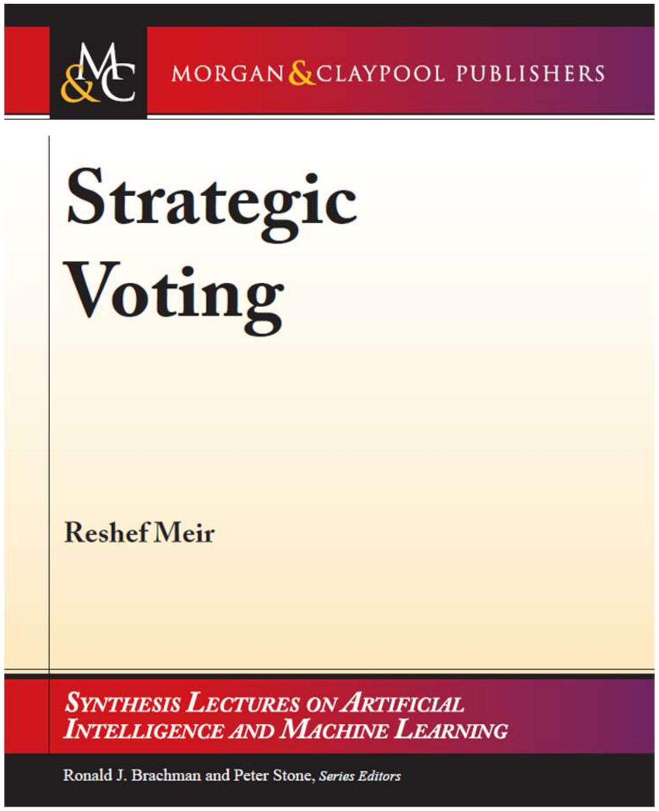
Class 2: Applying behavioral insights to social choice theory

(all non-behavioral SC in one slide)

- Nash equilibrium is essentially worthless
- The Paradox of Voting
- **Uncertainty** must play a role
- Many "economic" models of strategic voting
  - Calculus of voting [Riker and Ordeshook'75]
  - Large games [Myerson and Weber'95]
  - Poisson Games [Myerson'00]
  - See [M. 2018, Section 6] for an overview
- The key: calculate probability of each tie



Implicit assumptions

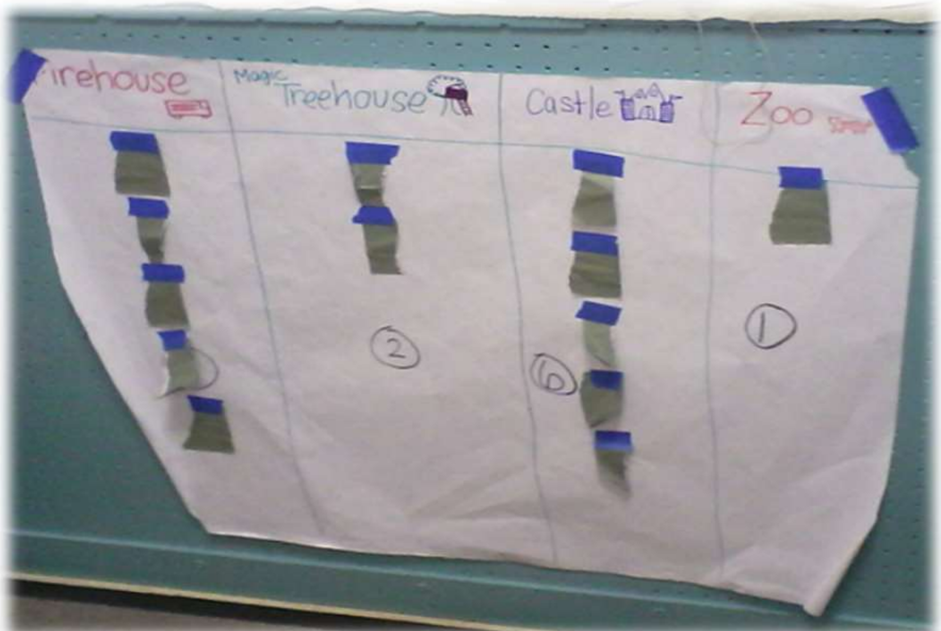
- Some of our assumptions already taking bounded rationality into account
  - Ordinal preferences
  - (computational) Hardness of manipulation
  - “Obvious manipulations”* and “Obvious strategyproofness”**
  - Communication complexity***

Who is boundedly rational here?

* P. Troyan and T. Morrill, Obvious manipulations, Journal of Economic Theory, 185 (2020), pp. 1–26.

**S. Li, Obviously Strategy-Proof Mechanisms, American Economic Review, 107 (2017), pp. 3257– 3287.

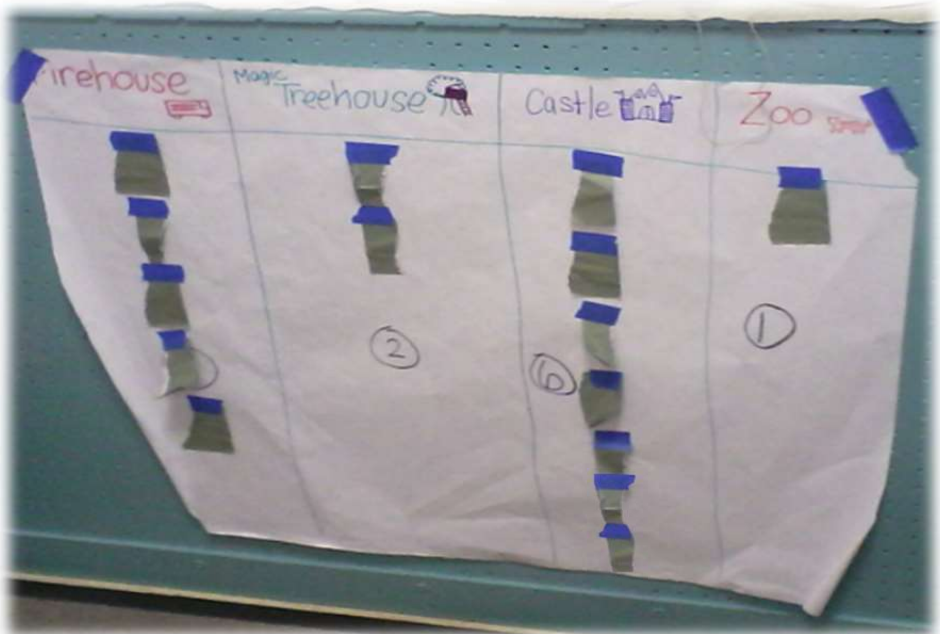
***Conitzer, Vincent, and Tuomas Sandholm. "Communication complexity of common voting rules EC 2005.



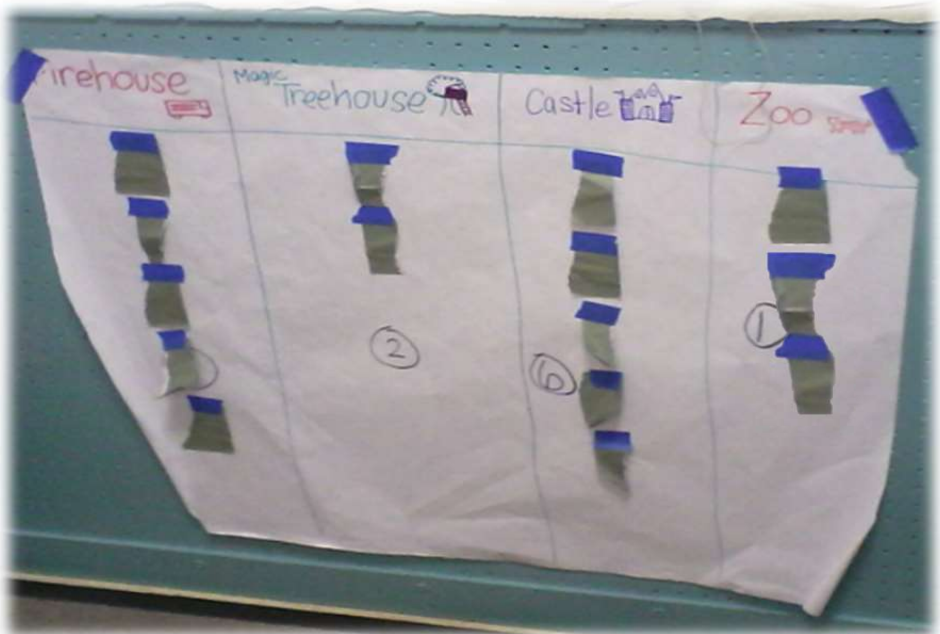
Least preferred

Most preferred

Least preferred



Most preferred



Least
preferred

Most
preferred

Recall: Approaches to bounded rationality

Modifying the **representation**
- Simplified representation
- Biased/simplified utility function
- Suitable for capturing a wide range of biases
- Can still apply standard game theoretic tools like Nash equilibrium

Modifying the **solution**
- Relax assumptions on optimizing the utility
- Heuristic strategies
- Different types of equilibria
- Alternatives to equilibria

Class 2: outline

- Some biases
- Some alternatives to Nash equilibrium
- Some voting heuristics

- What is a good behavioral (voting) theory?
- Cognitively grounded heuristics

- Preferences

Biases in voting

- Under voting rule f, and action profile $a = (a_i, a_{-i})$, candidate $f(a)$ wins
- Voter i gets utility of $v_i(f(a))$

- Recall Rabin's recipe (for an additive bias):

$$u'_i(a) = v_i\big(f(a)\big) + \text{Þ}_i \cdot h(a)$$

What can this h be?

Biases in voting (1)

- Truth bias [M. et al. AAAI'10, Dutta&Laslier SCW'10]
  - Ceteris paribus, the voter prefers to be truthful
  - Some "cost" for manipulating $h(a) = \epsilon$ if $a_i = top(L_i)$
  - Implications: removes many unreasonable Nash equilibria
    - Sometimes all equilibria

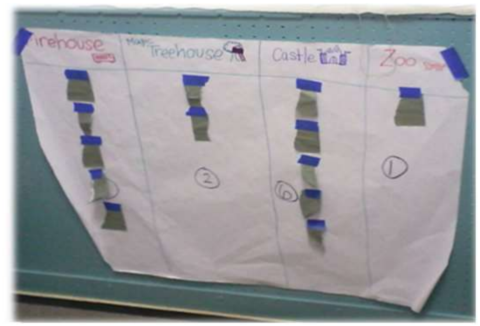
- Lazy bias [Desmedt and Elkind EC'10]
  - Ceteris paribus, the voter prefers to abstain
  - Some "cost" for voting $h(a) = \epsilon$ if $a_i = \perp$
  - Implications: equilibria with few or just one active voter
  - This is what created the Paradox of Voting in the first place!

See Section 6.3 in the book

Biases in voting (2)

$D \succ C \succ B \succ A$

- Some voters compromise for C, other don’t

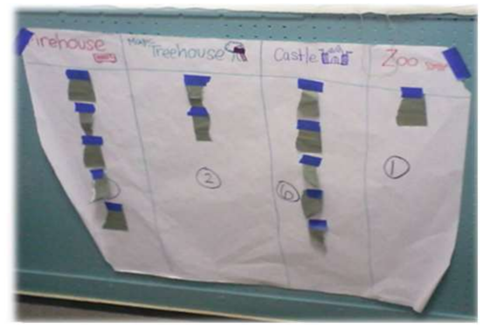


A B C D

Biases in voting (2)

🤔 D ≻ C ≻ B ≻ A

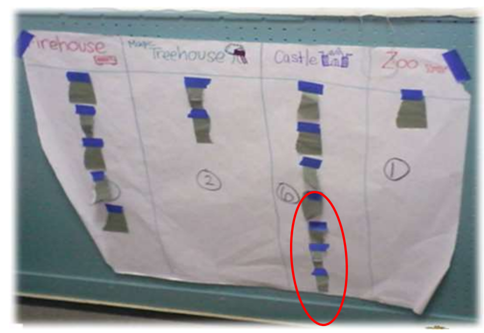
- Some voters compromise for C, other don't
- More people compromise when C is popular!
  - Contradicts rational voting
  - Will return to this in Class 3



A B C D

- Leader bias
  - Voter gets some extra utility for voting "to the winner"

$$h(a) = \epsilon \text{ if } a_i = f(a)$$



A B C D

L. M. Bartels. Presidential Primaries and the Dynamics of Public Choice, Princeton University Press, 1988
Meir, Gal, Tal. "Strategic voting in the lab: compromise and leader bias behavior." JAAMAS 34 (2020): 1-37.

Biases in voting (3)

- Pro-social bias
  - Voter’s utility from the winner “multiplied” by size of society $h(a) = (n-1)v_i(f(a))$
  - An alternative solution for paradox of voting

- More realistic: voter gets some utility from “voting like her friends”
  - The MBD model*:
    - ONLY social utility and truth-bias (no utility from outcome!)
  - Doodle study**:
    - Voter gets some utility from “appearing” cooperative to others

*Li, J., and Lee, L.-f. Binary choice under social interactions: an empirical study with and without subjective data on expectations. Journal of Applied Econometrics 24, 2 (2009), 257–281.

**Zou, James, Reshef Meir, and David Parkes. "Strategic voting behavior in doodle polls." CSCW 2015.

Behavioral voting models

- Mattei
- QRE
- Learning from sample (Rubinstein)
- Heuristic voting
- Meir: Local dominance, social utility (Doodle),
- Comparing few pairs – reduce cognitive load

Alternatives to (Nash) equilibrium (1)

- Recall Quantal Response Equilibrium
  - Players play suboptimal actions with some probability
- Can be applied to voting
- Was done e.g. for Plurality*
  - Every manipulation played with some probability
  - Show an equilibrium still exists
- Still requires tie probabilities!

*R. D. McKelvey and J. W. Patty. A theory of voting in large elections. GEB, 57(1):155–180, 2006

Alternatives to (Nash) equilibrium (2)

- “Trembling Hand” Equilibrium*
  - Similar to QRE, but error probability goes to 0
  - Formal definition somewhat contrived

Sounds more like “super-rational” than bounded rational! [Aumann, GEB’97]

- Applied also to Plurality Voting **
- Implication: any tie can occur with nonzero probability
  - Removes many unreasonable equilibria

* Selten, R. 1975. Reexamination of the perfectness concept for equilibrium points in extensive games. IJGT 4(1):25–55.

** See Section 6.5 in the book under “Robust Equilibrium”

Alternatives to (Nash) equilibrium (3)

- Recall “Cognitive Hierarchy”:
  - Level 0 behavior is very simple
  - Level k is play optimal response to level k-1
- Now consider voting
  - Level 0 voters are truthful
  - Level 1 voters are “G-S manipulators”
  - Level 2 voters are “counter manipulators”
- Challenge: no cardinal utilities
- Partial characterization of optimal level-2 responses and outcomes

Elkind, Edith, et al. "Cognitive hierarchy and voting manipulation in k-approval voting." Math. Social Sciences 108 (2020): 193-205.

Voting heuristics

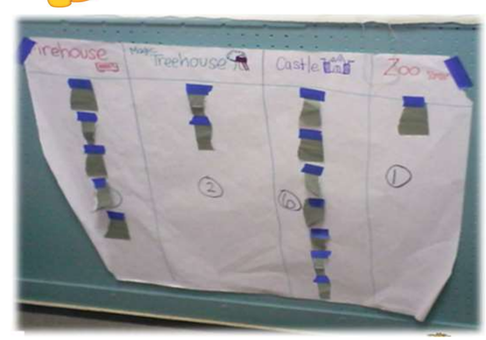
- Being truthful is easy but not always best
- Difficult to know what is best
  - Requires many assumptions, much information, and complex behavior

- Solution: <u>heuristics</u>
- We will consider several examples
- See also Chapter 8 in the book

Voting heuristics (1)

- Why voting for C?
- Most preferred among “viable candidates” {A,C}
- Most common and simple example: **K-pragmatist** *
    - “Vote for your favorite candidate among the K candidates with highest scores”
- Can be applied to any scoring rule
- What is the right K?

$D \succ C \succ B \succ A$



A B C D

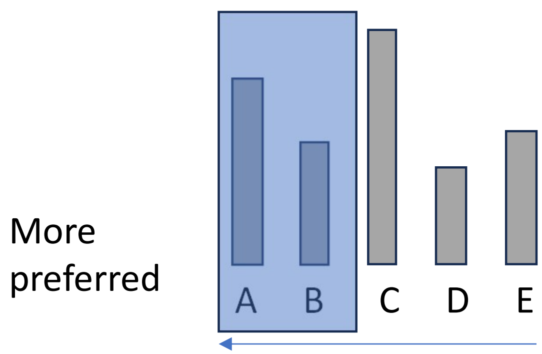
*A. Reijngoud and U. Endriss. Voter response to iterated poll information. AAMAS’12, pages 635-644.

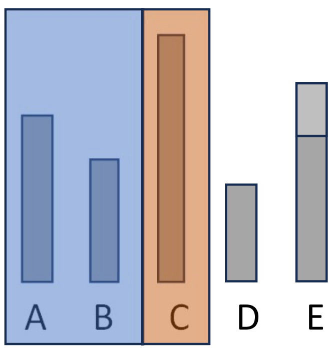
Voting heuristics (2)

- Laslier's Leader Rule
  - Defined only for Approval

"Approve all alternatives that are strictly preferred to the leader;

Then approve the leader if it is preferred to the runnerup"





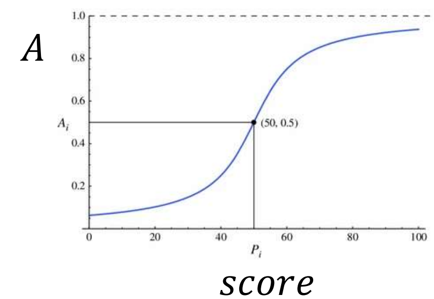
J.-F. Laslier. Laboratory experiments on approval voting. Handbook on Approval Voting, pages 339–356

Voting heuristics (3)

- Consider multiple referenda with interdependent binary issues
- Votes are binary vectors $a \in \{0,1\}^k$
- Utility of vote a_i strongly depends on which issues are accepted

How to vote?

- Assign a “heuristic value” to every vote, composed on 3 factors:
  - The naïve value $v_i(a_i)$
  - The “attainability” $\mathrm{Att}(a_i) = \prod_{j=1}^{k} A(score(a_{ij}))$
  - The empirical value of a_i in previous rounds $E(a_i)$
- Vote for a_i maximizing $v_i(a)Att(a_i)E(a_i)$



C. Bowman, J. K. Hodge, and A. Yu. The potential of iterative voting to solve the separability problem in referendum elections. Theory and Decision, 77(1):111–124, 2014

Voting heuristics (3)

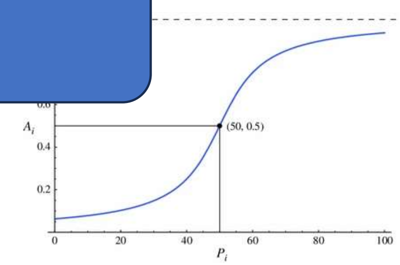
- Vote for a_i maximizing $v_i(a_i)Att(a_i)E(a_i)$

"truthful' value

A heuristic substitute
for probability
(of what?)

Learning from experience

(vs. description)



$score$

Voting heuristics (3)

- Vote for a_i maximizing $v_i(a)Att(a_i)E(a_i)$
- Adapted to Plurality* and to Approval**

*Fairstein, Roy, et al. "Modeling people's voting behavior with poll information." *AAMAS 2019*

**Scheuerman, Jaelle, Jason Harman, Nicholas Mattei, and K. Brent Venable. "Modeling voters in multi-winner approval voting." AAAI 2021

Voting heuristics (recap)

- We saw three examples of heuristics
- There are many more
- Are those good heuristics?
- What is a good heuristics?
  - Prescriptive vs. descriptive
- What is a good equilibrium model?

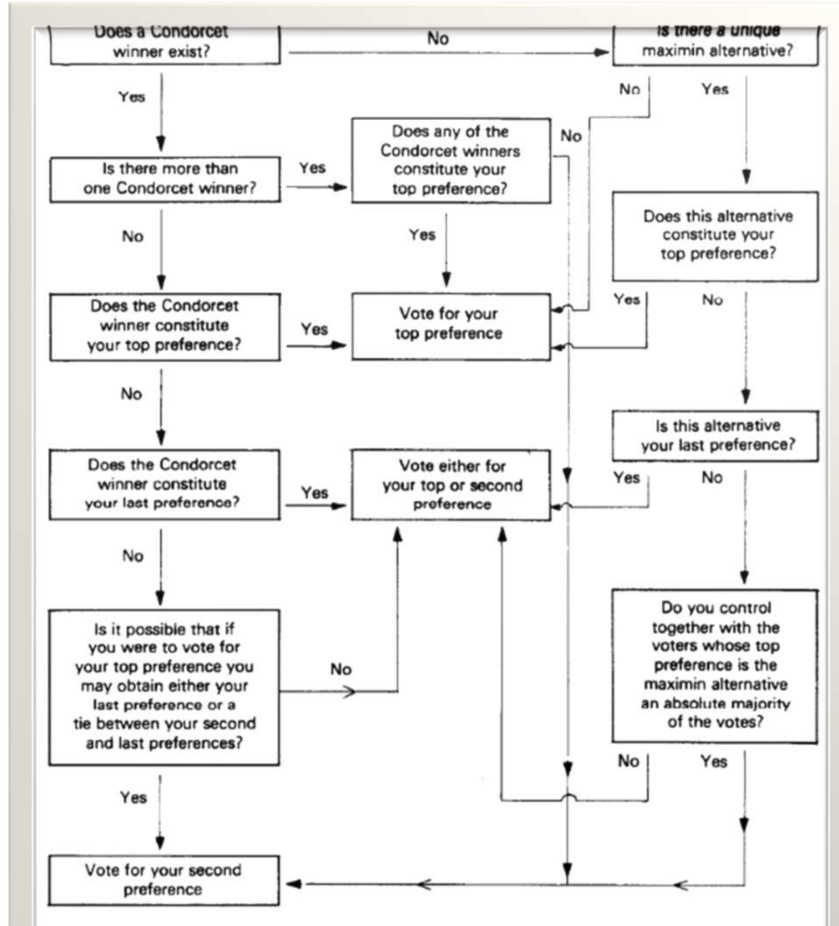


FIGURE 1. Flowchart of the new model

So what is a good behavioral theory?

- Is ecologically reasonable: May result from many different processes
  - Cognitive limitations, heuristics, lack of information…

- Can explain **many** behavioral phenomena
  - Individual choice, games
  - Including (seemingly) contradicting phenomena

- Can **predict** behavior

Choice prediction competition by plonsky and Erev
https://arxiv.org/abs/1904.06866

So what is a good behavioral voting theory?

See Section 6.1 in book

- Theoretic criteria
  - Considers self interest/ equilibrium. Discriminative power. Broad scope.
- Behavioral criteria
  - Behavior fits reasonable voters' knowledge and capabilities
- Scientific criteria
  - Prediction, robustness

Vote prediction competition?

What’s in a voting theory?

Existence/Frequency of manipulation, Equilibrium analysis, Turnout, Convergence, welfare, Fairness…

Behavioral model

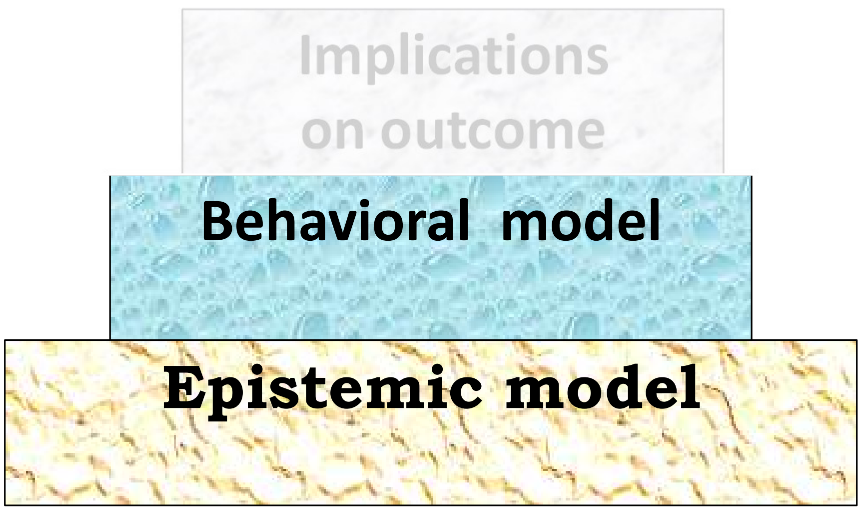
How do voters **act** based on their information and own preferences?

Epistemic model

How do voters get and **represent information** on preferences and actions of others?

What’s in a voting theory?

Example I: Calculus of voting



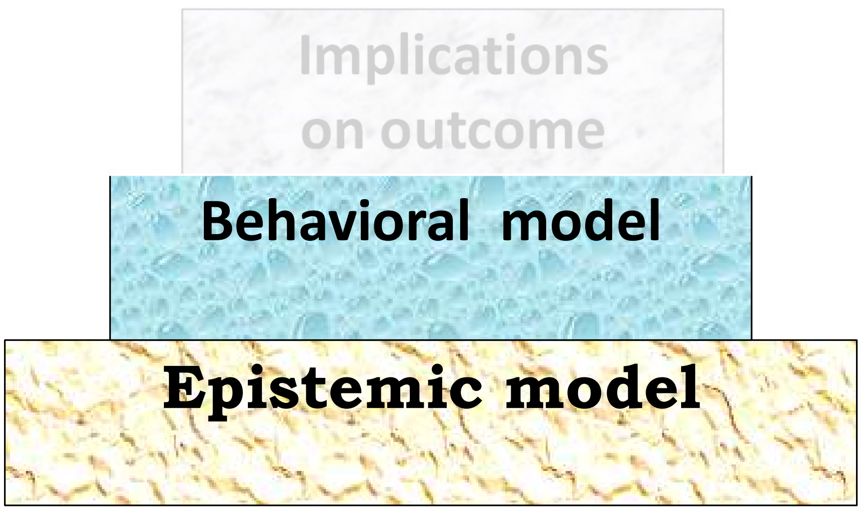
Existence/Frequency of manipulation, Equilibrium analysis, Turnout, Convergence, welfare, Fairness…

Voters play Bayes-Nash equilibrium

Voters know the correct distribution over preference profiles

What's in a voting theory?

Example II: Leader Rule



Existence/Frequency of manipulation, Equilibrium analysis, Turnout, Convergence, welfare, Fairness…

?

?

(arguable) Desiderata for voting models

See Section 6.1 in book

- Theoretic criteria
  (voters follow best interest)
- Behavioral criteria
  (voters' beliefs and capabilities)

Bounded rationality

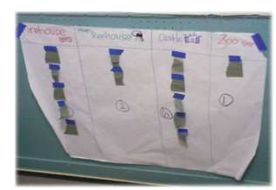
- Scientific criteria:
  (Robustness, Simplicity, consistent with data, Discriminative power)

	Ad-hoc heuristics	Expected utility (e.g. Cal. of Voting)	Structured heuristics
Theoretic criteria	X	V	
Behavioral criteria	V	X	

Let’s build a simple theory!

Epistemic model

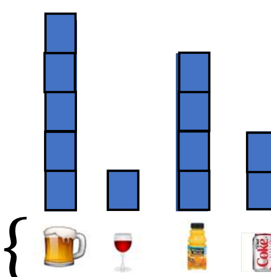
Voters know others’ **votes**
(or only vote counts)



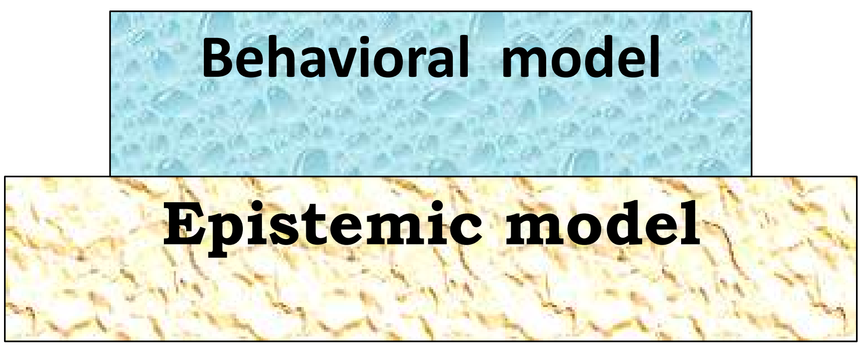
Let’s build a simple theory!

Epistemic model

Voters know others’ **votes**
(or only vote counts)

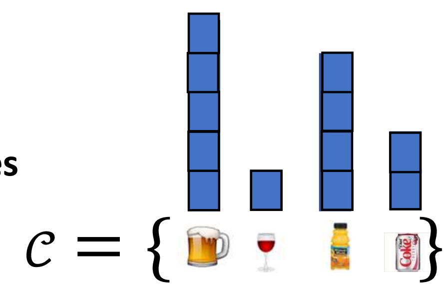
$\mathcal{C} = \{$  $\}$

Let’s build a simple theory!

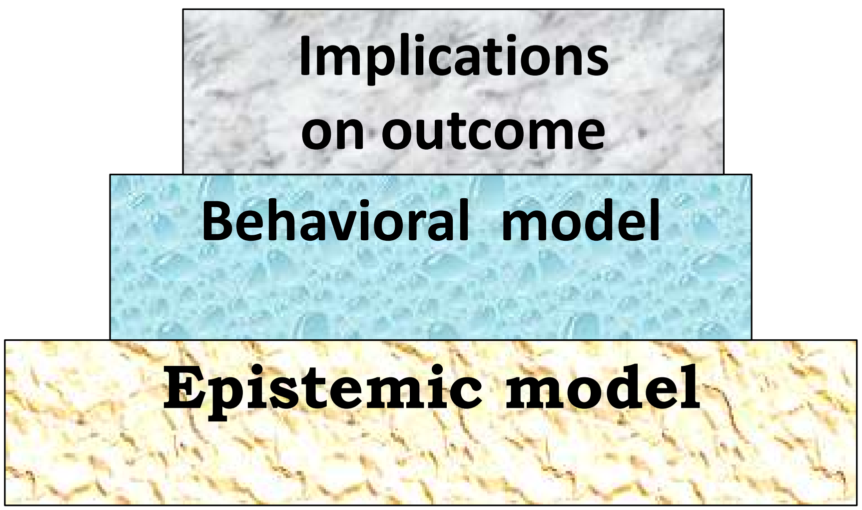


Voters pick best action

Voters know others’ **votes**
(or only vote counts)



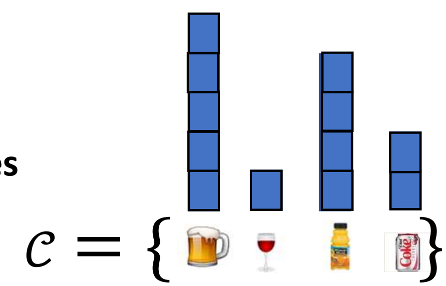
Let’s build a simple theory!



Stable states are the Nash equilibria (Obvious)
Plurality: Voters will always converge
[M. et al. 2010,2017]

Voters pick best action

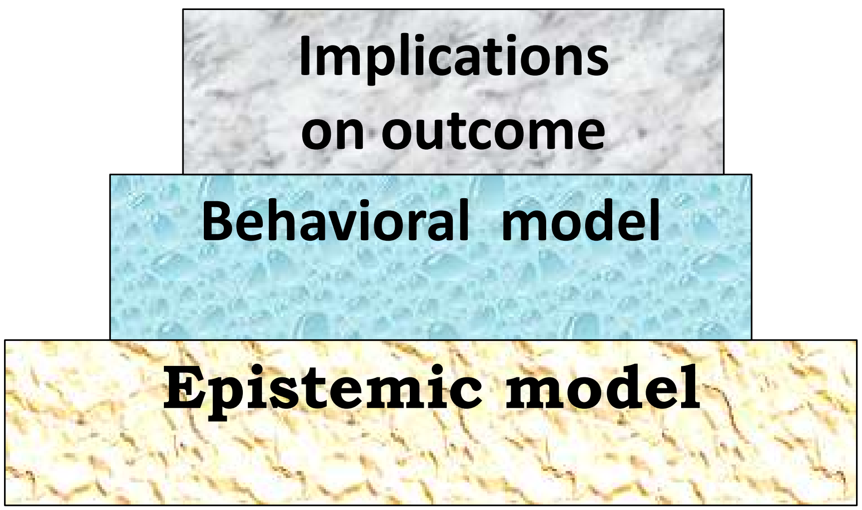
Voters know others’ **votes**
(or only vote counts)



Meir, R., Polukarov, M., Rosenschein, J. S., & Jennings, N. R. (2017). Iterative voting and acyclic games. Artificial Intelligence, 252, 100-122.

Let’s build a simple theory!

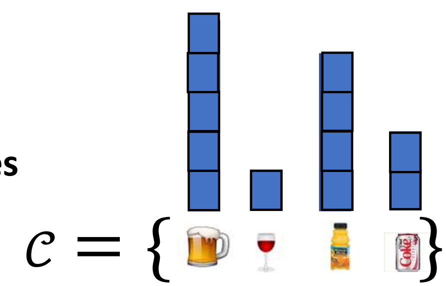
But our starting point was that NE were useless…



Stable states are the Nash equilibria (Obvious)
Plurality: Voters will always converge [M. et al. 2010,2017]

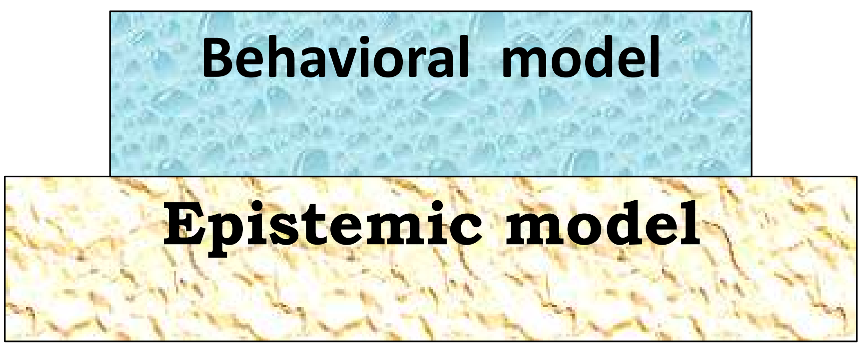
Voters pick best action

Voters know others’ **votes** (or only vote counts)



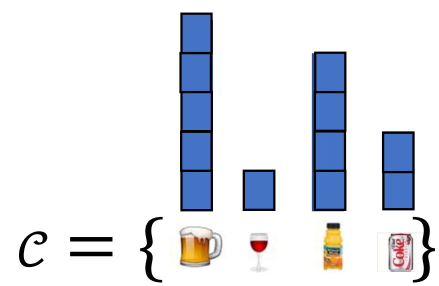
Meir, R., Polukarov, M., Rosenschein, J. S., & Jennings, N. R. (2017). Iterative voting and acyclic games. Artificial Intelligence, 252, 100-122.

Let’s build a (less) simple theory



Voters pick best action

Voters know *something about* others’ votes



Epistemic model

Some options:

3 X	$A \succ B \succ C \succ D$
2 X	$B \succ C \succ A \succ D$
2 X	$C \succ A \succ D \succ B$

(Borda)

A

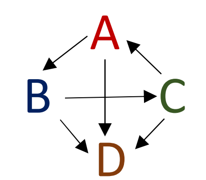
Only leader

$A > C > B > D$

Aggregate rank

A	B	C	D
15	12	13	2

Aggregate scores



Pairwise relations

A. Reijngoud and U. Endriss. Voter response to iterated poll information. In AAMAS'12, pages 635–644.

U. Endriss, S. Obraztsova, M. Polukarov, and J. S. Rosenschein. Strategic voting with incomplete information,

Epistemic model

Some options:

"…the state of information may as well be regarded as a ***characteristic of the decision-maker*** *as a characteristic of his environment" [Simon '57]*

Any profile consistent with A leading is possible

(Borda)

A

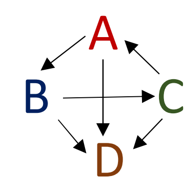
Only leader

A > C > B > D

Aggregate rank

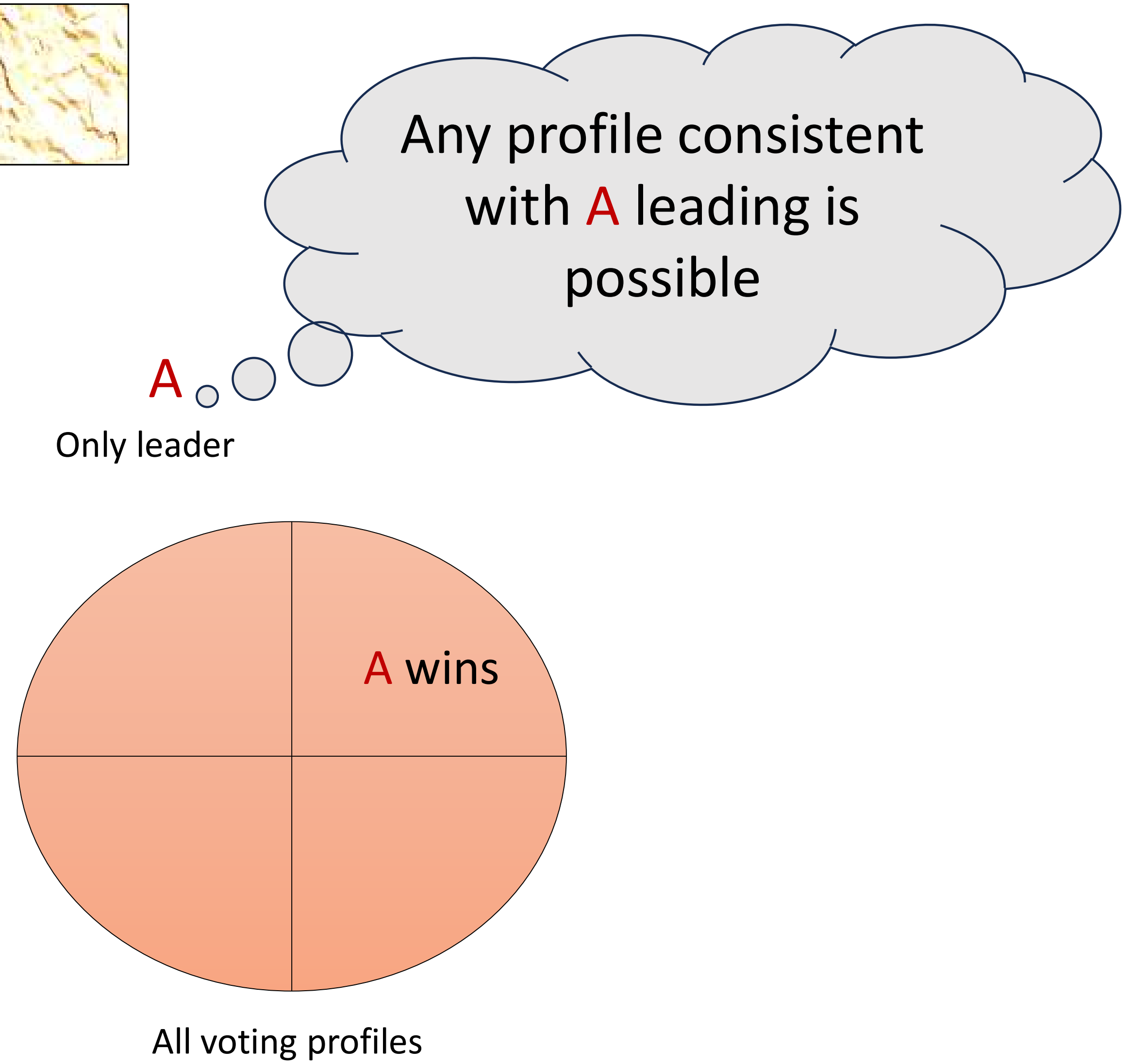
A	B	C	D
15	12	13	2

Aggregate scores



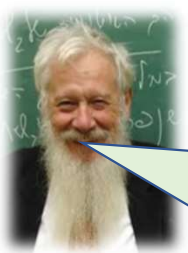
Pairwise relations

Epistemic model



Behavioral model

How should a (boundedly) rational voter vote?

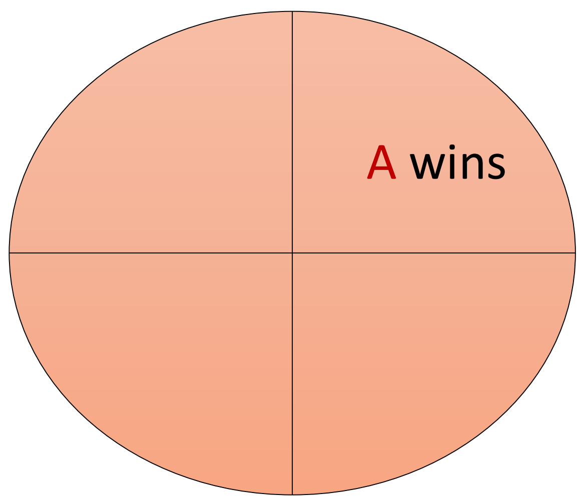


Rational agents avoid $\boxed{\text{dominated}}$ strategies!

Any profile consistent with A leading is possible

A

Only leader



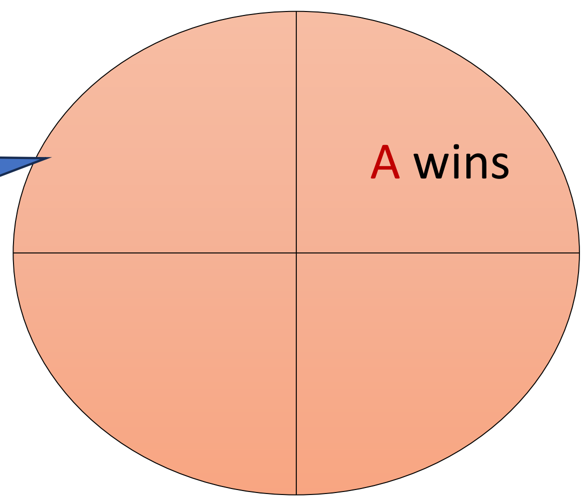
All voting profiles

 $C \succ A \succ B \succ D$

Recall: Dominating and dominated strategies

<u>Definition</u>: Action a_i **dominates** action a_i' if for any profile $\boldsymbol{a}_{-i}$ of the other players, i weakly prefers to play a_i over a_{-i} (and strictly prefers in some profiles).

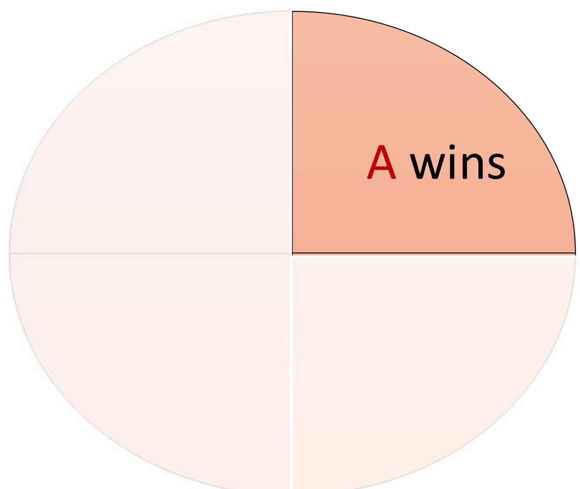
Pop quiz: which strategies are dominated (in Plurality?)



All voting profiles

Recall: Dominating and dominated strategies

<u>Definition</u>: Action a_i **dominates** action a_i' if for $\overbrace{\text{any}}^{\textbf{possible}}$ profile $\boldsymbol{a}_{-i}$ of the other players, i weakly prefers to play a_i over a_{-i} (and strictly prefers in some profiles).



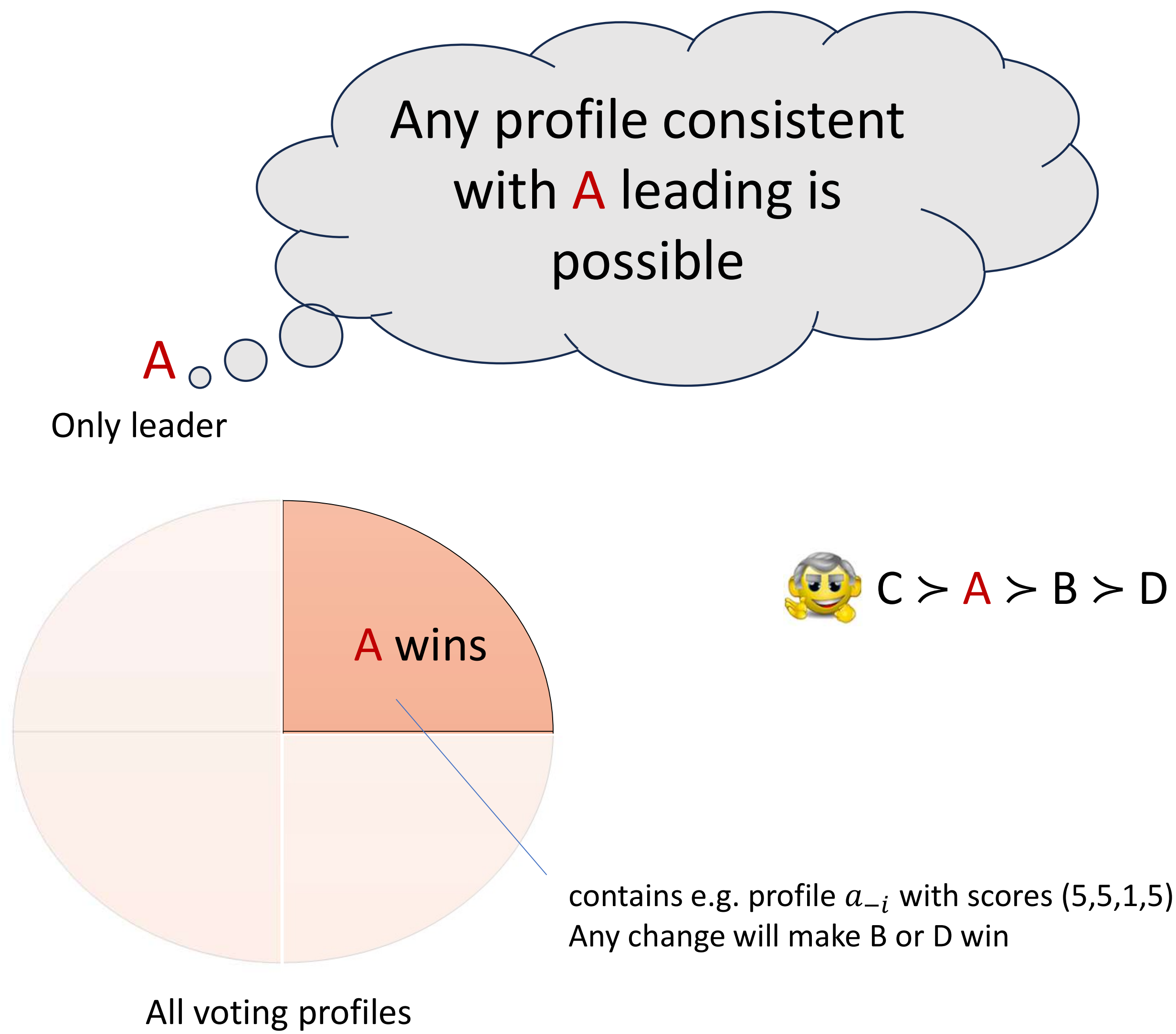
All voting profiles

Behavioral model

How should a (boundedly) rational voter vote?

Avoid votes that are dominated **within the set of possible states**

No vote dominates truth under Borda (in this example!)



Behavioral model

How should a (boundedly) rational voter vote?

Avoid votes that are dominated **within the set of possible states**

Truth dominated by

a_i'=C ≻ B ≻ D ≻ A

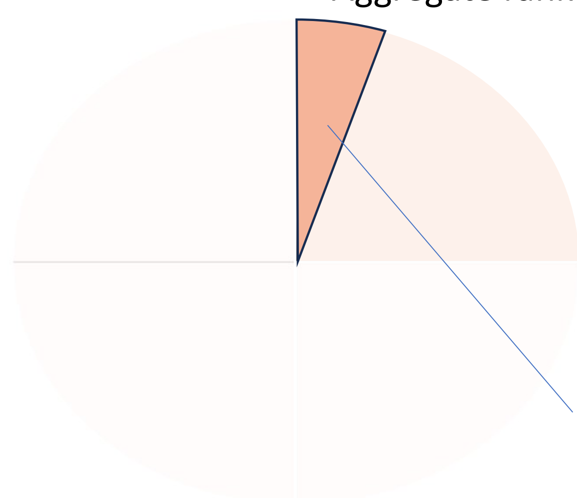
Under Borda

(Manipulation exists)

Any profile consistent with A ranked above C etc. is possible

A > C > B > D

Aggregate rank

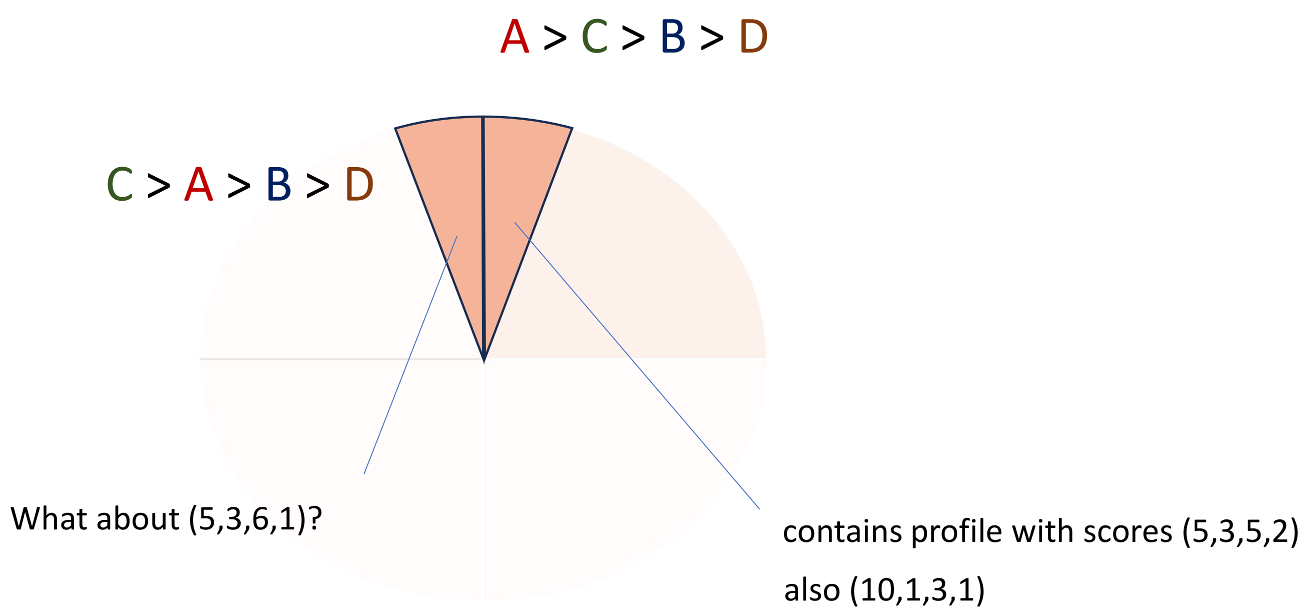


All voting profiles

 C ≻ A ≻ B ≻ D

- contains e.g. profile a_{-i} with scores (5,3,5,2) where a_i' makes C win
- $f(a_i', a_{-i})$ is always A or C

Are those beliefs reasonable?



Local Dominance

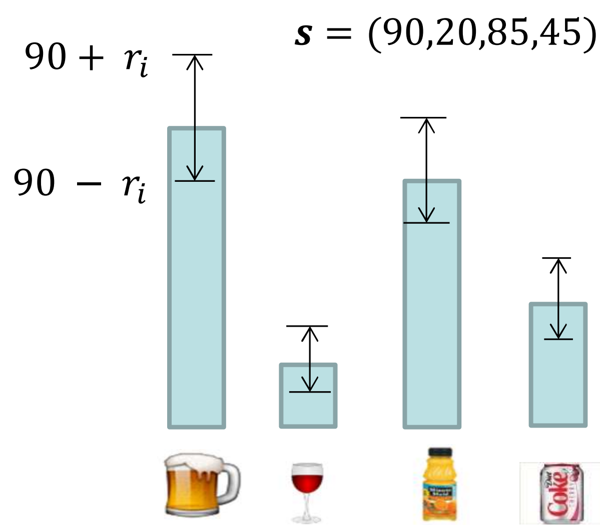
- We keep the same **Behavioral model**
- **Epistemic model** based on distance between profiles (or scores)

Epistemic model

Prospective scores $\boldsymbol{s}$

- E.g. from a poll
- "world state"

Uncertainty level $r_i \geq 0$



Voter i considers as "possible" all states close enough to $\boldsymbol{s}$. $S(\boldsymbol{s}, r_i) = \{\boldsymbol{s}' : \|\boldsymbol{s}' - \boldsymbol{s}\| \leq r_i\}$

– Example I: "*additive uncertainty*"

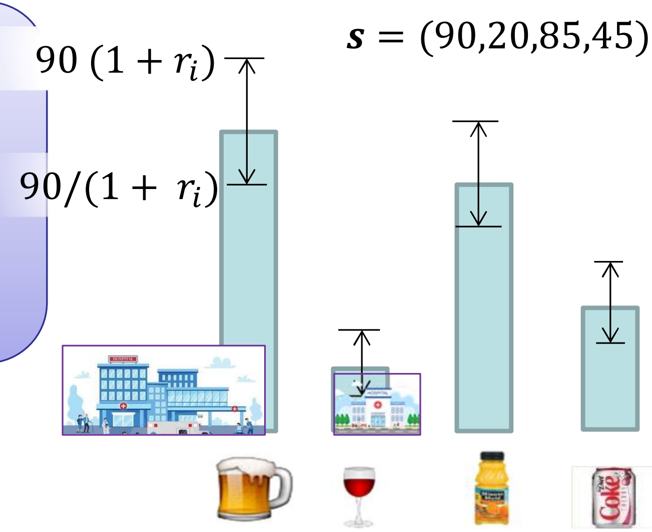
Meir, Reshef, Omer Lev, and Jeffrey S. Rosenschein. "A local-dominance theory of voting equilibria" EC 2014.

Epistemic model

Prospective scores $\boldsymbol{s}$

- E.g. from a poll
- “world state”

Uncertainty level $r_i \geq 0$



Voter i considers as “possible” all states close enough to $\boldsymbol{s}$. $S(\boldsymbol{s}, r_i) = \{\boldsymbol{s}' \colon \|\boldsymbol{s}' - \boldsymbol{s}\| \leq r_i\}$

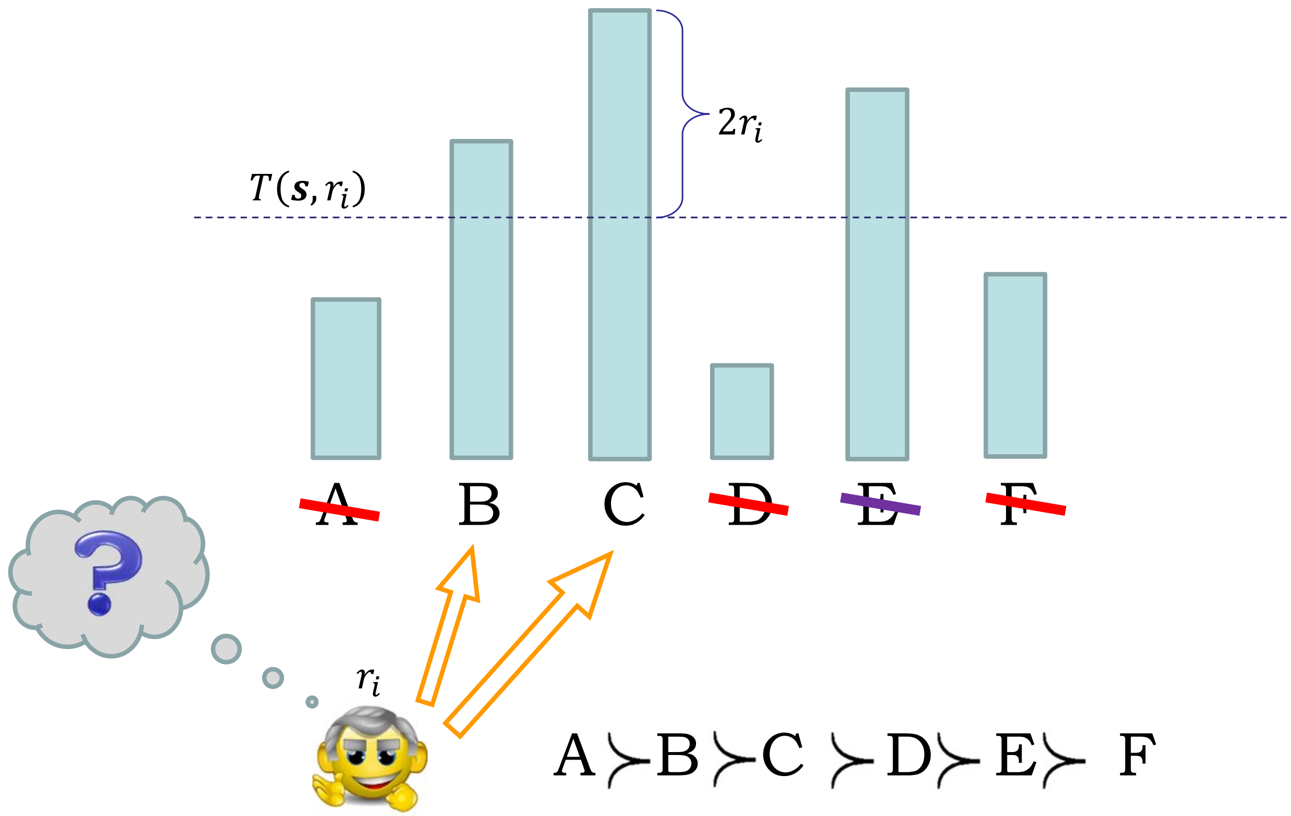
– Example I: “*additive uncertainty*"

– Example II: “*multiplicative uncertainty*"

Meir, Reshef, Omer Lev, and Jeffrey S. Rosenschein. "A local-dominance theory of voting equilibria” EC 2014.

Lemma: All dominance relations in state $\boldsymbol{s}$ are characterized by a single threshold $T(\boldsymbol{s}, r_i)$: (depends on winner's score)

c **is dominated** iff **below the threshold** *or* **least preferred**.*



Justified heuristics

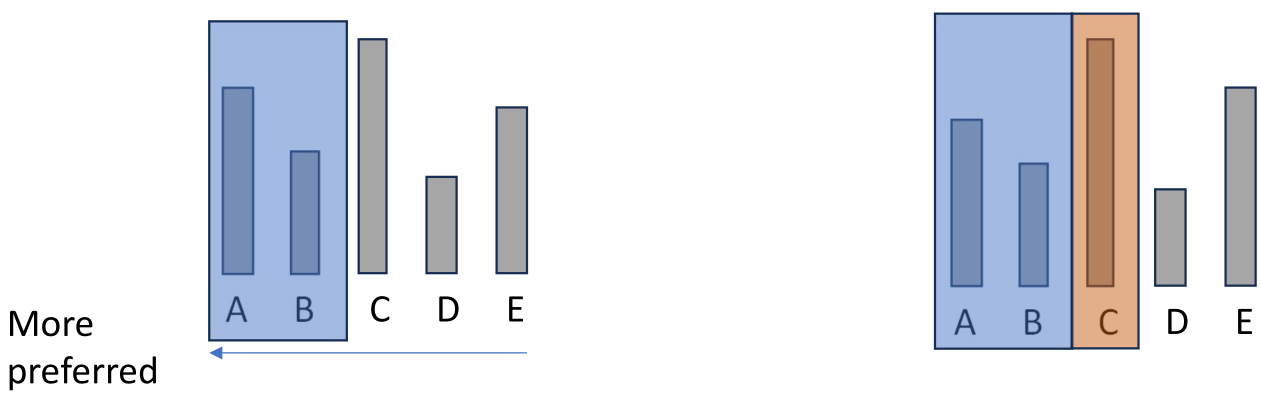
- The K-pragmatist heuristic is easy to justify based on partial information and local dominance
- What about the Leader rule?
  - Cannot be justified as a dominance move under any set of **possible states** ☹
  - Laslier provides justification using a statistical model and **probabilities**
- Is there something in between?
  - Multiple certainty levels*

*Lev, Omer, et al. "Heuristic voting as ordinal dominance strategies." AAAI 2019.

Recall: Laslier’s Leader Rule

- Another voting heuristic
- Defined only for Approval

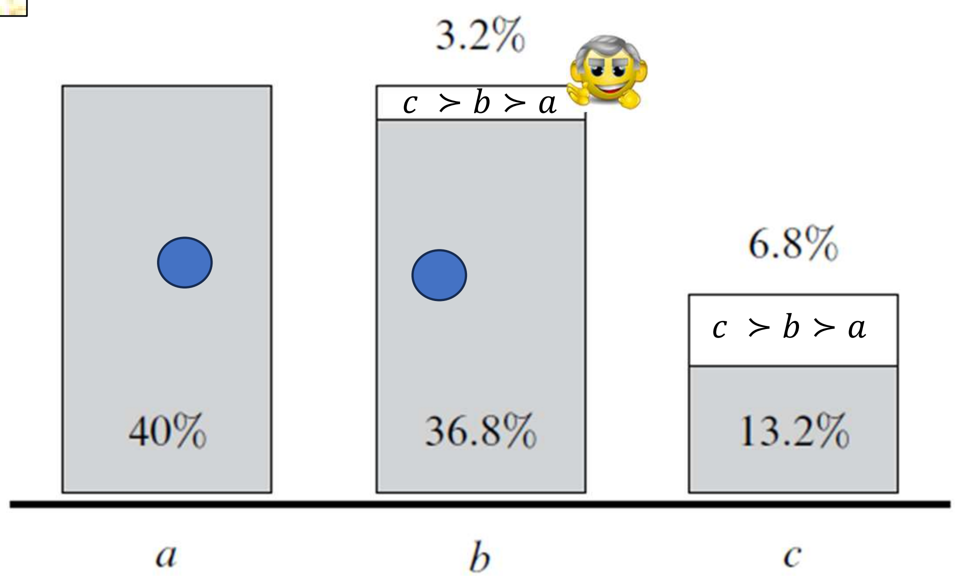
“Approve all alternatives that are strictly preferred to the leader;
Then approve the leader if it is preferred to the runnerup”



Relying on small samples – in voting

Epistemic model

A voter is asking $k = 2$ random friends.



Behavioral model

 $c \succ b \succ a$

Votes as if the sample is the entire profile

Osborne, Martin J., and Ariel Rubinstein. "Sampling equilibrium, with an application to strategic voting." GEB 45.2 (2003): 434-441.
(see also Section 8.2.1 in the book)

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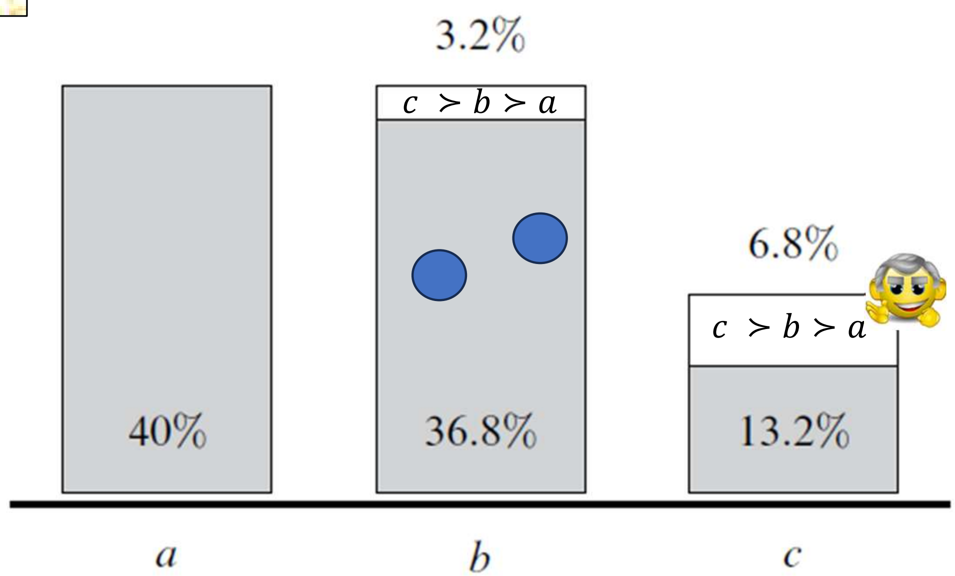

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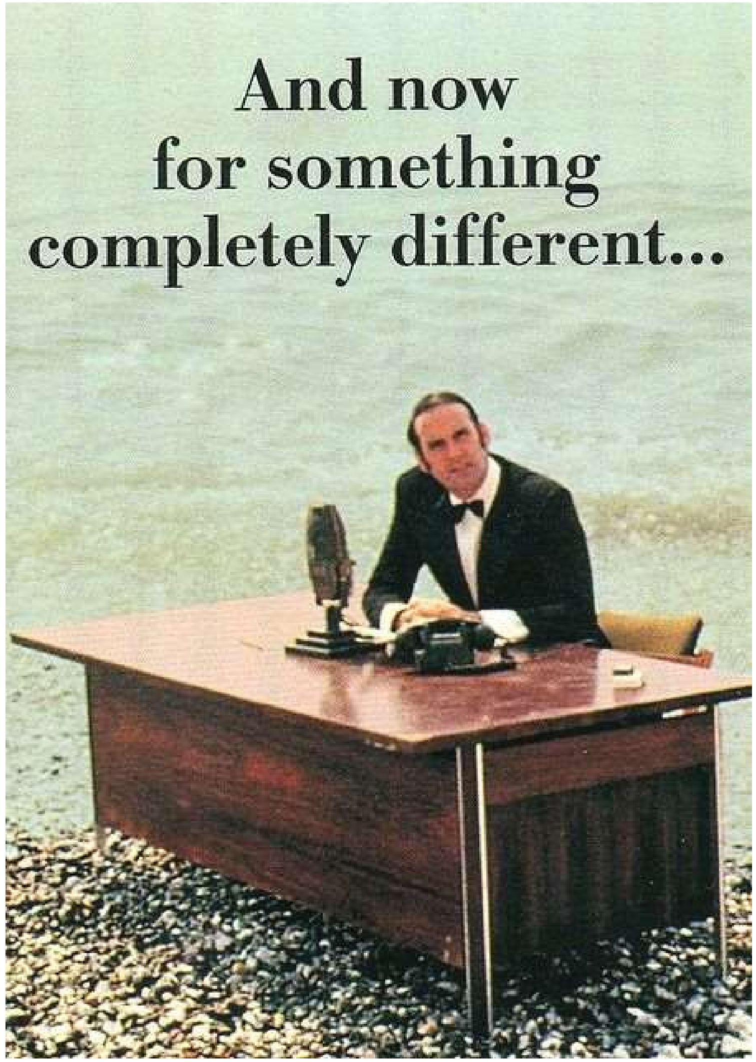
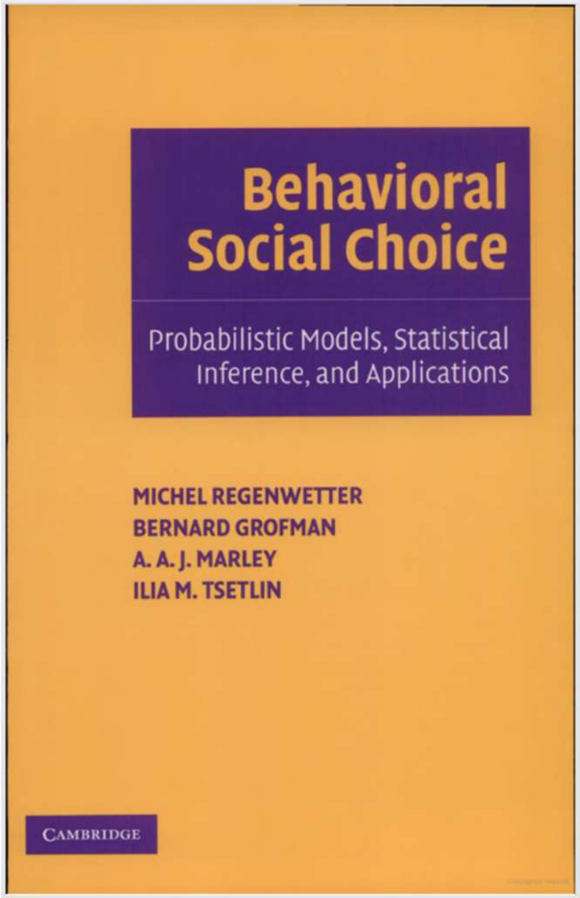

And now
for something
completely different...

- We want to know the full profile
- Only have access to some comparisons or vote counts
- Need to make structural assumptions
  - E.g. single-peak, single-crossing
- Those are often too strong in practice (never hold)
- Instead, make *probabilistic assumptions*

“any ‘reconstruction’ of majority preferences from ballot or survey data can be sensitive to the underlying implicit or explicit model of decision making”

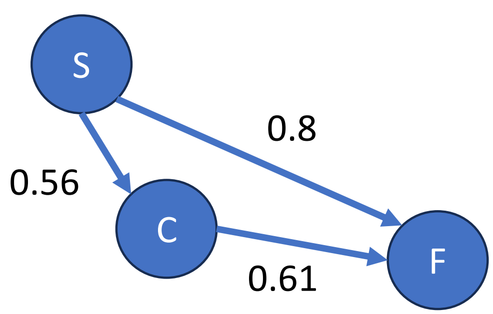


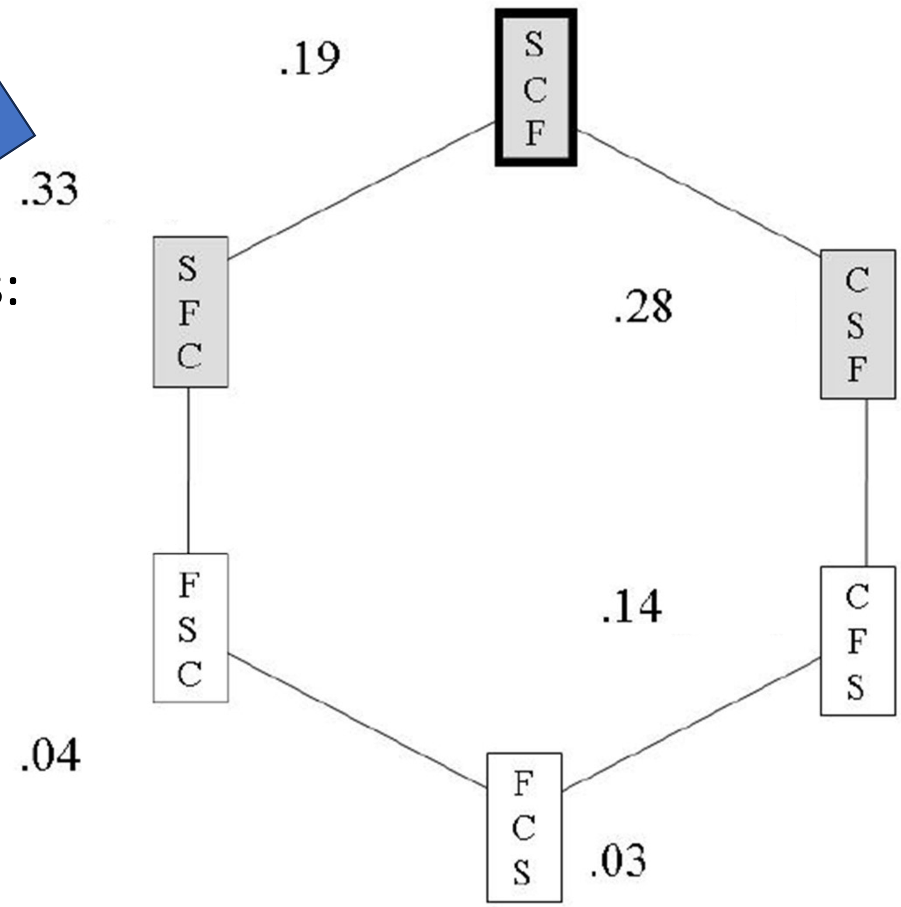
Regenwetter, Michel. Behavioral social choice: probabilistic models, statistical inference, and applications. Cambridge University Press, 2006.

When does society have transitive preferences?

= no cycles

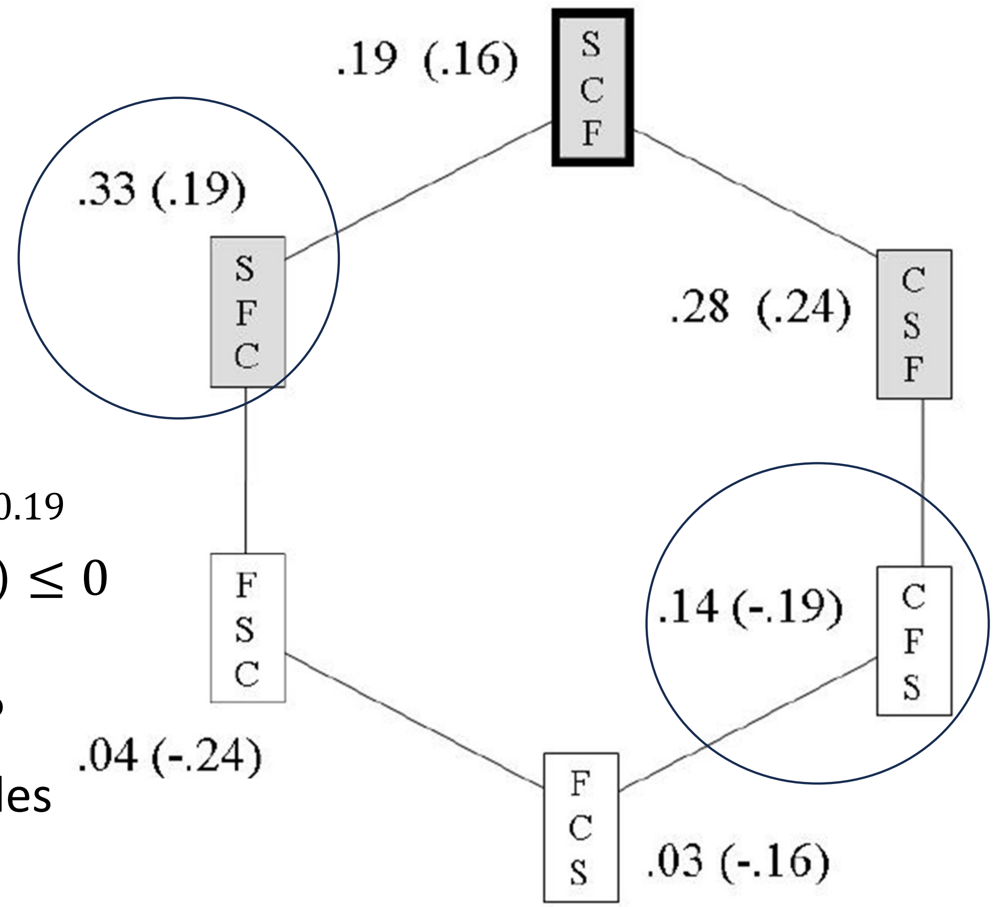
- Sen's sufficient condition for no cycles:
  - There is a candidate c that is either:
    - Never first $(P(cab) = 0 \,\&\, P(cba) = 0)$; or
    - Never last; or
    - Never middle
- Obviously does not hold
- Still no Majority cycles





German National Election Survey 1972

- We can consider **Net preference probabilities**
- $\Gamma(\pi) \coloneqq P(\pi) - P(-\pi)$
  - e.g. $\Gamma(SFC) \coloneqq P(SFC) - P(CFS) = 0.33 - 0.14 = 0.19$
- c is "Net never-first" if $\Gamma(\mathrm{cab}) \leq 0$ & $\Gamma(\mathrm{cba}) \leq 0$
  - Similarly for never-last and never-middle
- Can you see if this applies to any candidate?
- Provide a full characterization of cyclic profiles using Net preferences on triplets



German National Election Survey 1972