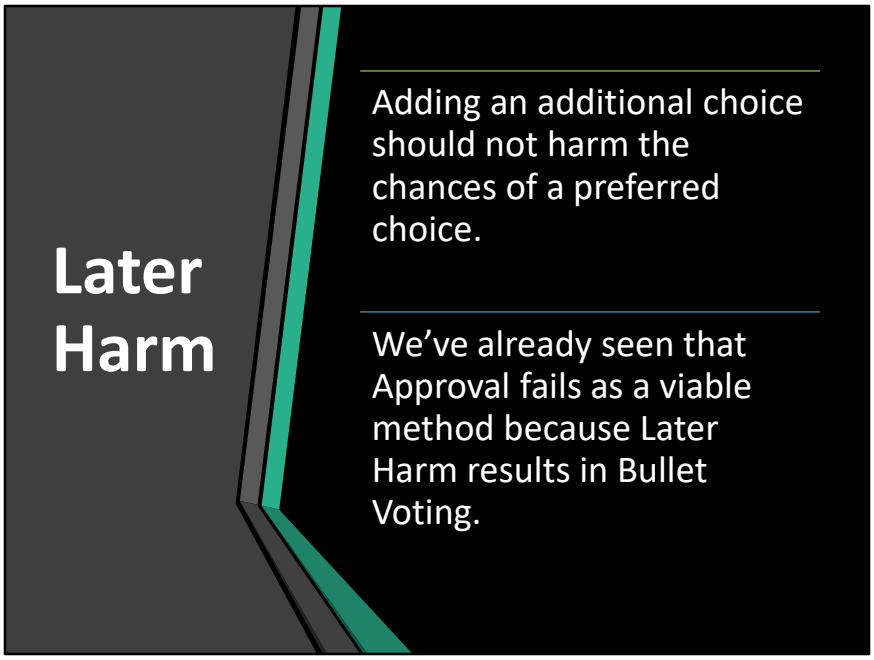
  When there is no Condorcet Winner the smallest subset that defeats all others.

  Named for the American Mathematician John Howard Smith.

- **Smith Criteria**

  The winner should be a member of the Smith Set.

Smith's work is relatively recent, he was still teaching math in 2011. Unfortunately, I could not find an image of him.



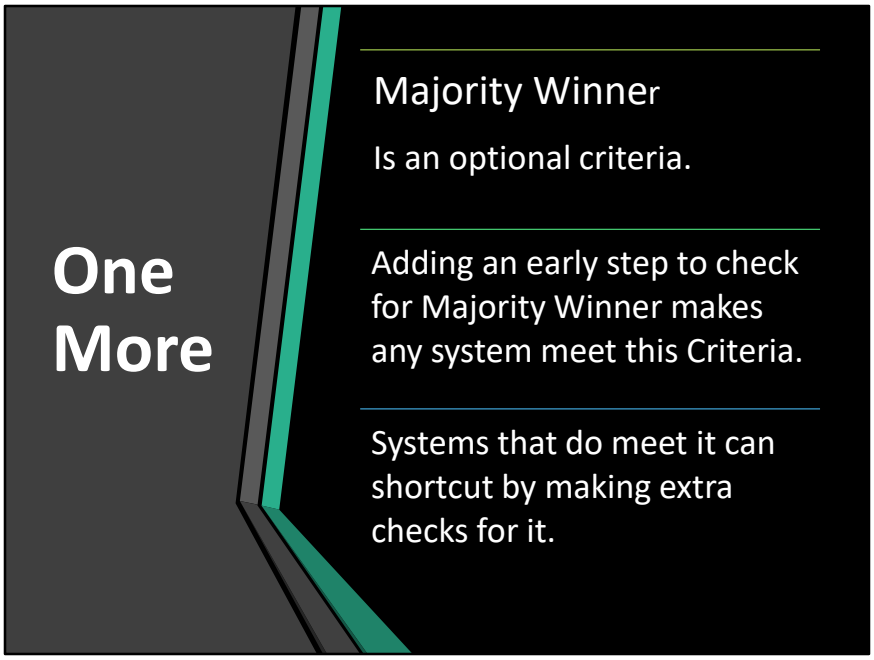
Later Harm is a big driver in strategic voting. Voters casting insincere ballots breaks preferential resolution and in the worst case voters are effectively back to plurality.

One More

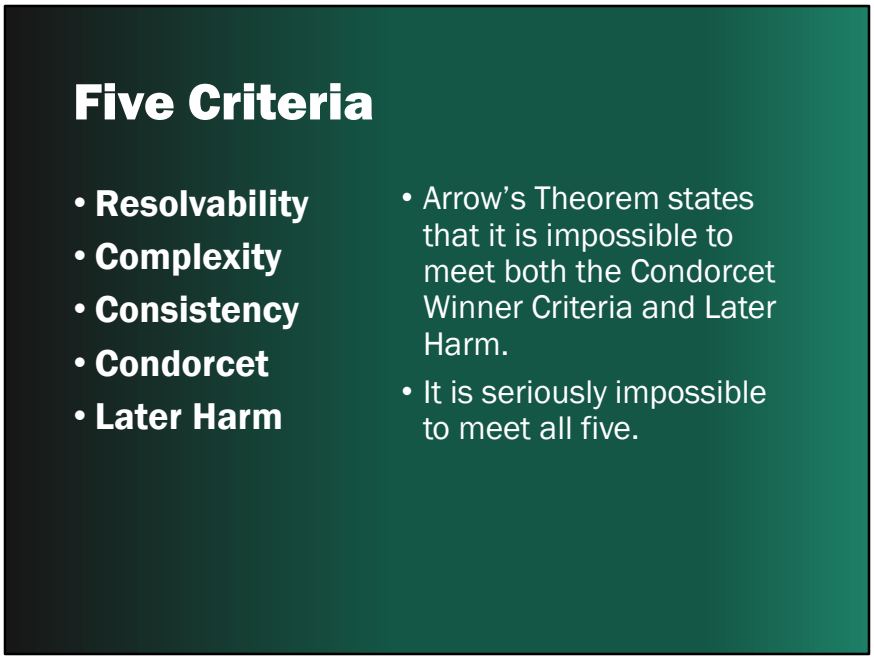
Resolvability

Majority vote meets Condorcet, Later harm and Consistency.

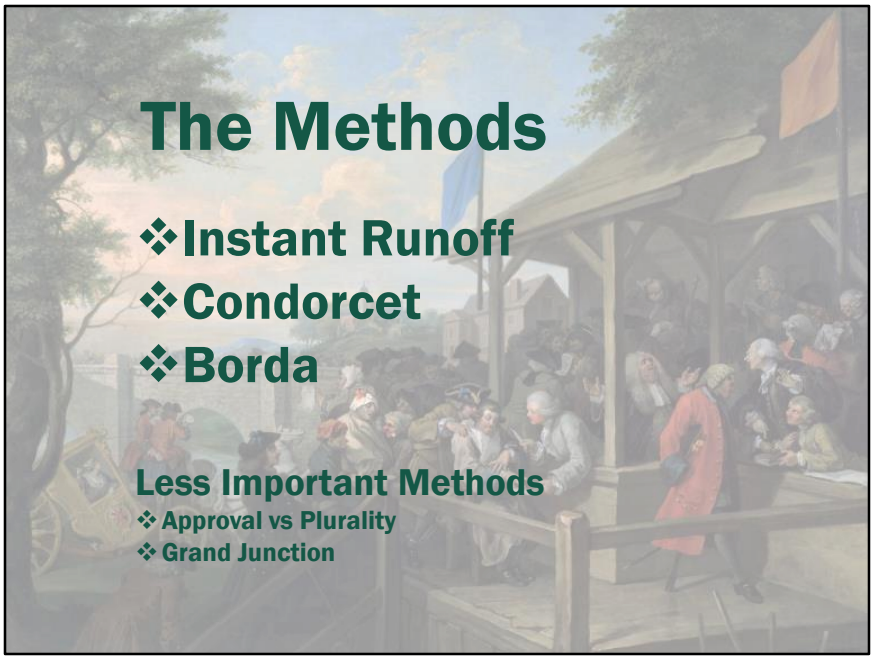
Unfortunately, Majority frequently fails to produce a winner, or even return a tie.



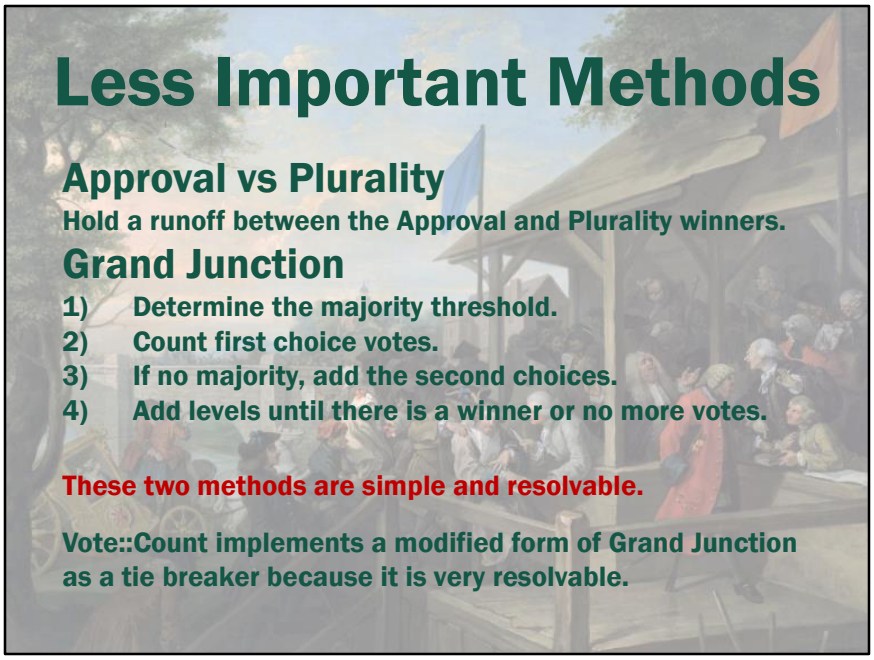
Supporters of Score Systems will often argue against Majority Winner as a desirable criteria. If A defeats B 51% to 49%, but most A supporters ranked B second, B might have a much higher Borda Score



This is the fundamental Paradox of Preferential Voting. We are unable to meet all of the Criteria we've set. There is no perfect Method, only tradeoffs.



There are, for all of the criteria, and sub-criteria we've considered, only three basic methods that are widely used.



Grand Junction is also known as the Bucklin Method for its inventor. It was used in Grand Junction for a few elections. The modified variant for tie breakers is the most resolvable tie breaker, the only more resolvable tie breaker is random, which isn't repeatable.

Instant Runoff Voting

- Also known as Alternative Vote or Hare Method (after its inventor).
- Requires a Majority.
- When there is no majority the low choice is eliminated, and the votes recounted.
- The most widely used method of counting preferential ballots.

Instant Runoff Voting

- Easy to Hand Count.
- Meets Later Harm.
- Meets Condorcet Loser, but not Condorcet Winner and Smith.
- Has a lot of consistency issues including:
  - The example many slides prior with the Rocky Road voters is possible with IRV
  - IRV handles cloning effects poorly.

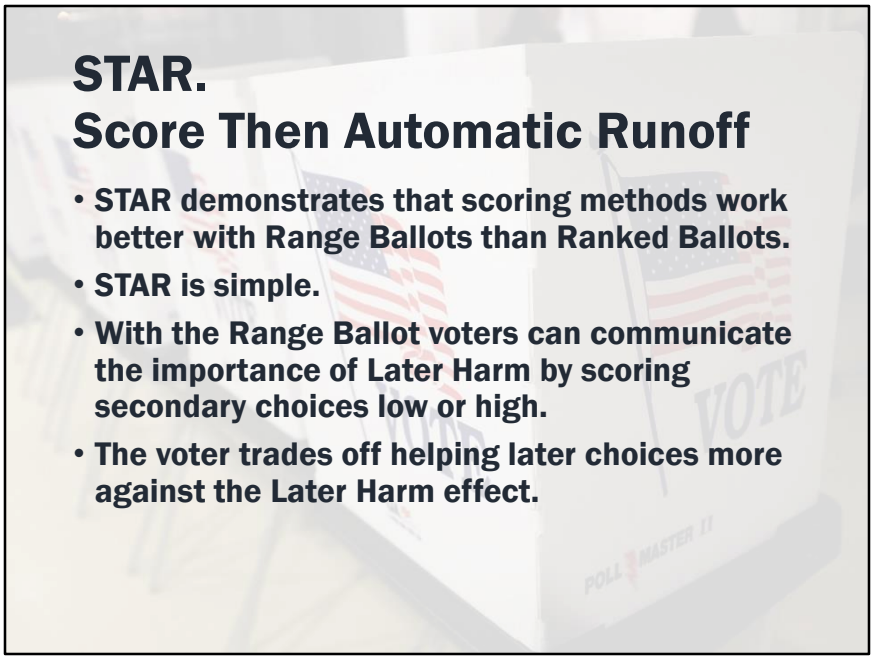
The Borda Count (Scoring Methods)

- Count Borda a contemporary and rival of Condorcet popularized Vote Scoring.
- Vote Count groups all scoring methods as part of the Borda family.

Like Condorcet, Count Borda made contributions in multiple fields.

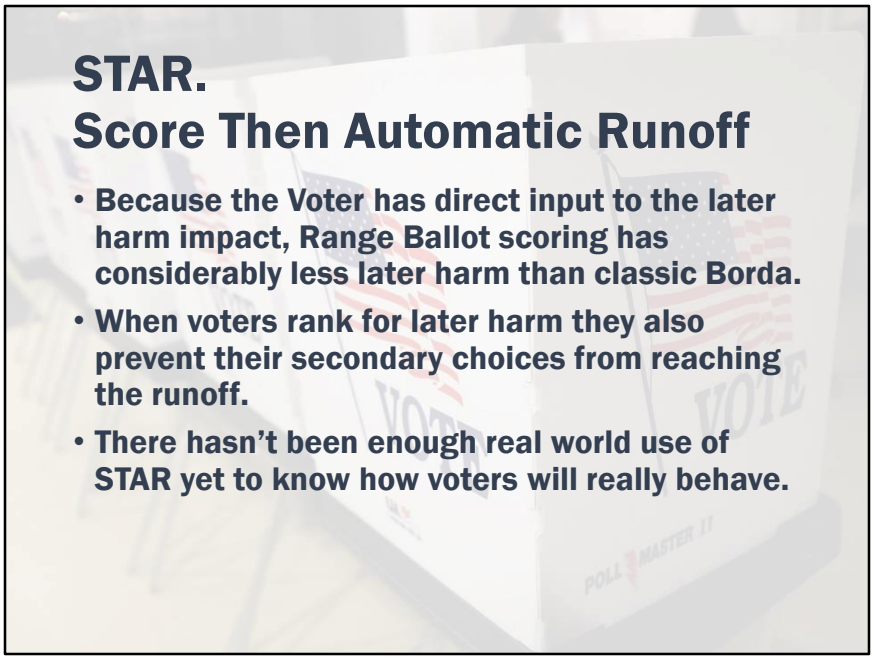
Scoring Methods

- Scoring Methods do not meet Later Harm.
- Borda's original Method severely fails Later Harm.
- Scoring Methods do not meet Condorcet Winner or Smith.

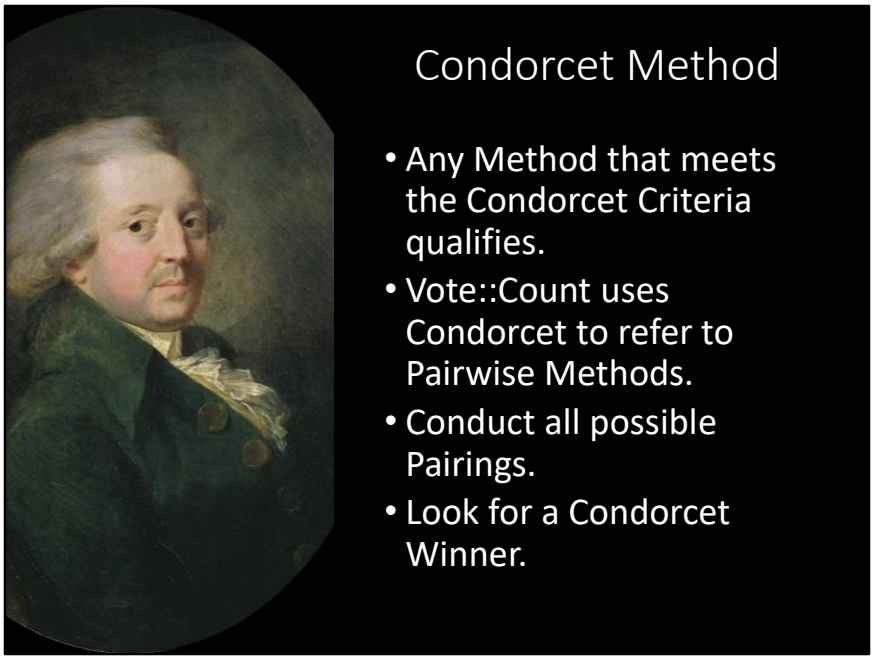


The name explains the process. Use the range ballot scores, take the top two choices and hold a runoff.

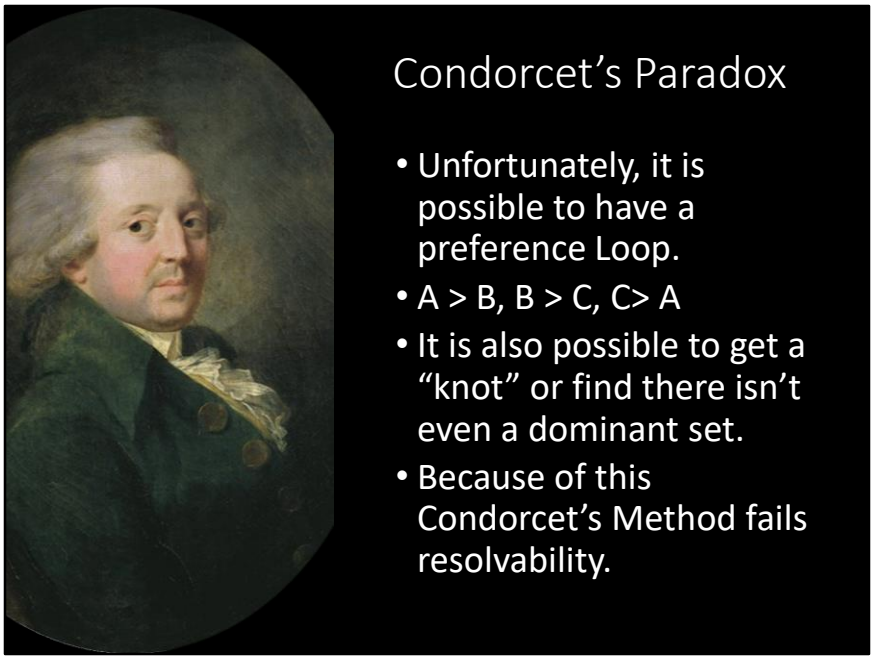
With range ballots the voter generates the scores.



Until recently almost all work and implementation of Preferential Ballots was with Ranked Ballots. It is only recently that there has been a lot of interest in Range Ballots, so STAR hasn't been around all that long.

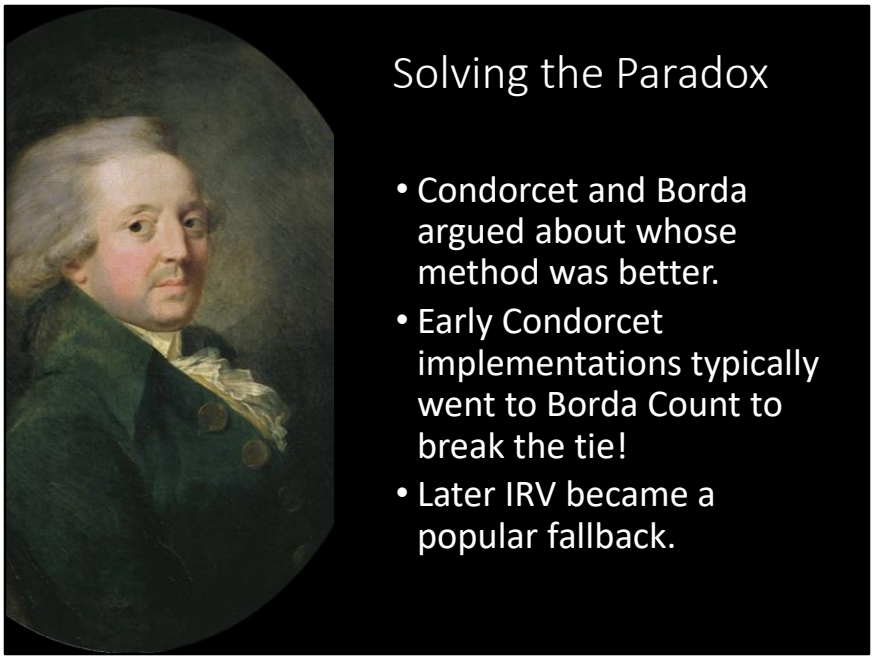


For the final method type we are back to our old hero, Condorcet.



Loops can actually occur at any odd number, but 5 is rare with real data and anything larger is limited in practice to sets of data designed to produce the effect.

Knot is a term Vote::Count uses to describe this, not an accepted math term.



Loops can actually occur at any odd number, but 5 is rare with real data and anything larger is limited in practice to sets of data designed to produce the effect.

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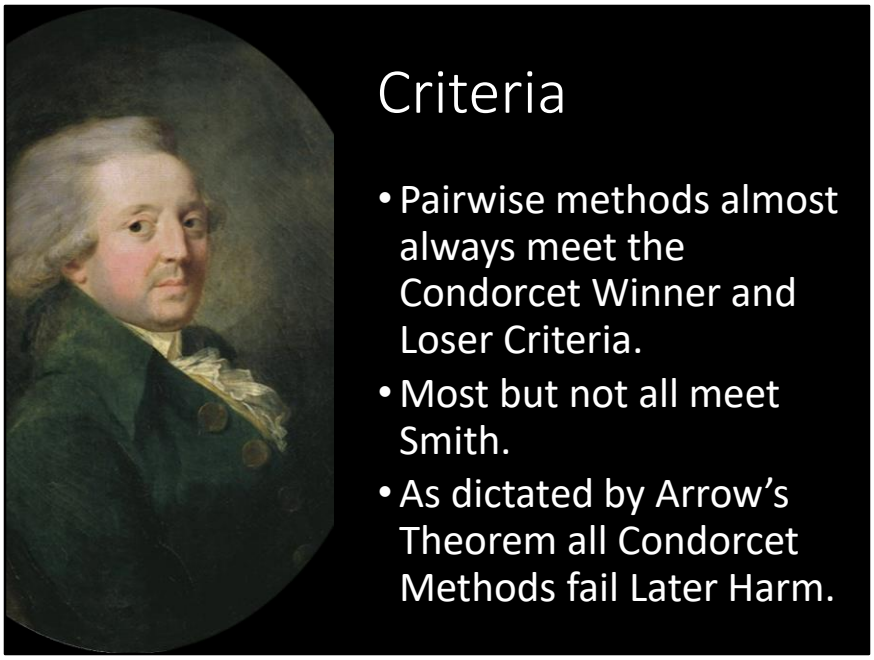
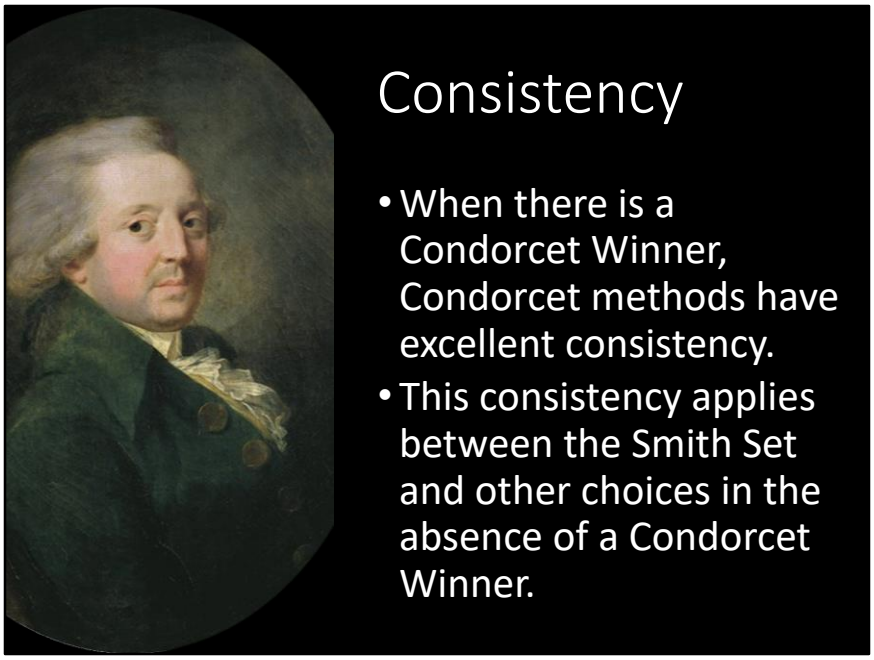


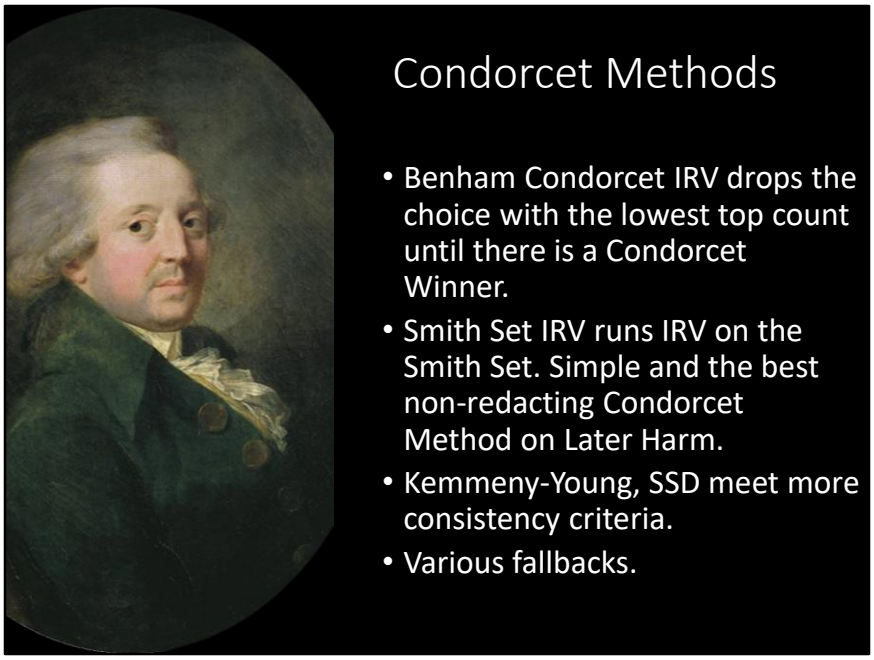
There is actually a method that meets Condorcet Winner and fails Condorcet loser, so I can't say always.



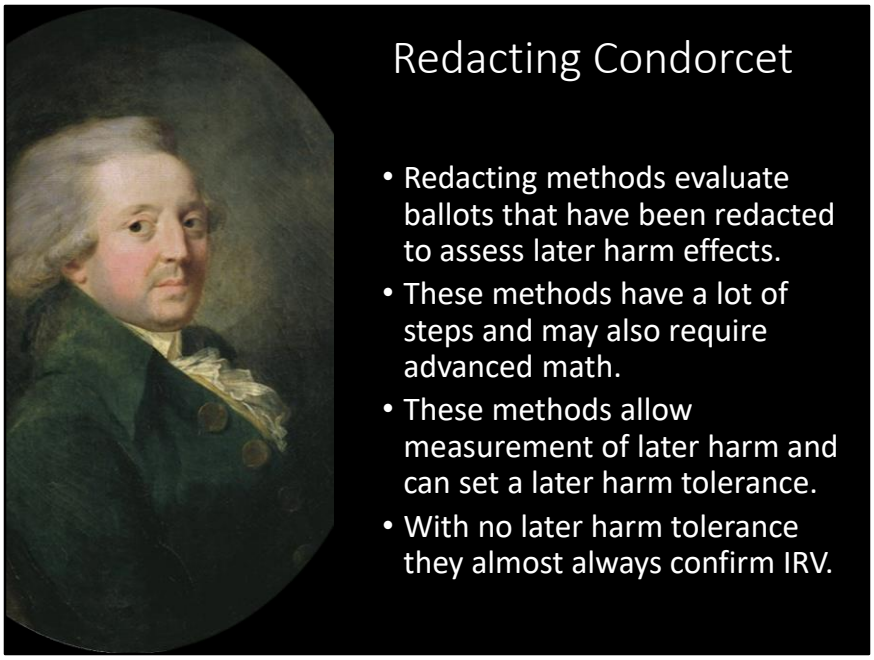
Consistency has many sub components, some of which are contradictory. Condorcet in this case meets all of the major concerns. Even though not mathematically correct, when there is a Condorcet Winner, I consider Condorcet methods to be consistent.

Complexity

- Benham Condorcet IRV is simple enough that it can be counted by hand.
- Smith Set IRV and other IRV and Borda Fallbacks are simple.
- The methods currently favored by Mathematicians: Kemmeny-Young and SSD require graduate level math.
- Other sub-methods also vary in complexity.



There are a lot more methods in this family than I have space to list or brain cells to comprehend.



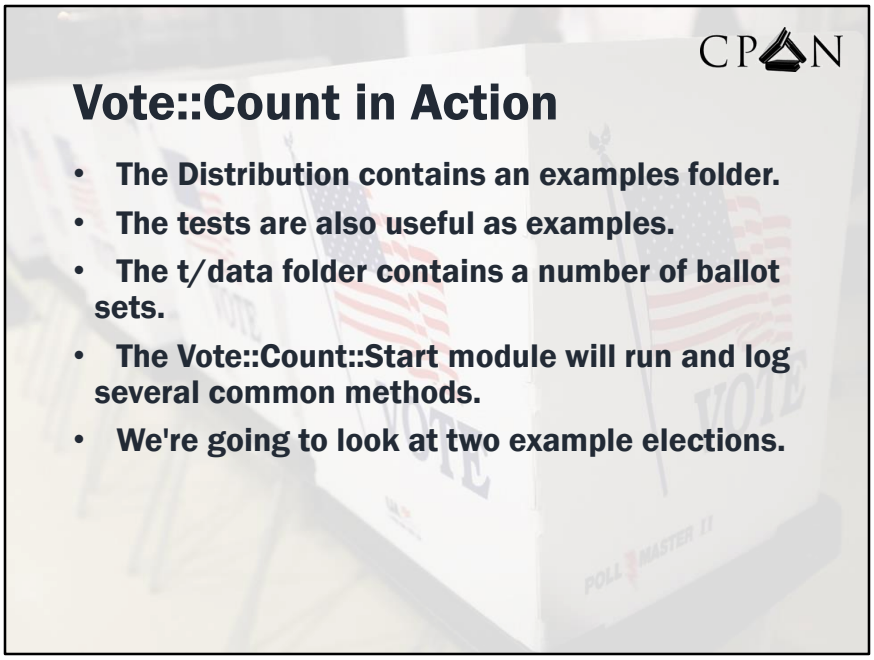
When IRV and Condorcet do not have the same winner there is almost always a Later Harm effect. Thus with no later harm tolerance the IRV winner should prevail. This fact has made these methods appear uninteresting. However, with them we can determine the number of votes the Condorcet Winner needed from the IRV winner and if that is less than their margin over the IRV Winner we can take the Condorcet Winner. Even with no tolerance allowed, in the 5% of elections where the Condorcet winner is confirmed over the IRV winner it is the better outcome, because the IRV outcome was an inconsistency effect.

The Best Method?

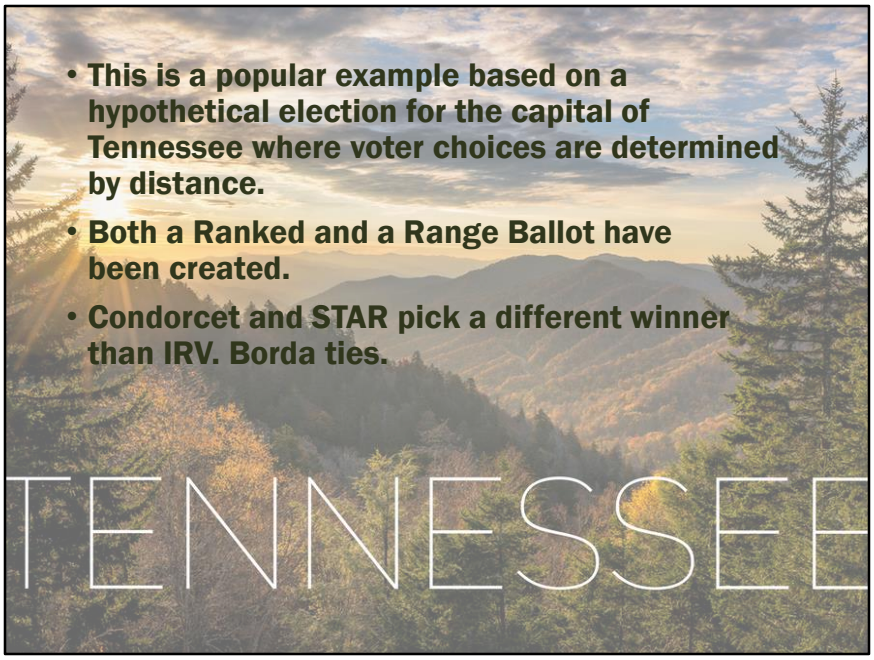
- Smith Set IRV: meets all 3 Condorcet Criteria, with less Later Harm.
- Borda: STAR is the best method in the Family, but it requires Range Ballots. STAR encourages voting strategies that can make STAR fail.
- IRV: Simple and Later Harm Protected
- Redacting Condorcet: Complex, better outcome than IRV.

Vote::Count can be downloaded from CPAN.

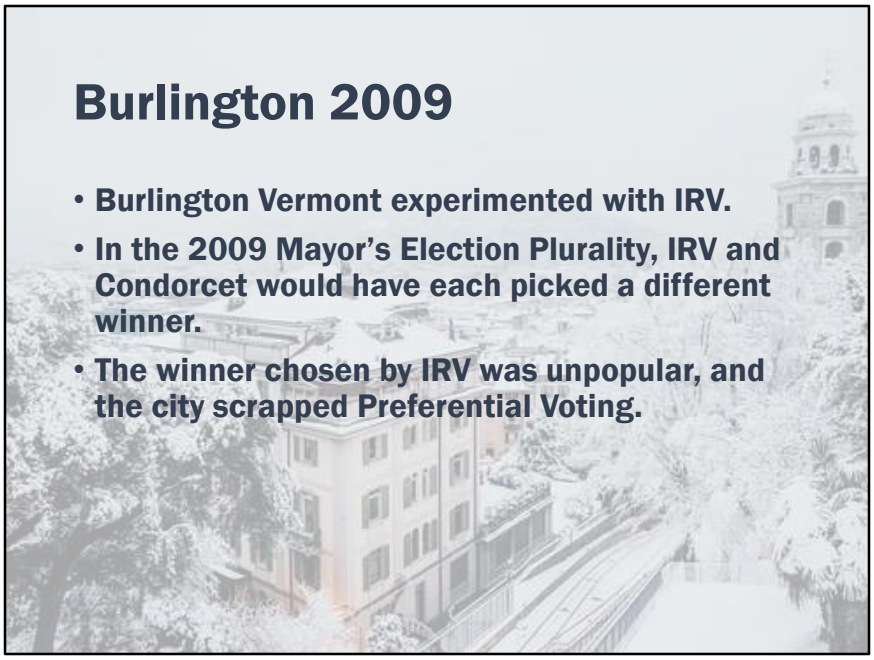
Search metacpan.org for documentation.



I've picked two interesting data sets for demonstration.



Tennessee is also a great cloning example. Memphis is located in the western part of the state far away from Nashville, Knoxville and Chattanooga In the Eastern Part of the State. Voters from the Eastern half of the state want any of the other choices than Memphis. There are more voters in the east than near Memphis, but Nashville is the closest eastern city. In this example voters also provided a ranking for all 4 choices.



Since this was a Ranked Choice election we only have ranked data for this one.

Vote::Count::Start

```
use 5.022;  # or later
use feature qw /postderef signatures/;

use Vote::Count::Start;
my $Election = StartElection(
   BallotFile => $filename,
   FloorRule  => 'Approval',
   FloorValue => 5,
   LogPath    => $outfolder,
   LogBaseName => $name . "_basic",
);
$Election->WriteLog();
```

Vote::Count's Start Module will setup and run several popular methods. Here is most of a script using it.

5.022 is the minimum Perl version you can use, it will work with any later version as well.

STAR

```
use 5.022;

use feature qw /postderef signatures/;
use Path::Tiny;

use Vote::Count::ReadBallots;
use Vote::Count::Method::STAR;
my $tennessee =
  Vote::Count::Method::STAR->new(
  LogTo => '/tmp/demo/tennessee_star',
  BallotSet => read_range_ballots('tennessee.range.json'),
);
$tennessee->STAR();
say '='x60 ;
say "Running STAR for Tennessee";
say $tennessee->logv();

$tennessee->WriteLog();
```

Here is a short script to run STAR.

```
BURLINGTON MAYOR 2009

VoteCount$ ./example/start.pl t/data/burlington2009.txt  /tmp/demo
============================================================
Running Basic RCV Methods for t/data/burlington2009.txt
Plurality Winner: WRIGHT
Approval Winner: MONTROLL
Applying Floor Rule of 5% Approval Count. vs Ballots Cast of 8976.
Floor Rule Eliminated:
WRITEIN
Remaining:
KISS, WRIGHT, MONTROLL, SIMPSON, SMITH
Borda Winner: MONTROLL

Instant Runoff Voting
Choices:
KISS, MONTROLL, SIMPSON, SMITH, WRIGHT
---
| Winner                   | KISS |
| Votes in Final Round     | 8374 |
| Votes Needed for Majority | 4188 |
| Winning Votes            | 4313 |
```

One of the choices Montroll wins Approval, Borda, and Condorcet, while two different choices win Plurality and IRV.

We’re looking at the terse/brief logging option. Vote count logs at 3 levels, a summary level, a detail level, and a debug level.

```
=========================================================
Running Strict CondorcetVsIRV for t/data/burlington2009.txt

Condorcet Winner is MONTROLL
Neither MONTROLL nor KISS were confirmed.

Redacted Ballots Winners:
Condorcet = WRIGHT, IRV = WRIGHT

Elected: KISS

=========================================================
Running Relaxed CondorcetVsIRV for t/data/burlington2009.txt

Condorcet Winner is MONTROLL
Neither MONTROLL nor KISS were confirmed.

Redacted Ballots Winners: Condorcet = WRIGHT, IRV = WRIGHT

The margin of the Condorcet over the IRV winner was: 587
MONTROLL's greatest loss with redacted ballots was 1110.

Elected: KISS
```

Relaxed is just the term votecount is using, it will probably change in a future release.

```
VoteCount$ ./example/start.pl t/data/tennessee.txt /tmp/demo
=========================================================
Running Basic RCV Methods for t/data/tennessee.txt
Plurality Winner: MEMPHIS
Approval Tie: CHATTANOOGA, KNOXVILLE, MEMPHIS, NASHVILLE
Applying Floor Rule of 5% Approval Count. vs Ballots Cast of 100.
Floor Rule Eliminated:

Remaining:
MEMPHIS, CHATTANOOGA, NASHVILLE, KNOXVILLE
Borda Tie: CHATTANOOGA, KNOXVILLE, MEMPHIS, NASHVILLE

Instant Runoff Voting
Choices:
CHATTANOOGA, KNOXVILLE, MEMPHIS, NASHVILLE
---
| Winner                   | KNOXVILLE |
| Votes in Final Round     | 100       |
| Votes Needed for Majority | 51        |
| Winning Votes            | 58        |
```

```
============================================================
Running Strict CondorcetVsIRV for t/data/tennessee.txt

Condorcet Winner is NASHVILLE
Neither NASHVILLE nor KNOXVILLE were confirmed.
Redacted Ballots Winners: Condorcet = NONE, IRV = MEMPHIS

Elected: KNOXVILLE

============================================================
Running Relaxed CondorcetVsIRV for t/data/tennessee.txt

Condorcet Winner is NASHVILLE
Neither NASHVILLE nor KNOXVILLE were confirmed.
Redacted Ballots Winners: Condorcet = NONE, IRV = MEMPHIS

The margin of the Condorcet over the IRV winner was: 36
NASHVILLE's greatest loss with redacted ballots was 16.

Elected: NASHVILLE
```

```
VoteCount$ ./example/star.pl
============================================================
Running STAR for Tennessee
Tue Oct  1 00:50:11 2019
| Rank | Choice      | Score |
|------|-------------|-------|
| 1    | NASHVILLE   | 352   |
| 2    | KNOXVILLE   | 307   |
| 3    | CHATTANOOGA | 289   |
| 4    | MEMPHIS     | 268   |

Automatic Runoff Winner: NASHVILLE
                           [ NASHVILLE: 68 -- KNOXVILLE: 32 ]
```

https://metacpan.org/pod/Vote::Count

https://github.com/brainbuz/Vote-Count

John Karr
http://techinfo.brainbuz.org