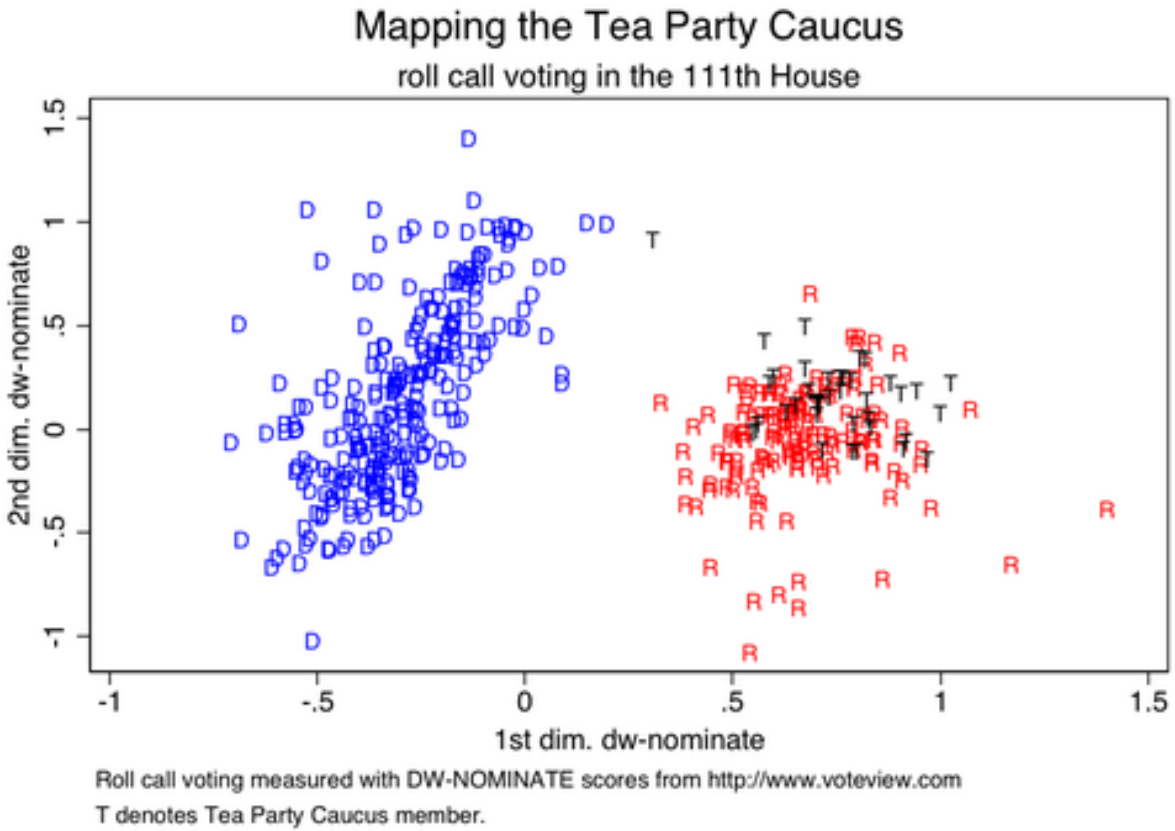
Supervised Topic Models

Advanced Machine Learning for NLP

Jordan Boyd-Graber

HIERARCHIES

Motivation: Representing Elected Officials with Ideal Points



An essential tool in political science: distinguish trends and characterize subgroups

Evaluation: Tea Party in the House

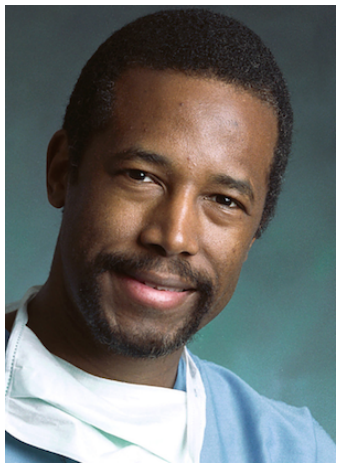
The Tea Party

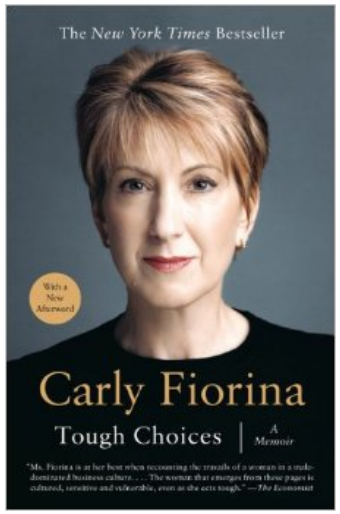
- American political movement for freedom, small government, lower tax
- Disrupting Republican Party and recent elections
- Organizations:
  - Institutional: Tea Party Caucus
  - Other: Tea Party Express, Tea Party Patriots, Freedom Works
- "**Conventional views of ideology as a single–dimensional, leftÂŰ-right spectrum experience great difficulty in understanding or explaining the Tea Party.**"

Goal

- Explain Tea Partiers in terms of issues and votes
- Identify Tea Partiers from their rhetoric

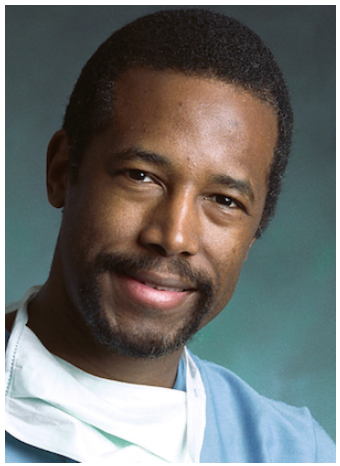
Not everyone has a voting record

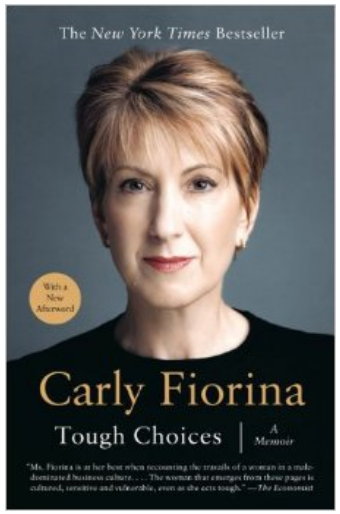




- Ideal points estimated based on voting record
- Not all candidates have a voting record
  - Governors
  - Entertainers
  - CEOs

Not everyone has a voting record





- Ideal points estimated based on voting record
- Not all candidates have a voting record
  - Governors
  - Entertainers
  - CEOs
- But all politicians—by definition—talk

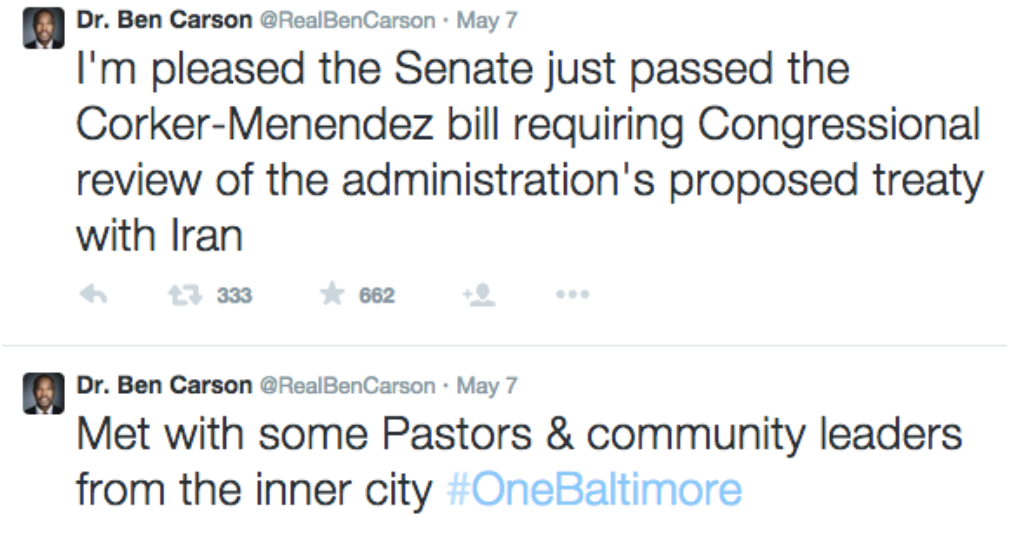
Let's use whatever data we have

A single model that uses:

- Bill text
- Votes
- Commentary

to map political actors to the same continuous space.

Let's use whatever data we have



A single model that uses:

- Bill text
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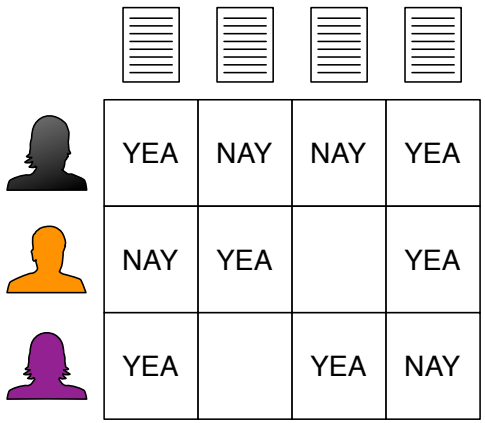
to map political actors to the same continuous space. This work: congressional floor speeches

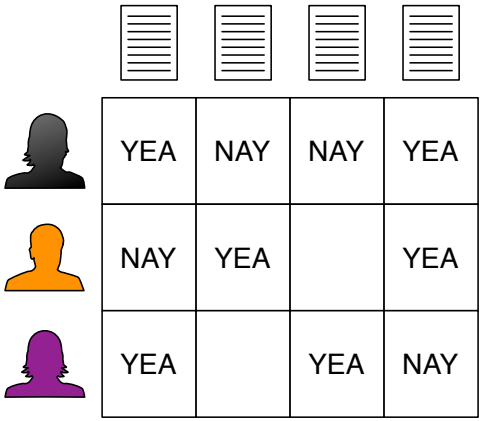
Outline

One-dimensional Ideal Point using Votes



One-dimensional Ideal Point using Votes

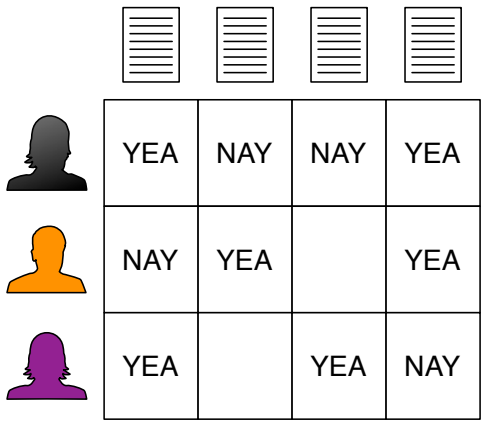
Legislator a votes 'Yea' on bill b with probability



$$p(v_{a,b} = \text{Yea}) = \Phi(u_a x_b + y_b)$$

$$\Phi(\alpha) = \frac{\exp(\alpha)}{\exp(\alpha) + 1}$$

One-dimensional Ideal Point using Votes



Legislator a votes 'Yea' on bill b with probability

One-dimensional ideal point of legislator a

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Polarity of bill b

Popularity of bill b

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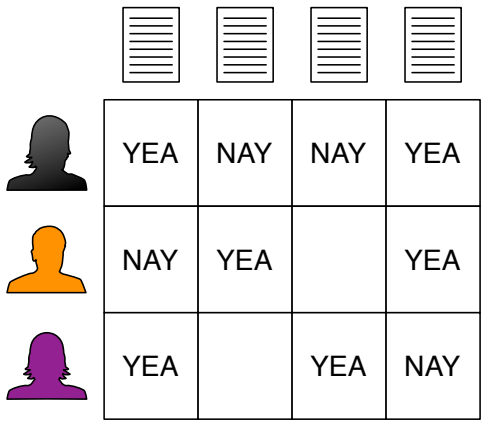

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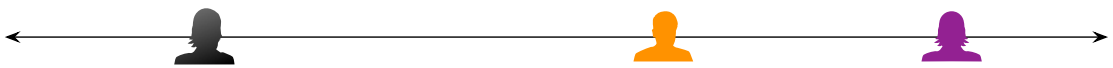

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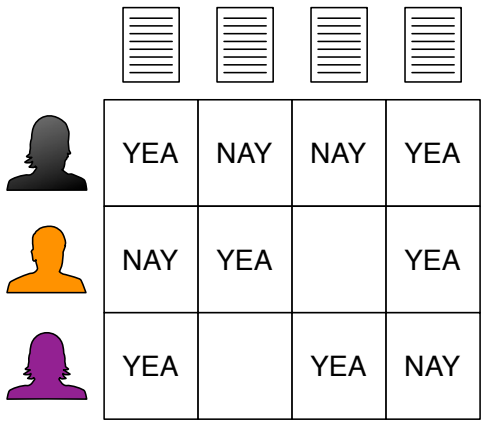

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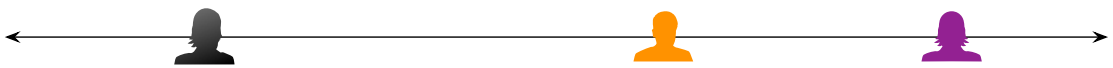

LIBERAL

CONSERVATIVE

Multi-dimensional Ideal Point using Votes

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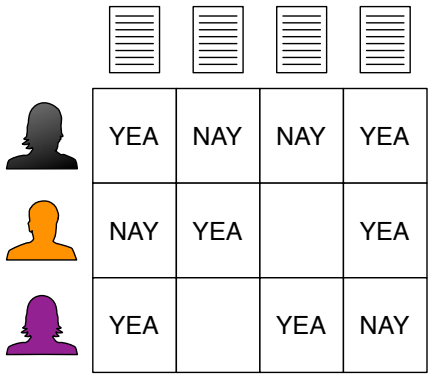

$$p(v_{a,b} = \text{Yea}) = \Phi\left(\sum_{k=1}^{K} u_{a,k} x_{b,k} + y_b\right)$$

Multi-dimensional Ideal Point using Votes

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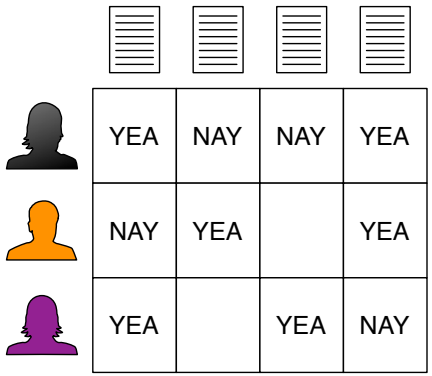

Multi-dimensional ideal point of legislator a

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K dimensions

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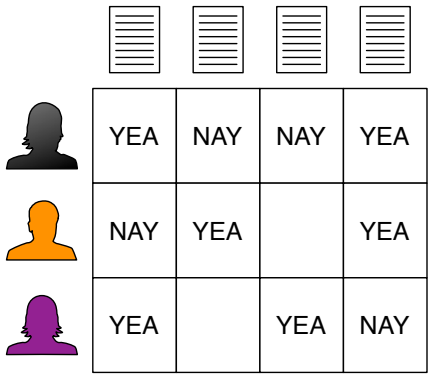

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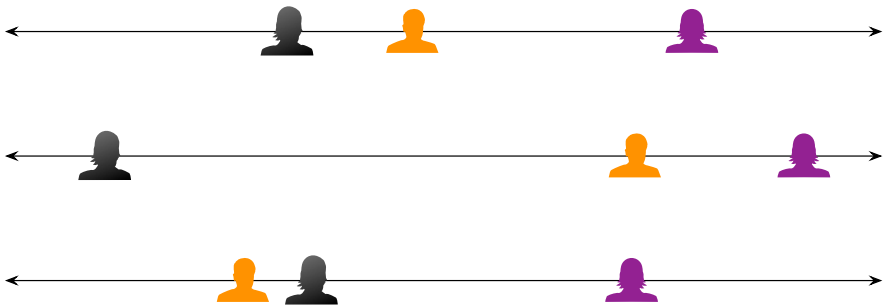

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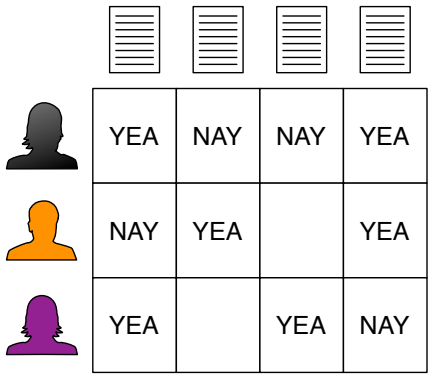

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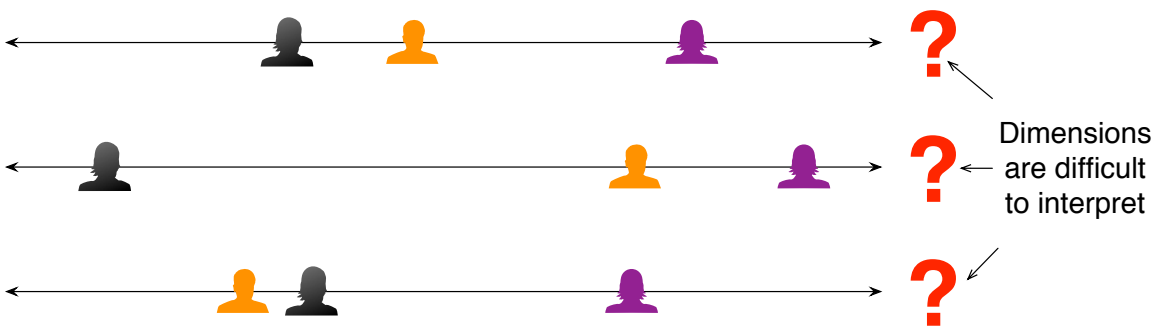
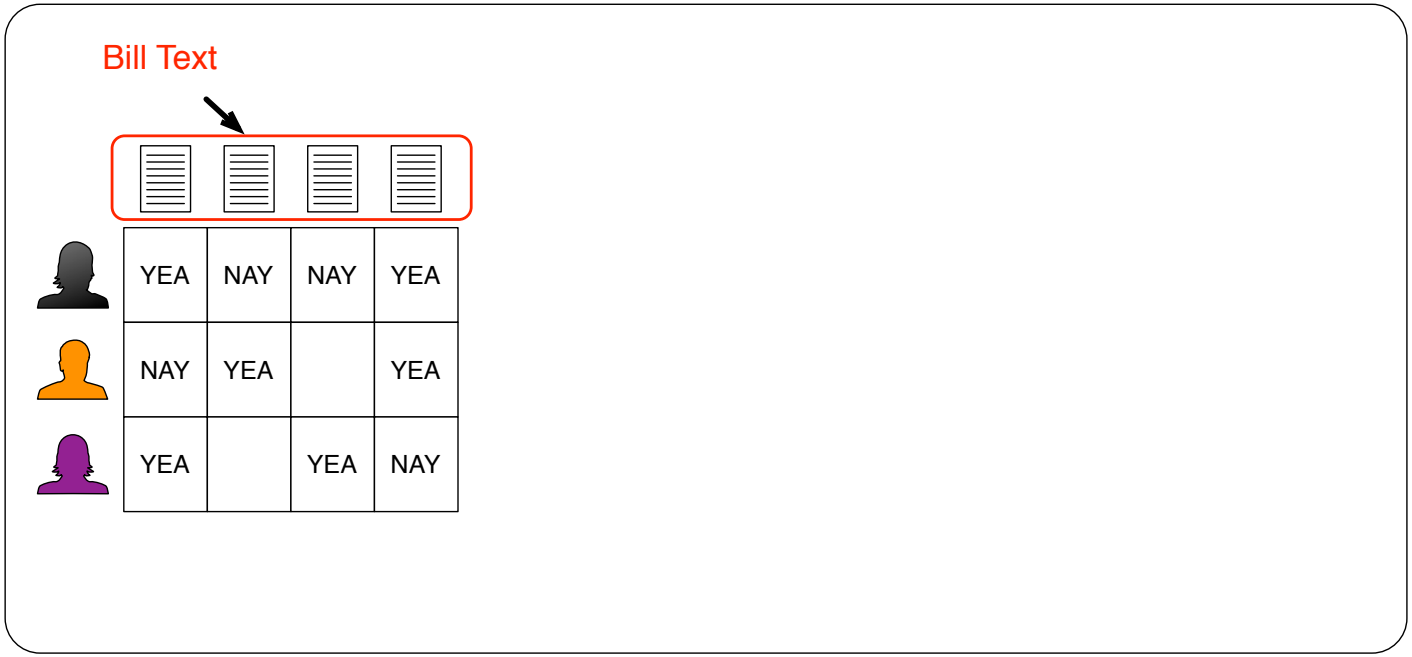
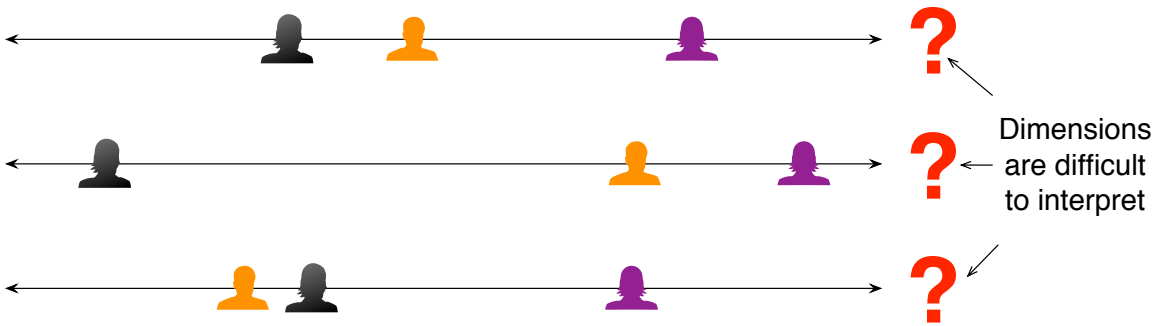


Multi-dimensional Ideal Point using Votes & Text





Multi-dimensional Ideal Point using Votes & Text

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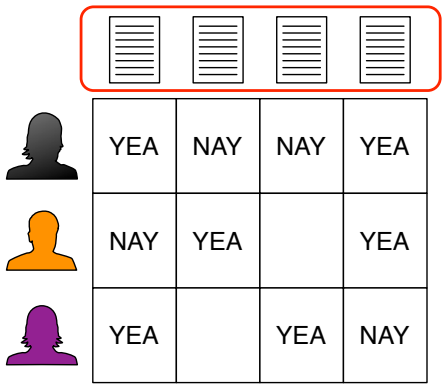

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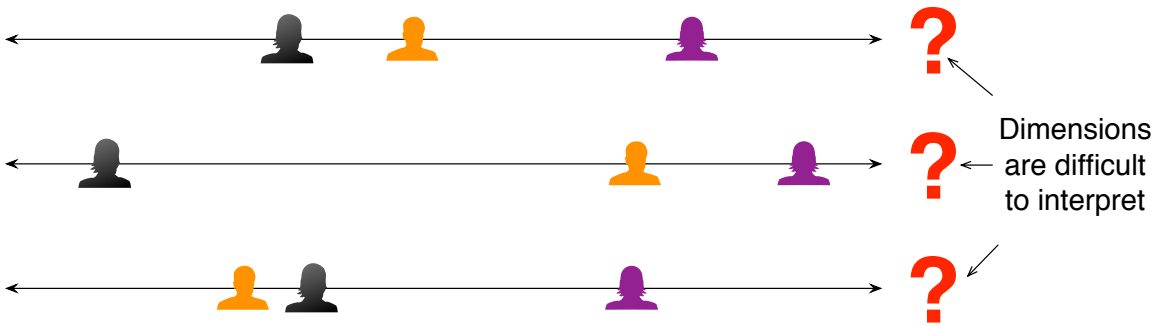

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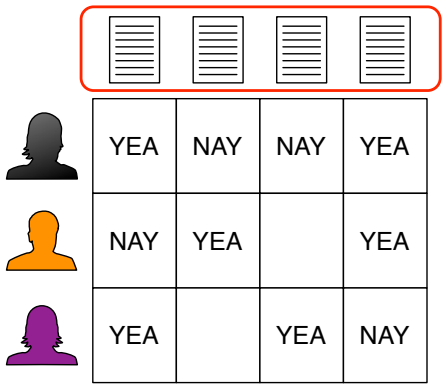

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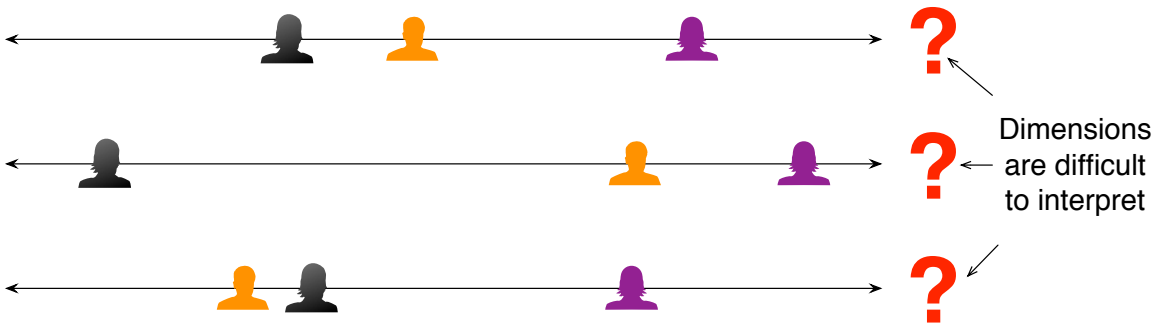
Multi-dimensional ideal point of legislator a

Topic proportion of bill b estimated from its text



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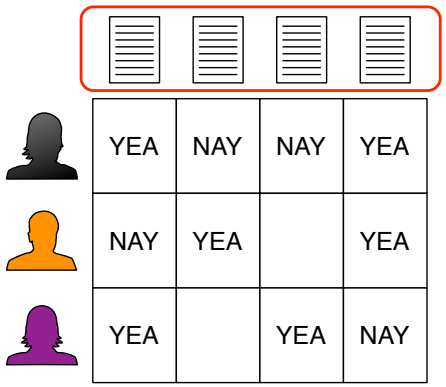

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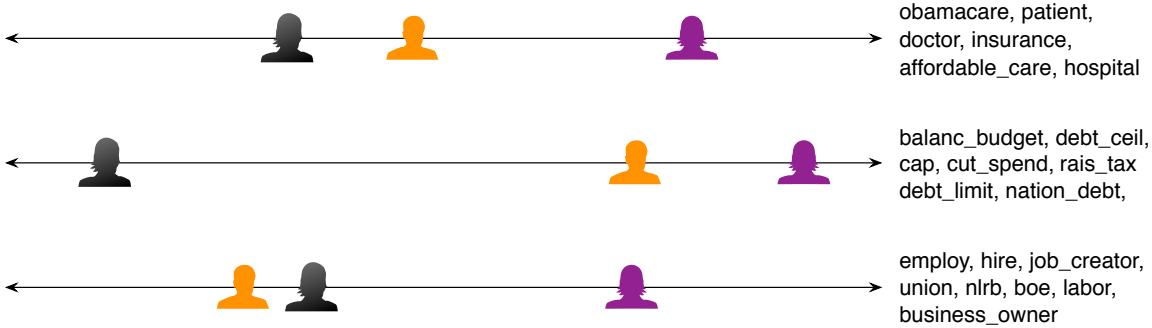


Outline

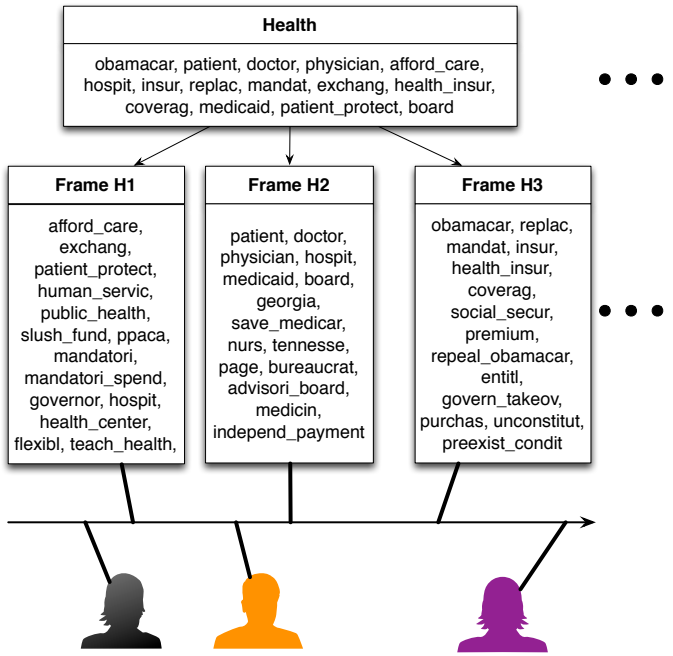
Hierarchical Ideal Point Topic Model: Intuition

What are your thoughts on the issue of **immigration**?

Hierarchical Ideal Point Topic Model: Overview

Using both votes and text to learn

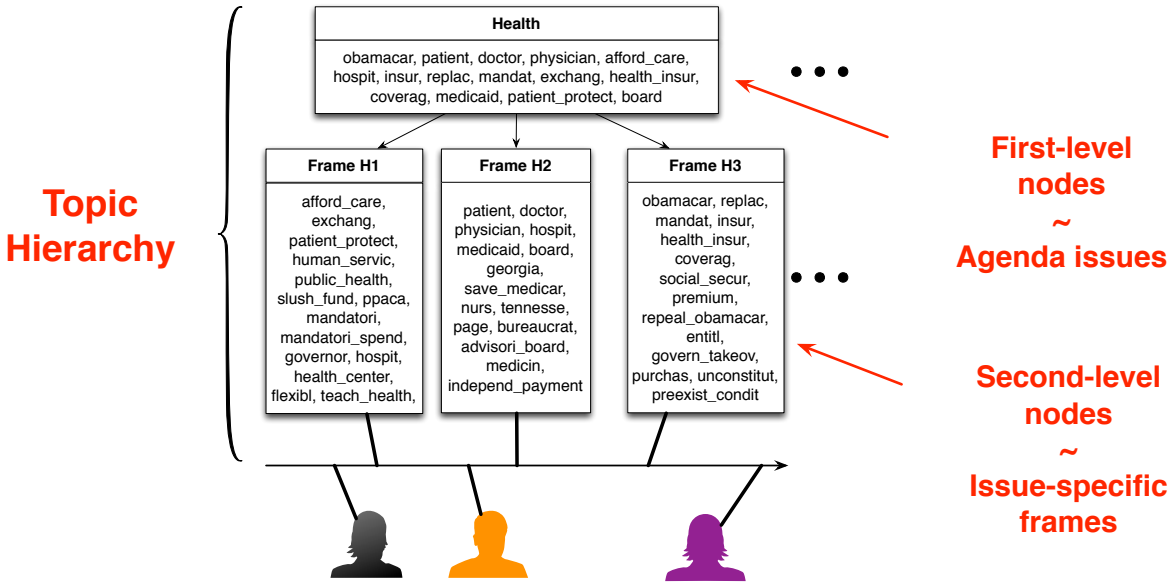
- Two-level topic hierarchy:
- Ideal points in multiple interpretable dimensions



Hierarchical Ideal Point Topic Model: Overview

Using both votes and text to learn

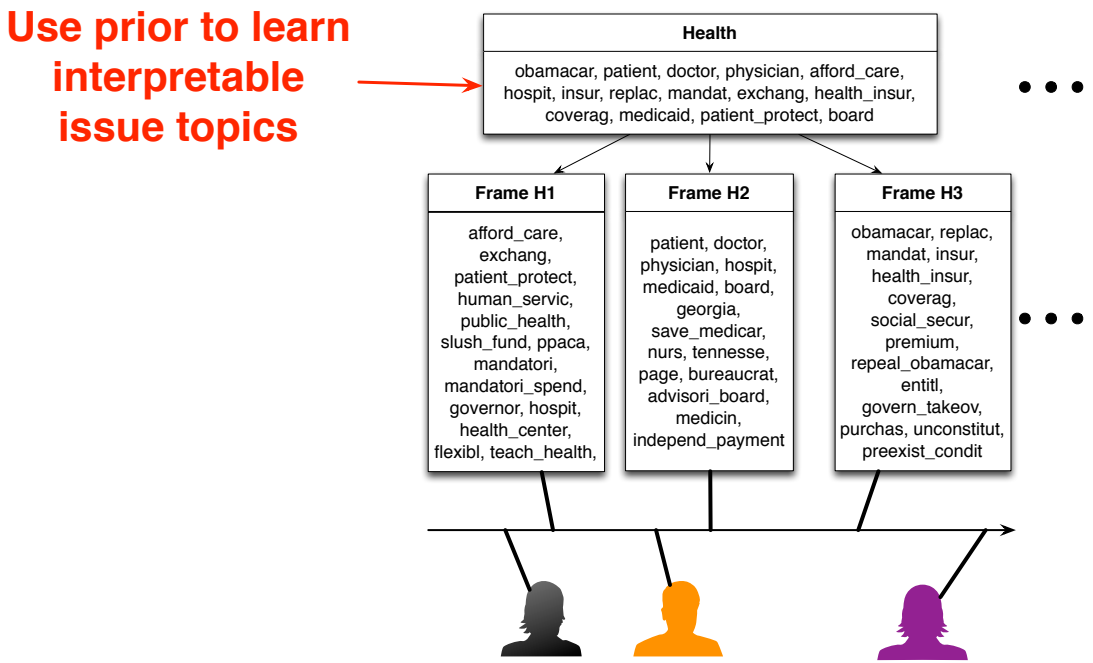
- Two-level topic hierarchy:
  - First-level nodes map to agenda issues
  - Second-level nodes map to issue-specific frames
- Ideal points in multiple interpretable dimensions



Hierarchical Ideal Point Topic Model: Overview

Using both votes and text to learn

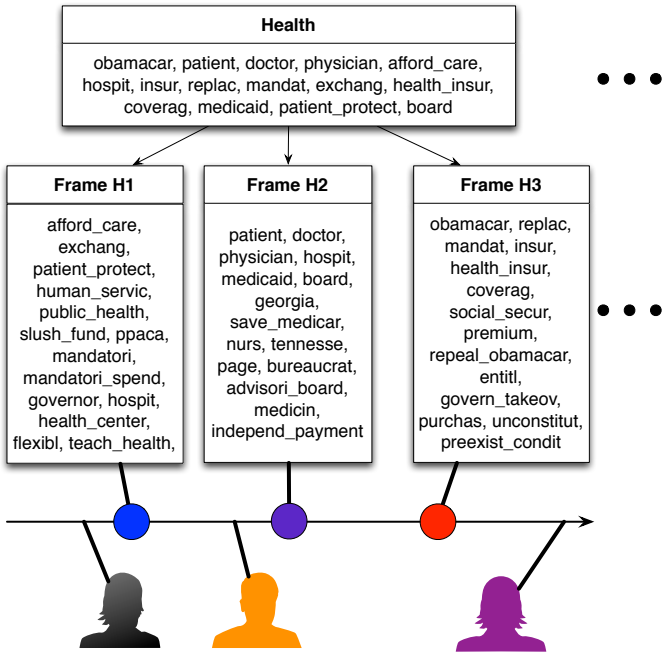
- Two-level topic hierarchy: Use existing labeled data to learn priors for interpretable issues
- Ideal points in multiple interpretable dimensions



Hierarchical Ideal Point Topic Model: Overview

Using both votes and text to learn

- Two-level topic hierarchy: Ideal points for frames for predictions using text only
- Ideal points in multiple interpretable dimensions



Learn ideal point for each frame

Hierarchical Ideal Point Topic Model: Overview

Using both votes and text to learn

- Two-level topic hierarchy:
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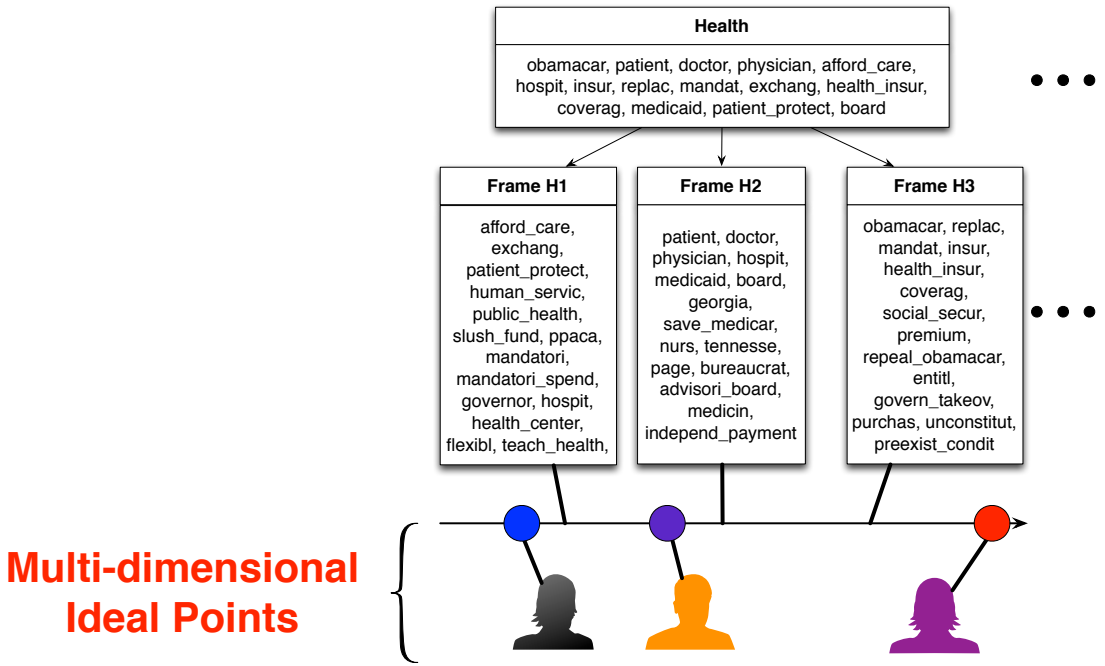
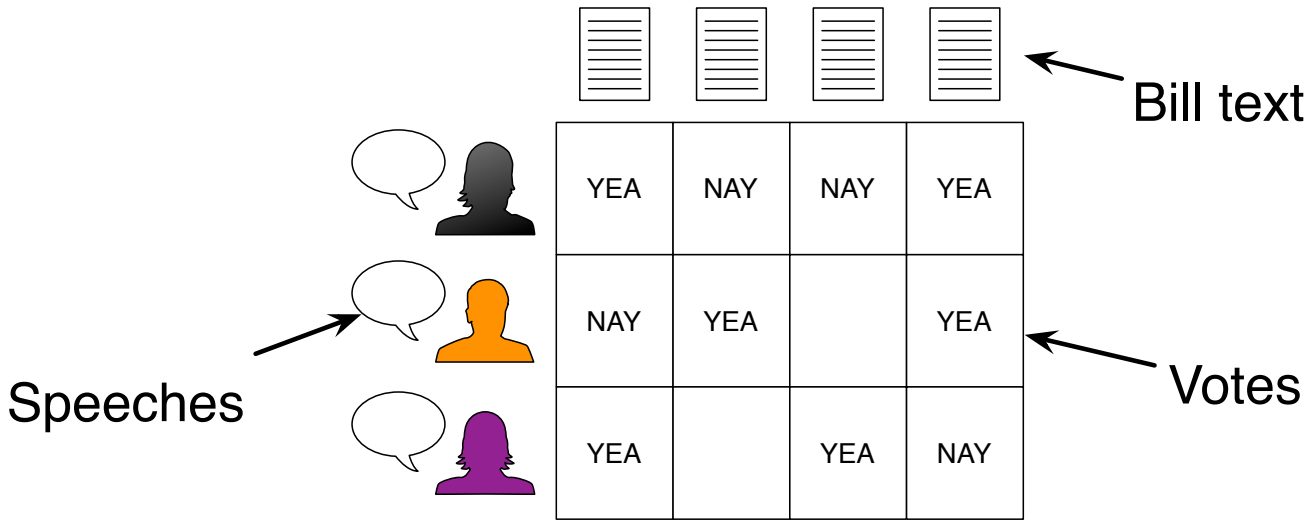


Hierarchical Ideal Point Topic Model: Overview

Hierarchical Ideal Point Topic Model: Inputs

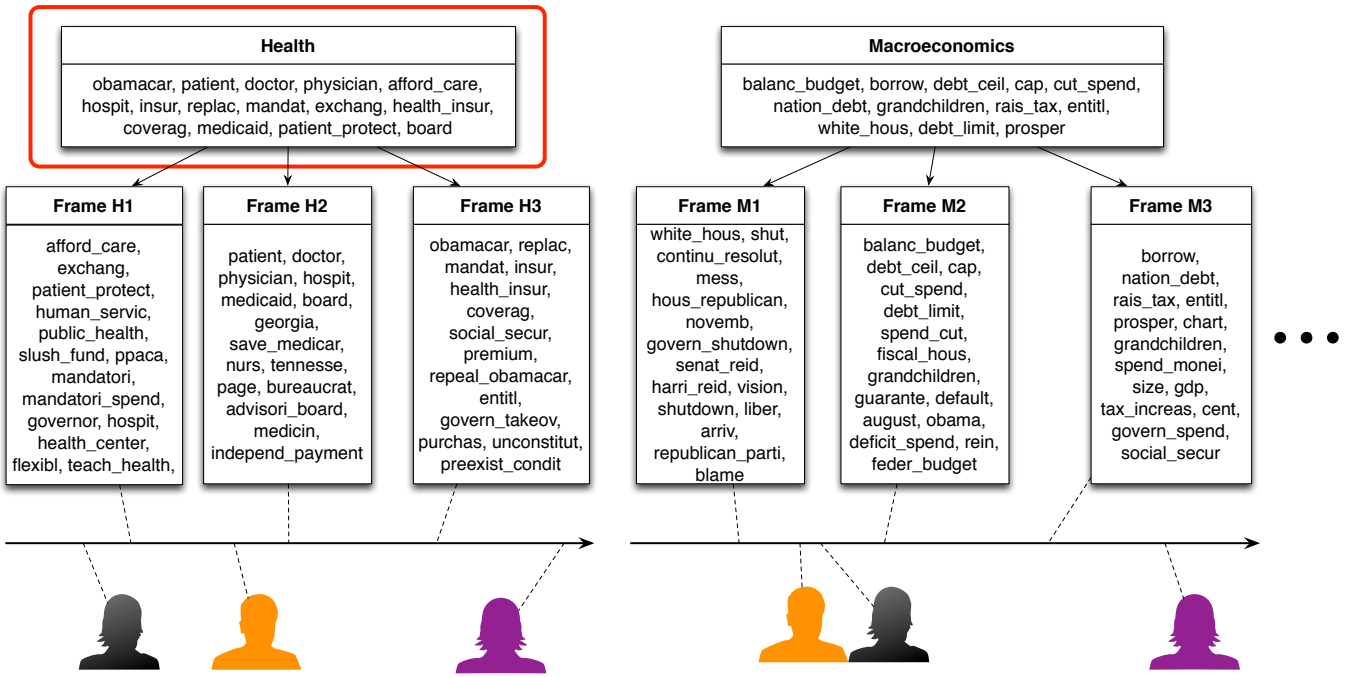
- A collection of votes $\{v_{a,b}\}$
- A collection of D speeches $\{\boldsymbol{w}_d\}$, each of which is given by legislator a_d
- A collection of B bill text $\{\boldsymbol{w}'_b\}$



Hierarchical Ideal Point Topic Model

Modeling bill text

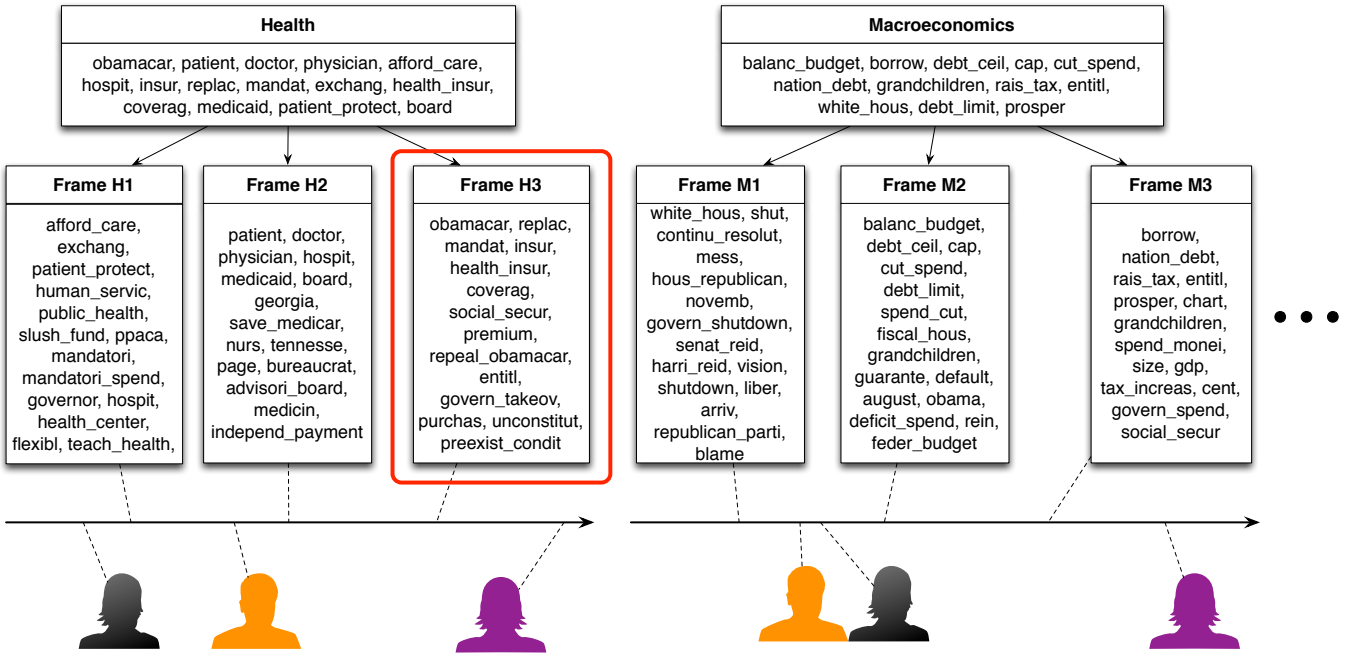
- Each bill text b is a mixture over K issues ϑ_b
- Each bill token generated from topic at first-level issue node



Hierarchical Ideal Point Topic Model

Hierarchical Ideal Point Topic Model: Generative Process

- Each speech d also has a distribution θ_d over K issues
- Each issue k, each speech d has distribution over frames $\psi_{d,k}$
- Each speech token from topic at second-level frame node



Hierarchical Ideal Point Topic Model

Hierarchical Ideal Point Topic Model: Modeling votes

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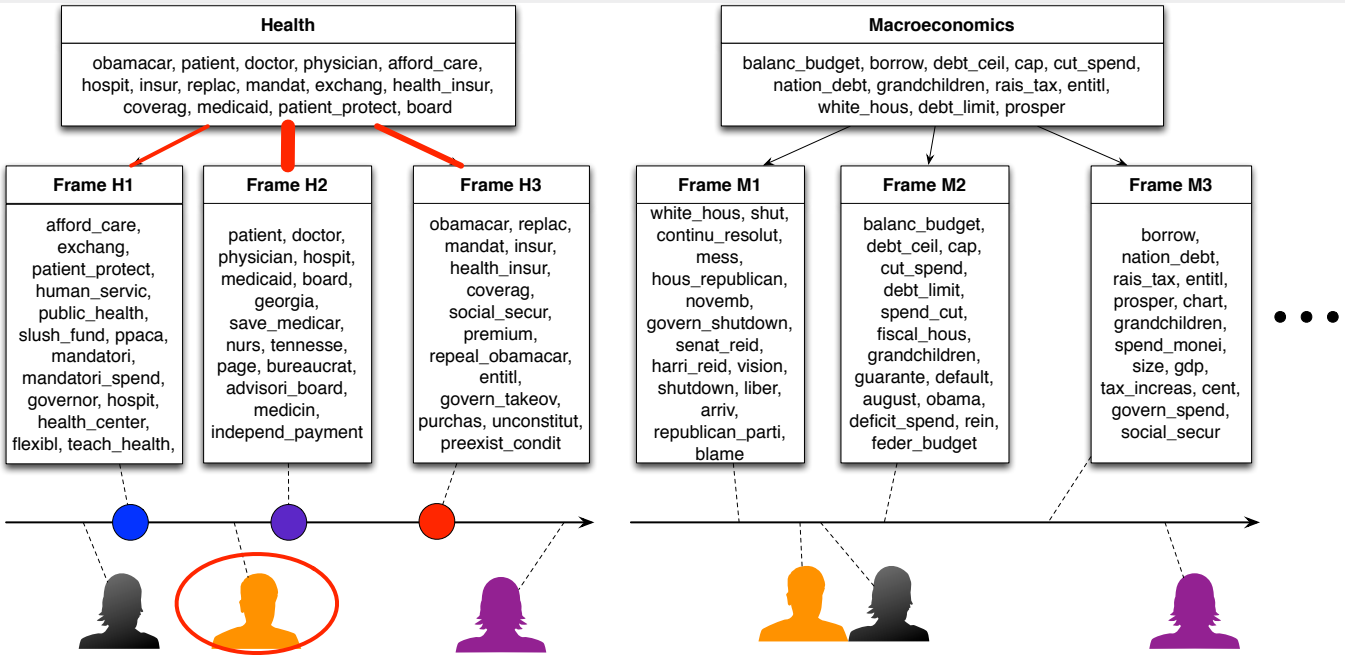
- Ideal point $u_{a,k} \sim \mathcal{N}(\sum_{j=1}^{J_k} \eta_{k,j} \psi_{a,k,j}, \rho)$



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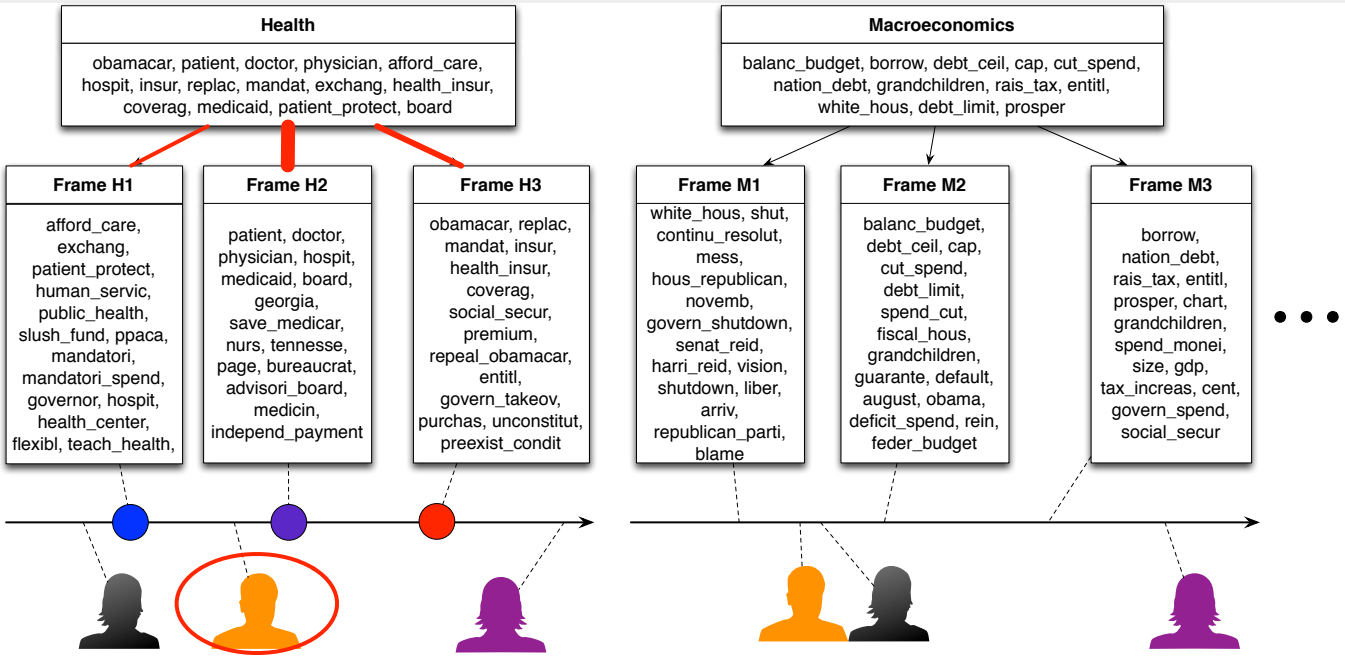

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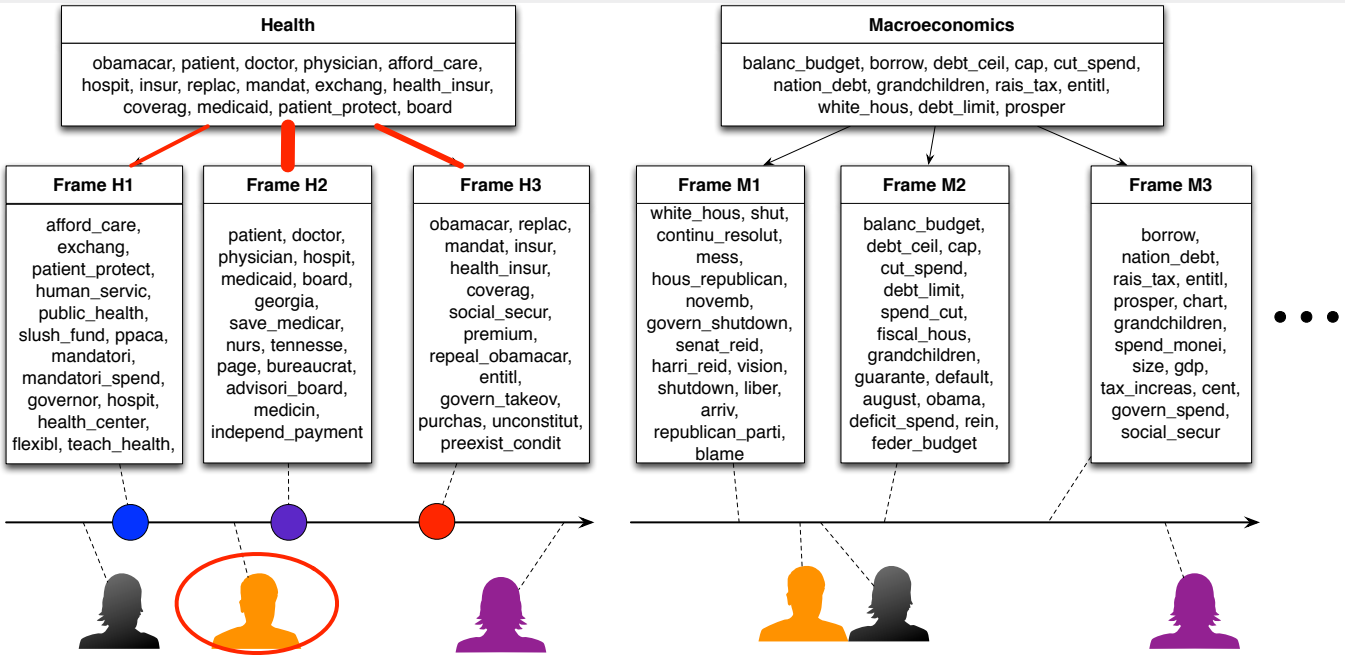

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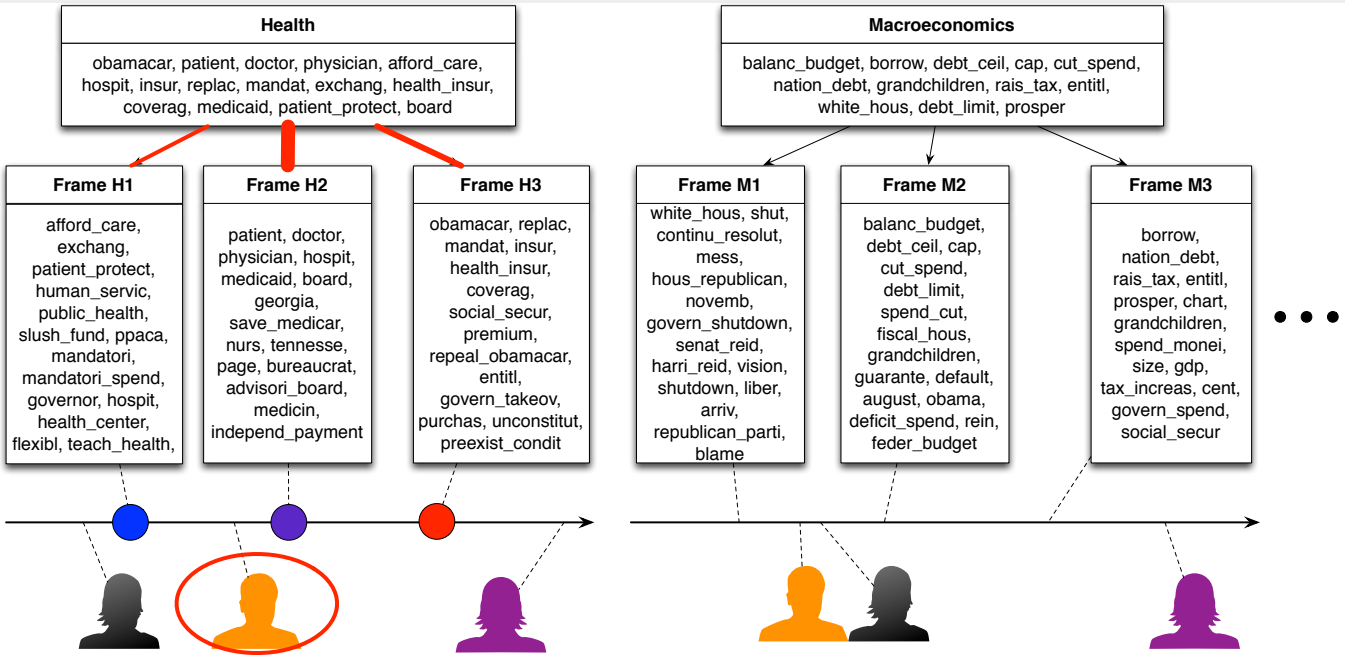

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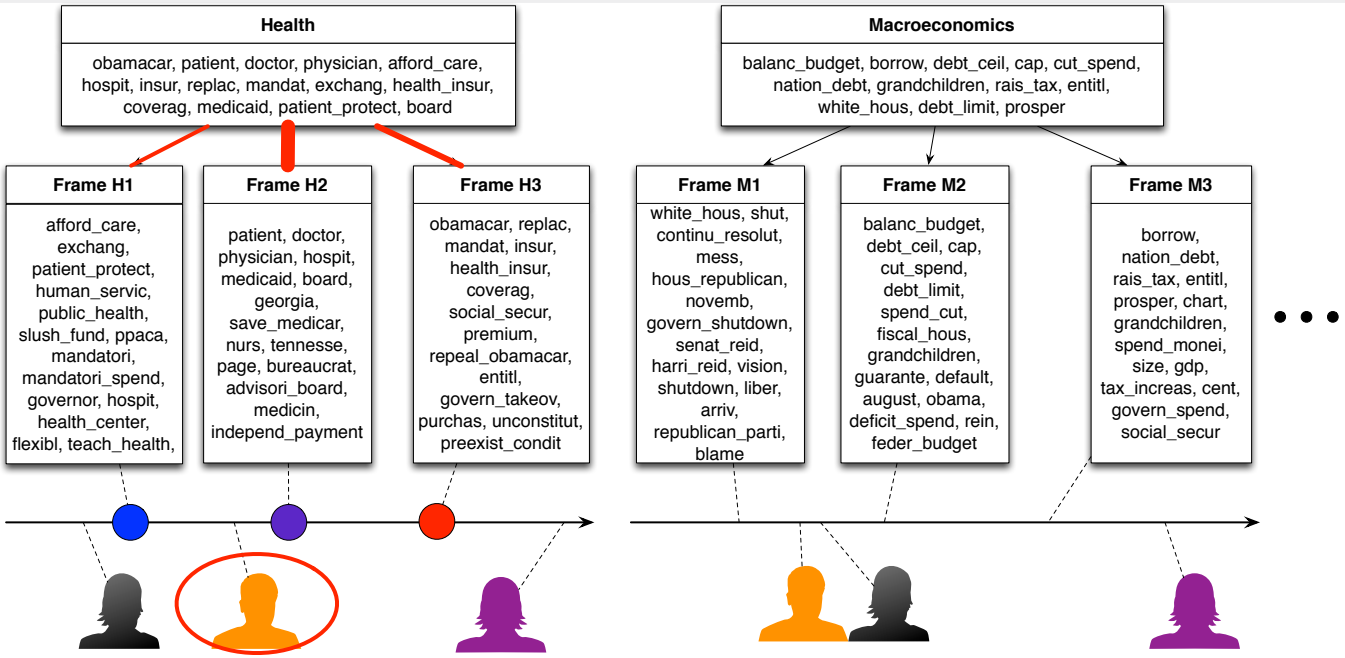
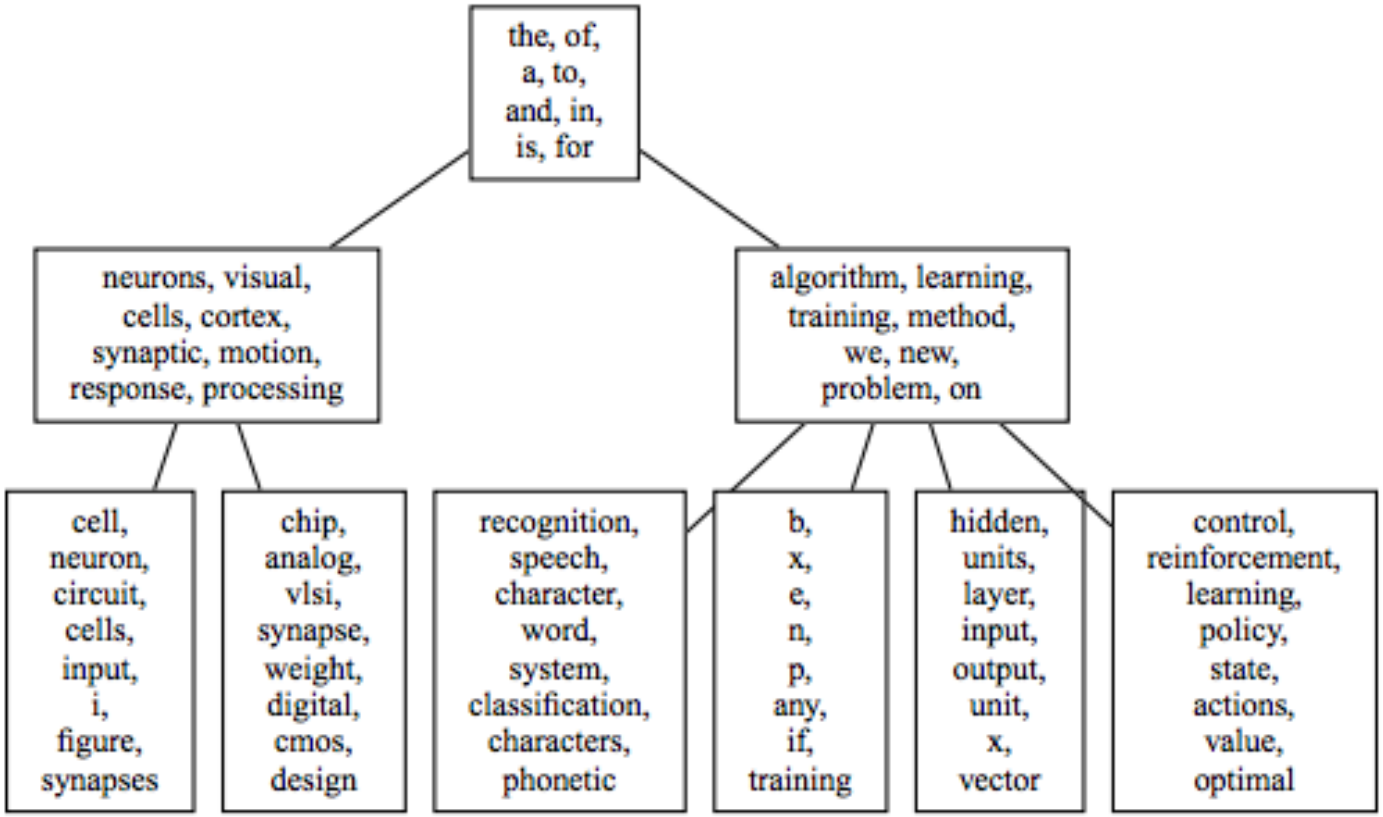


Nested Chinese Restaurant Process

- Start at a CRP, choose a table
- That table has not just a dish (distribution over words) but also business card
- That card tells you which restaurant to go to next
- You do this L times

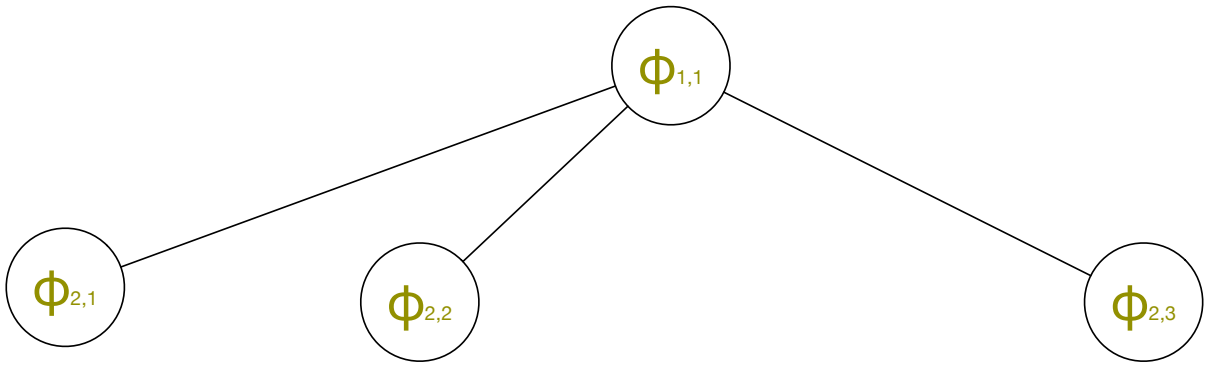
Topic Hierarchies



Generative Process

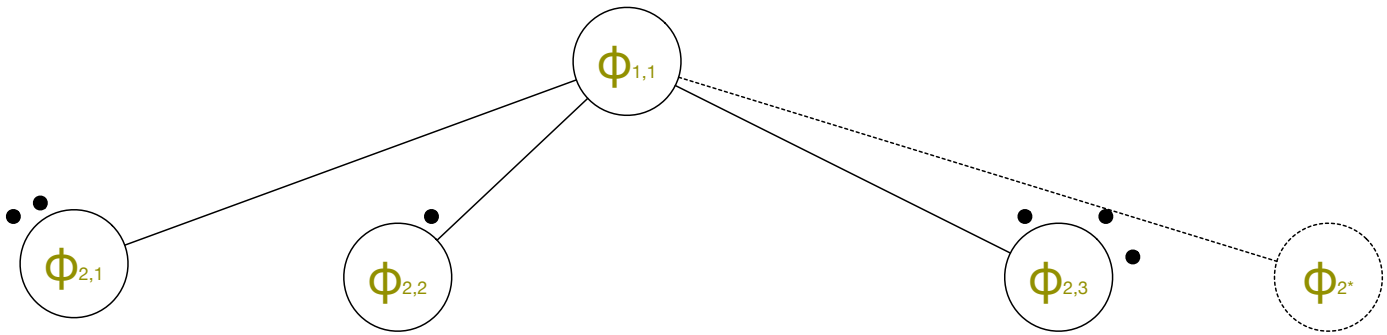
Start at the root node

Generative Process



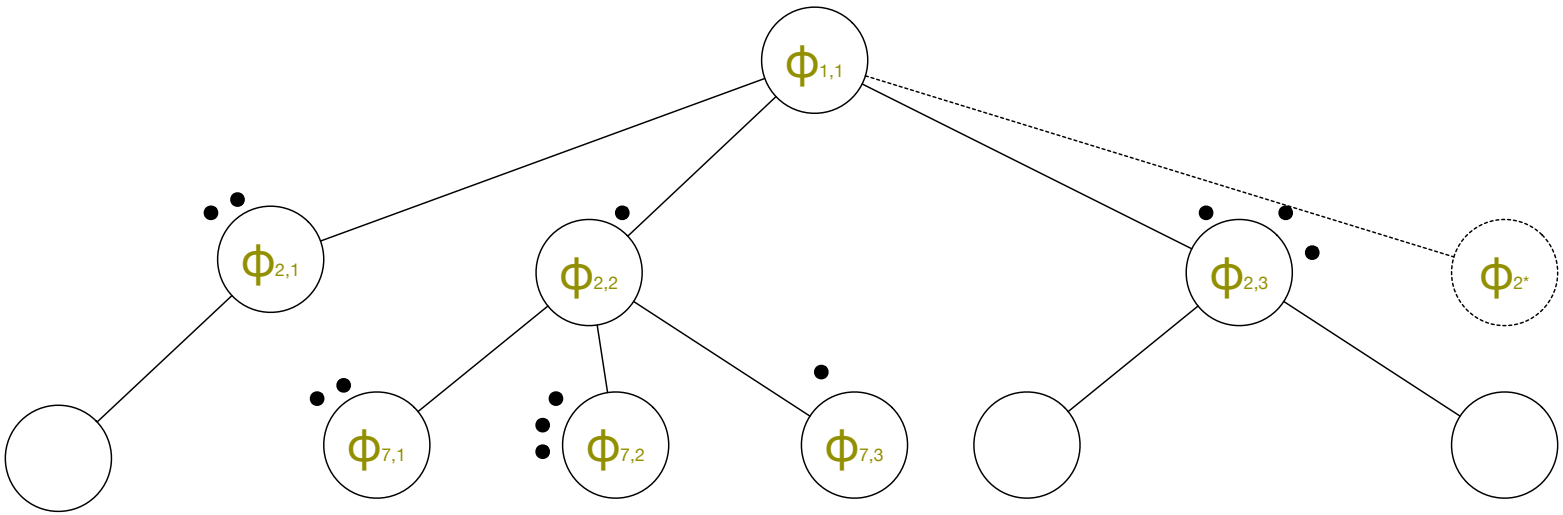
Need to choose which table to sit at

Generative Process



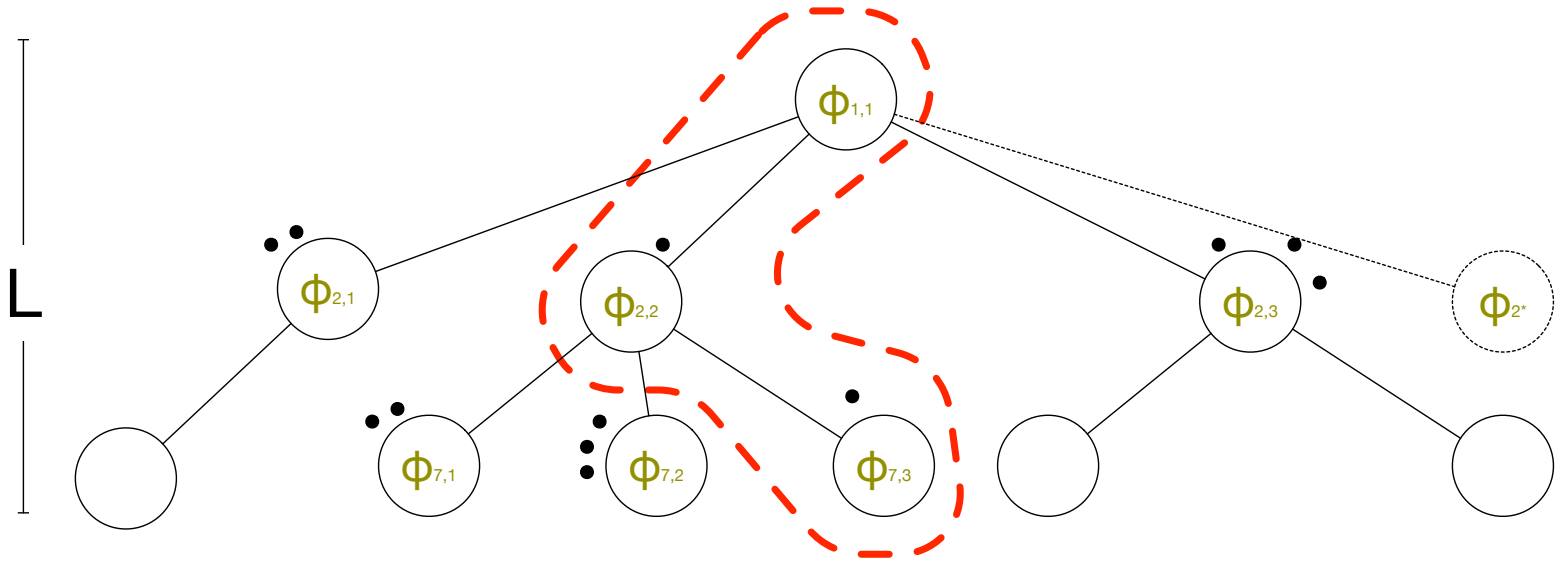
This is a CRP! (Can create new table too.)

Generative Process



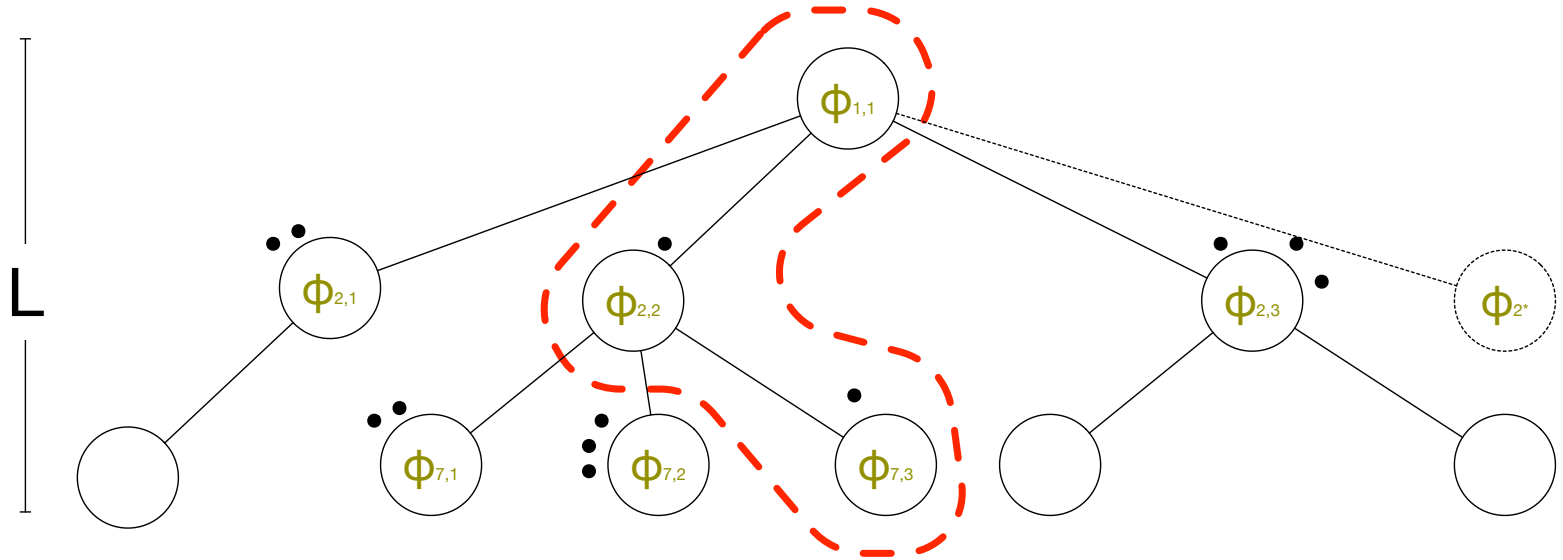
Repeat

Generative Process



Your path then becomes the set of topics you use for this document

Generative Process



Warning: Probably don't want to only use one path per document (but useful explanation)

Evaluation: Tea Party in the House

The Tea Party

- American political movement for freedom, small government, lower tax
- Disrupting Republican Party and recent elections

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Data

- 240 Republican Representatives in the 112^{th} U.S. House
- 60 are members of the Tea Party Caucus (self-identified)
- 60 key votes selected by Freedom Works (2011-2012)
- Speeches, bill text and voting records from the Library of Congress

Outline

Tea Party Caucus Membership Prediction

Experiment setup

- Task: Binary classification of whether a legislator is a member of the Tea Party Caucus
- Evaluation metric: AUC-ROC
- Classifier: SVM^{light}
- Five-fold stratified cross-validation

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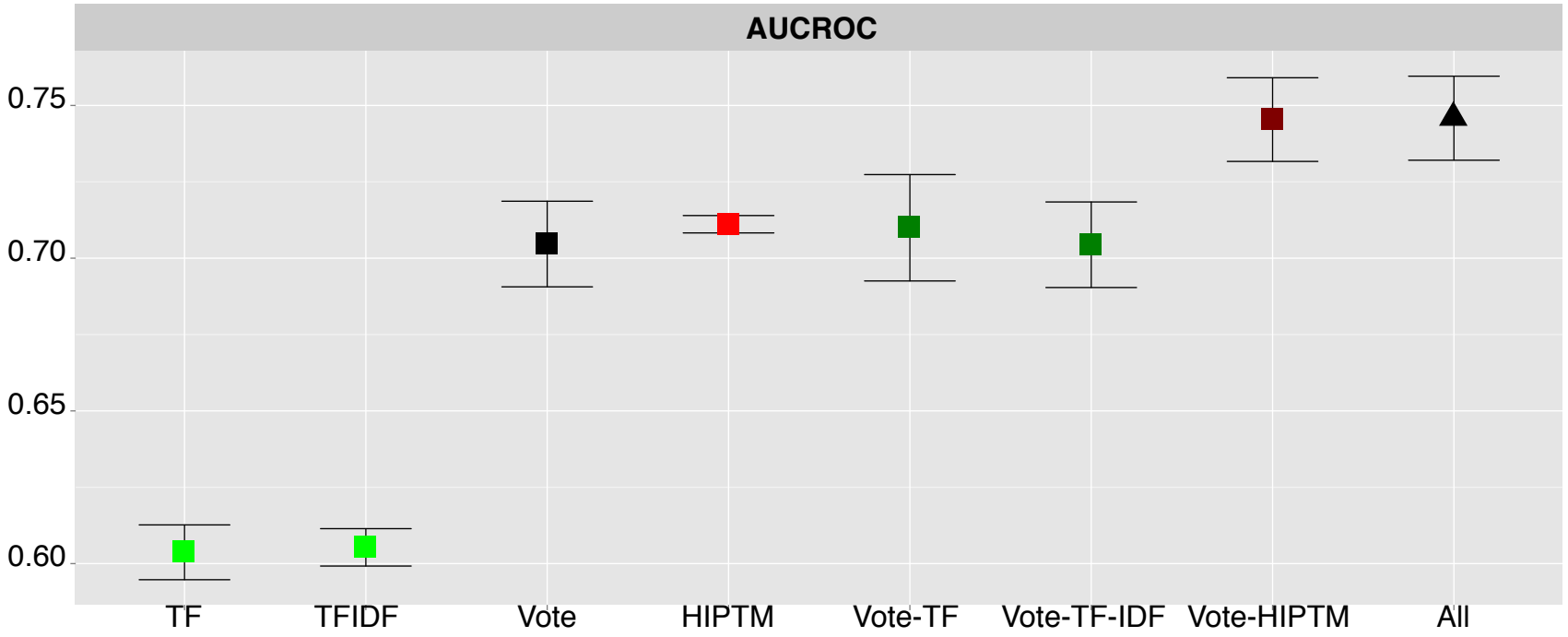
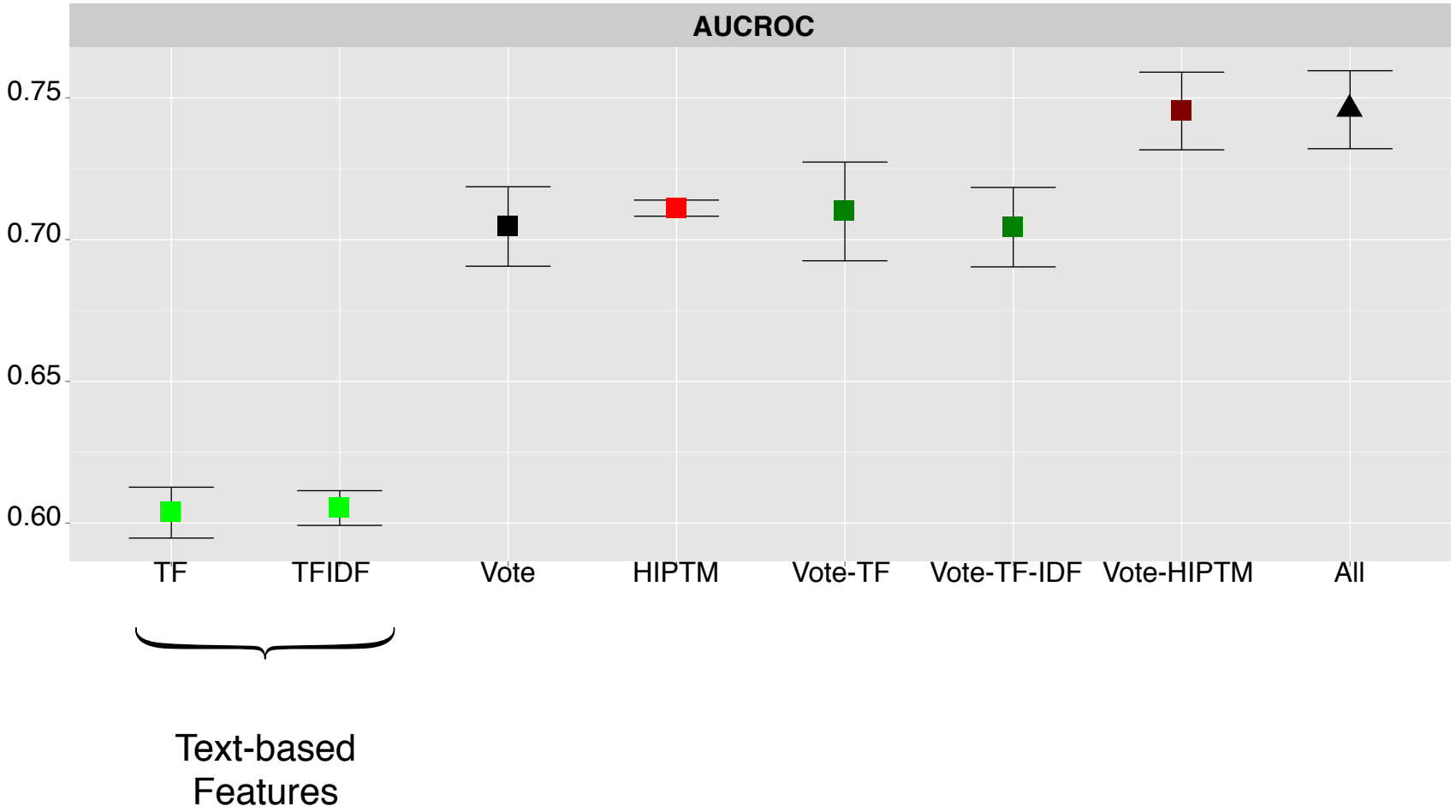
Features

- Text-based features: normalized term frequency (**TF**) and **TF-IDF**
- **Vote**: binary features
- **HIPTM**: features extracted from our model including
  - K-dim ideal point $u_{a,k}$ estimated from both votes and text
  - K-dim ideal point estimated from text only $\eta_k^T \hat{\psi}_{a,k}$
  - B probabilities estimating a's votes $\Phi(x_b \sum_{k=1}^{K} \vartheta_{b,k} u_{a,k} + y_b)$

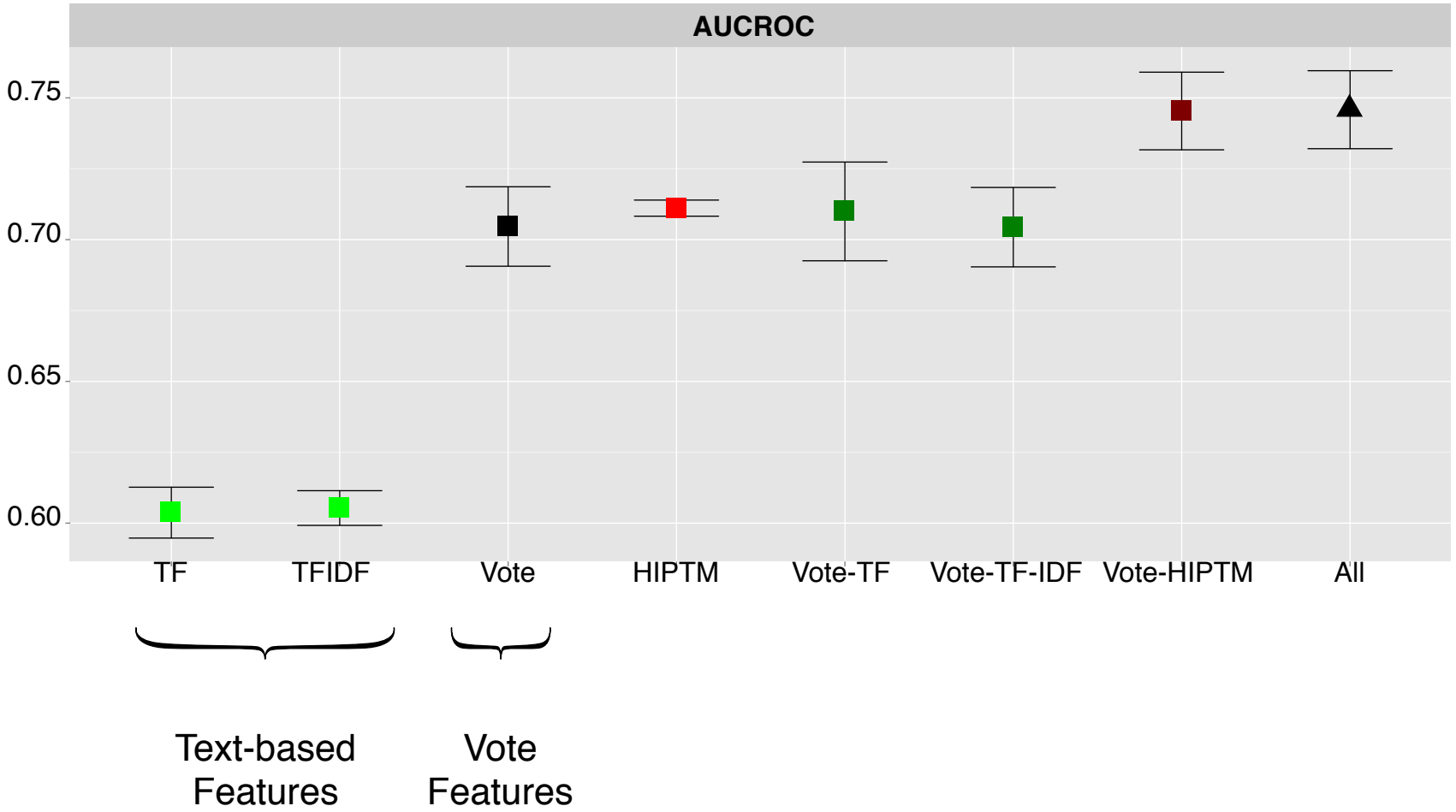
Tea Party Caucus Membership Prediction: Votes & Text



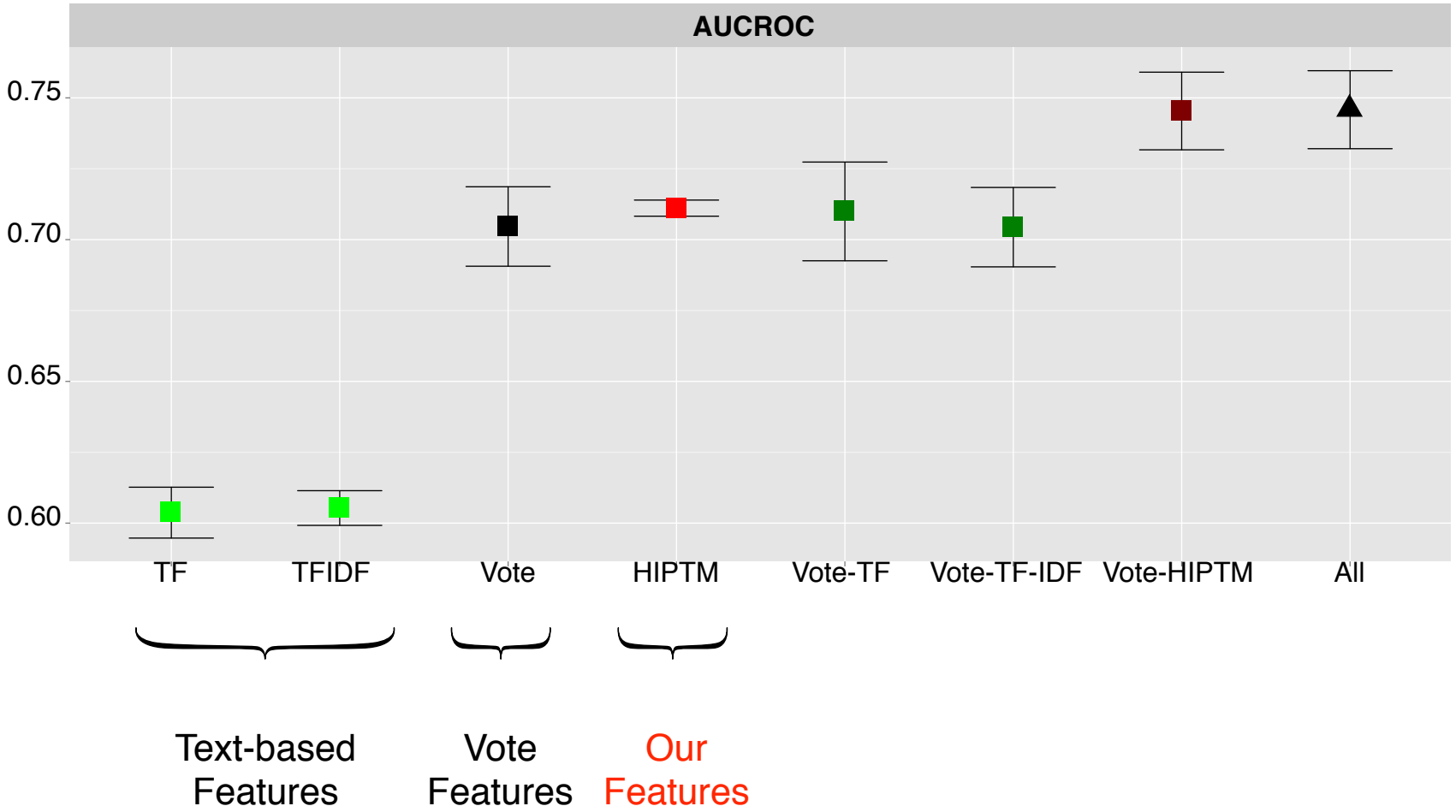
Tea Party Caucus Membership Prediction: Votes & Text



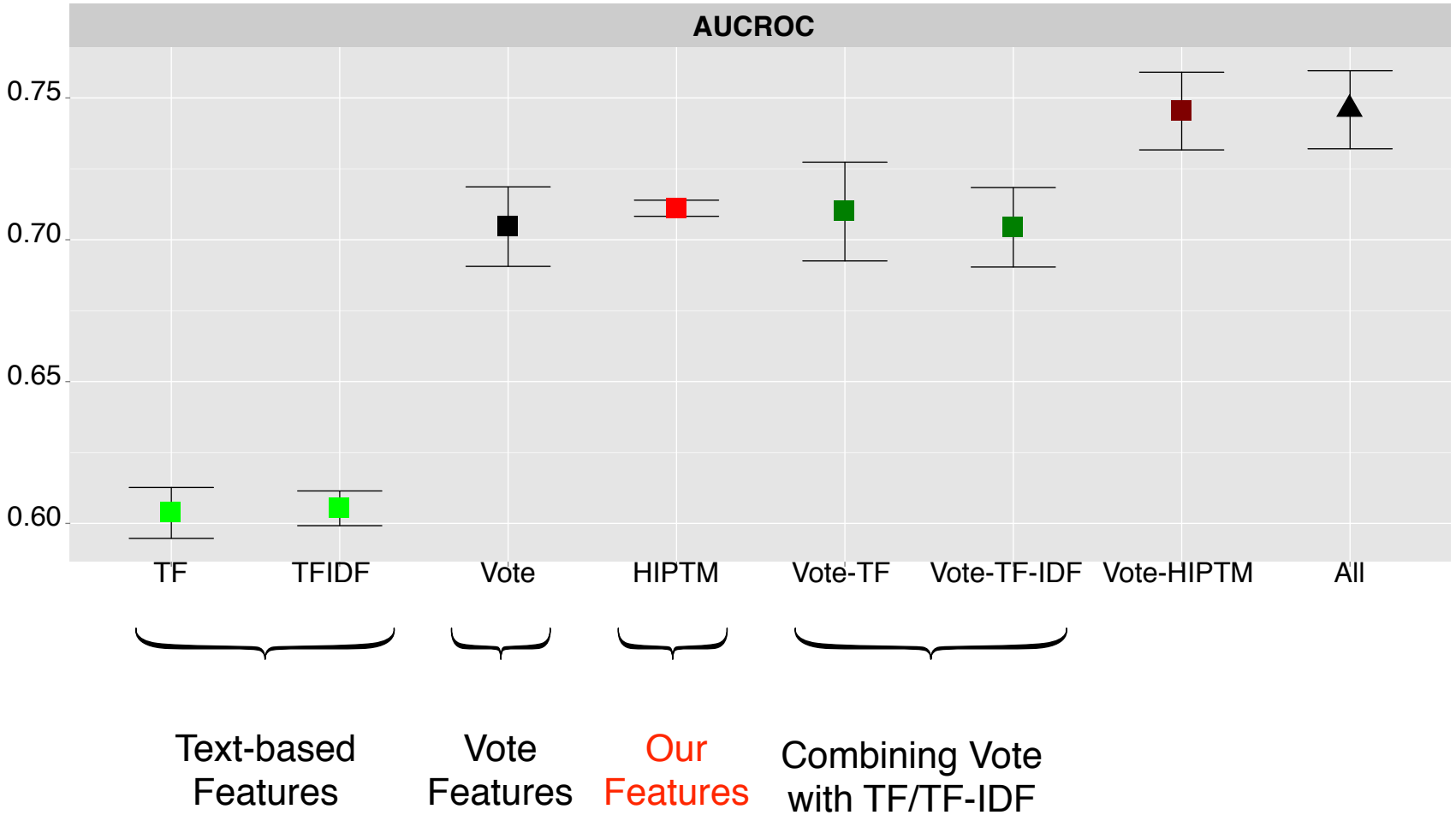
Tea Party Caucus Membership Prediction: Votes & Text



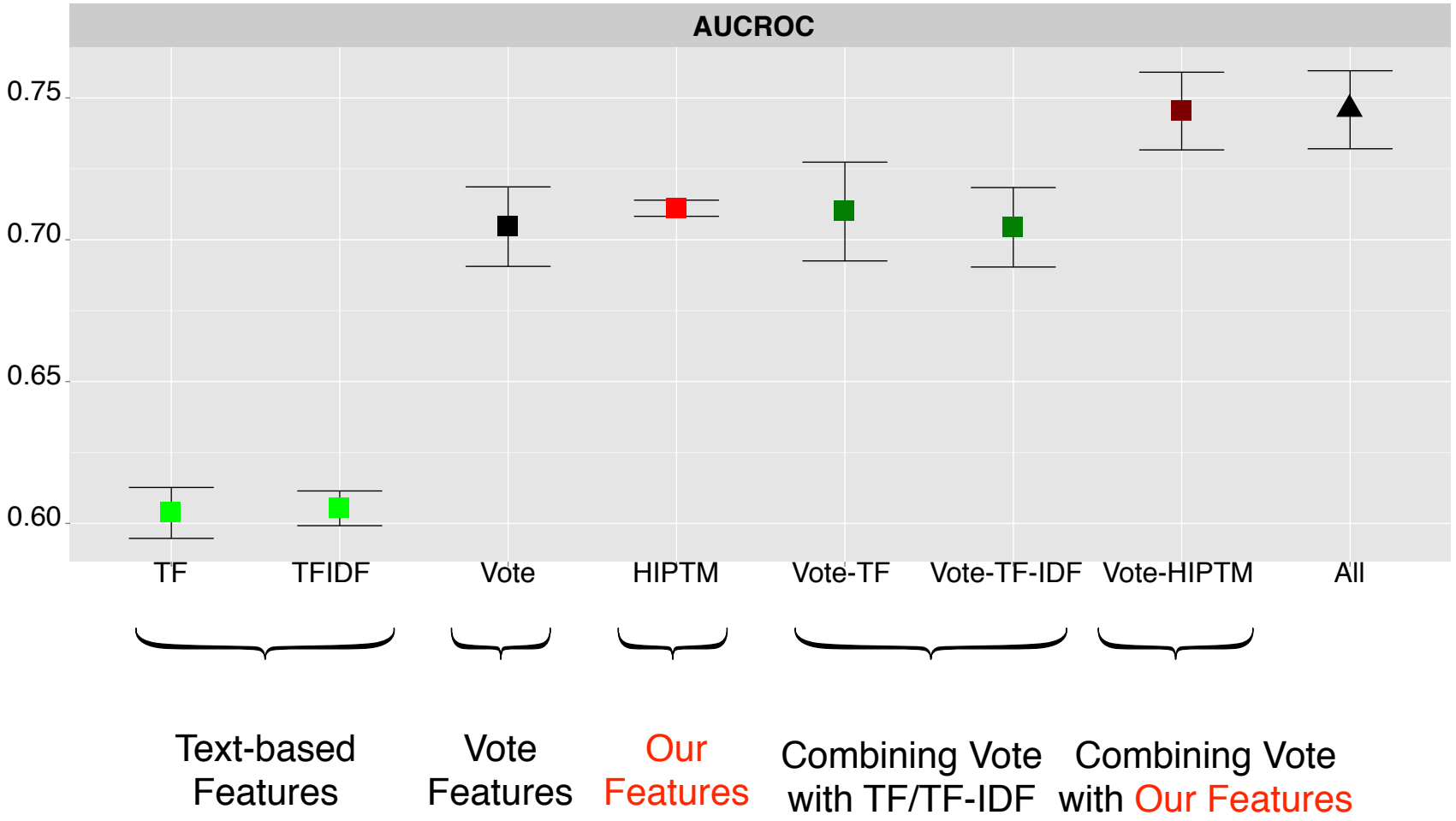
Tea Party Caucus Membership Prediction: Votes & Text



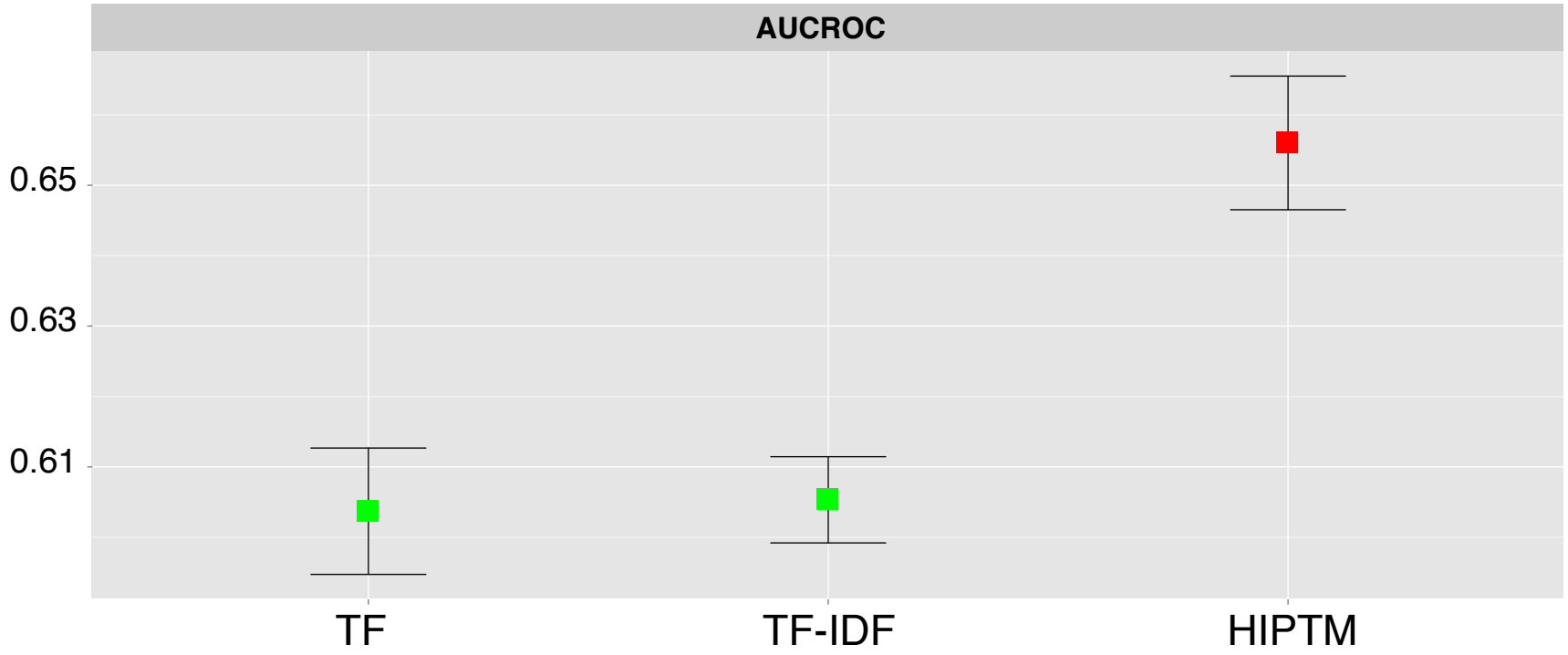
Tea Party Caucus Membership Prediction: Votes & Text



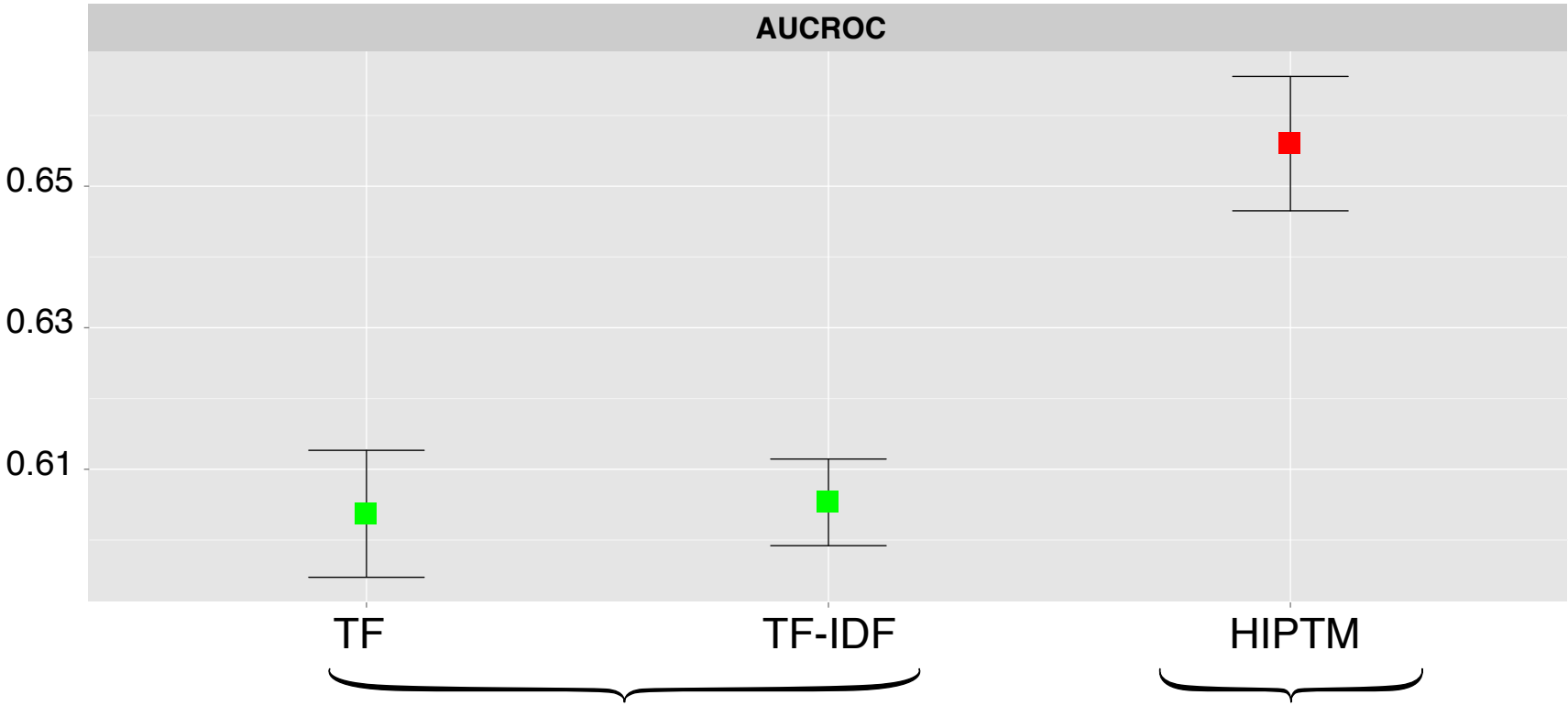
Tea Party Caucus Membership Prediction: Votes & Text



Tea Party Caucus Membership Prediction: Text Only



Tea Party Caucus Membership Prediction: Text Only



Training: text only
Test: text only

Training: text and votes
Test: text only

Outline

One-dimensional Ideal Points

One-dimensional Ideal Points

One-dimensional Ideal Points

- **Alexander** and **Crenshaw**'s votes only agree with Freedom Works 48% and 50% respectively
- Both voted for raising the debt ceiling and are listed as "traitor"

John T. Reed on Headline News

points and perspectives not offered elsewhere

House Tea Party Caucus members	how they voted on debt ceiling increase
Sandy Adams, Florida	traitor
Robert Aderholt, Alabama	traitor
Todd Akin, Missouri	no
Rodney Alexander, Louisiana	traitor
Michele Bachmann, Minnesota, Chairman	no
Rob Bishop, Utah	no
Ander Crenshaw, Florida	traitor
Michael C. Burgess, Texas	traitor

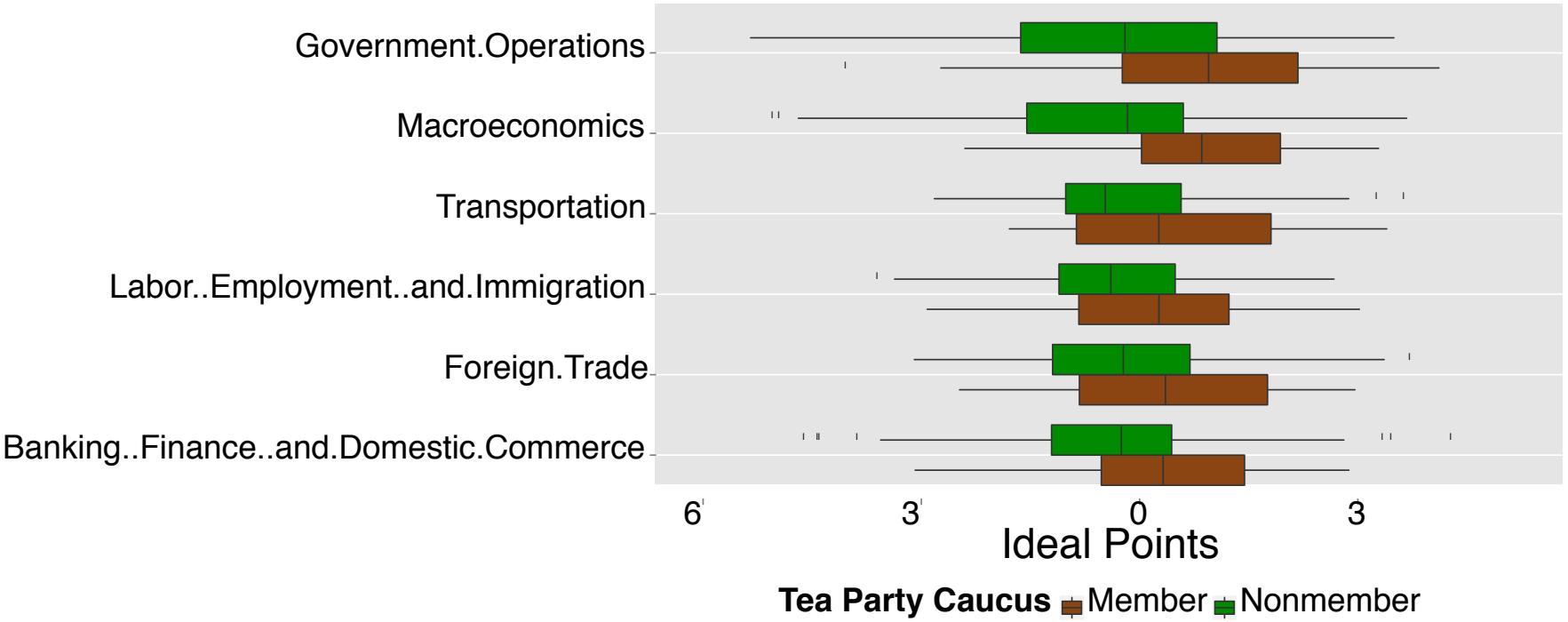
One-dimensional Ideal Points

- **Flake** and **Amash** didn't self-identify as members of the Tea Party Caucus but have been endorsed by other Tea Party organizations

NEW REPUBLIC

"Some 46 House members and six senators had been [Tea Party] . . . In addition, there were about 18 other House members like Trey Gowdy, Mark Meadows, and Justin Amash, and several senators, including Jeff Flake and Pat Toomey, who owed their election to support from the Tea Party and its Washington allies."

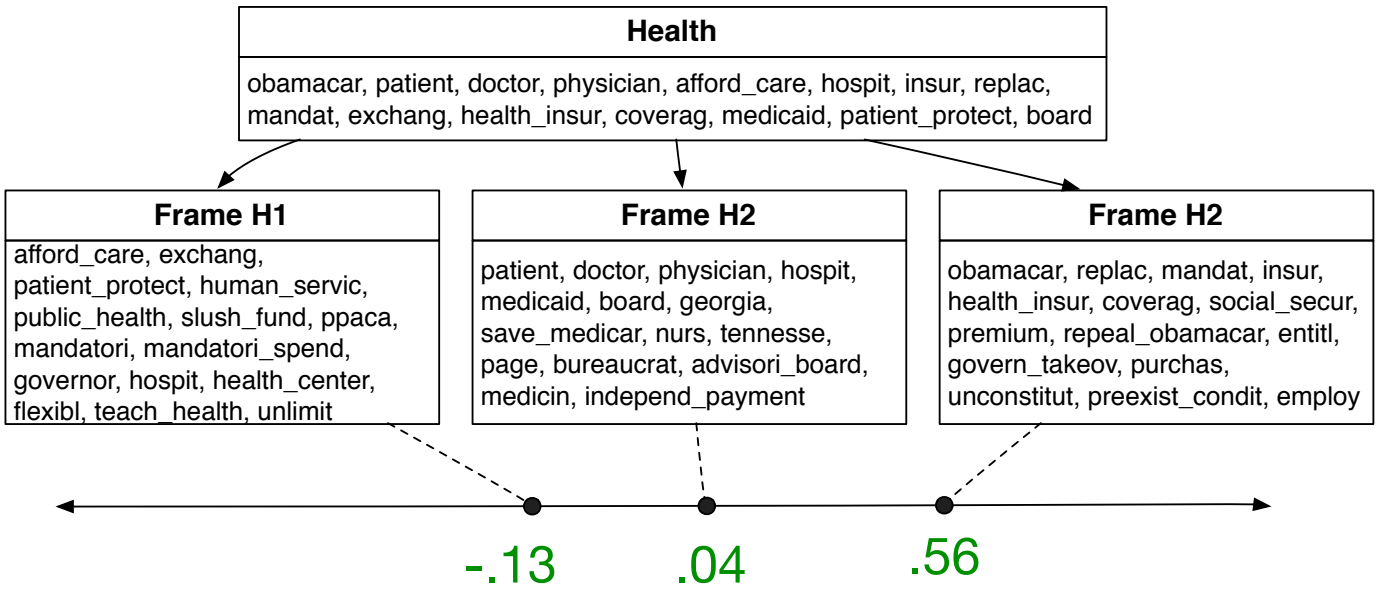
Multi-dimensional Ideal Points



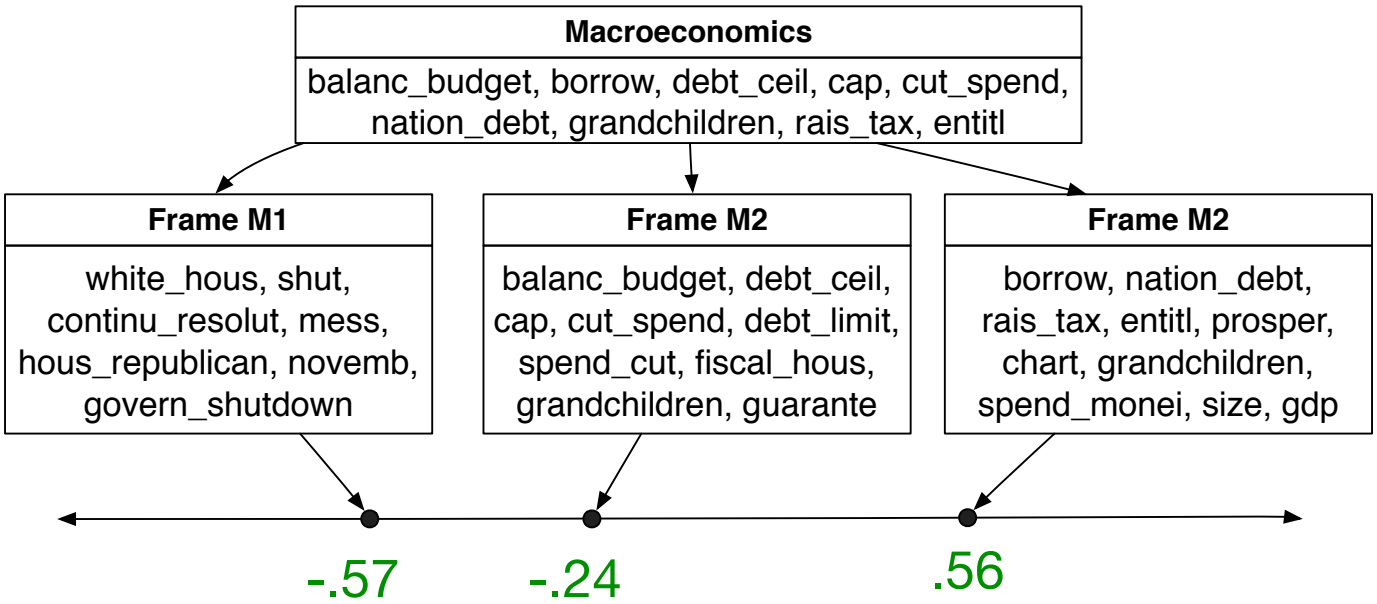
Freedom Works' key votes on most highly polarized dimensions are about government spending

Outline

Framing Healthcare

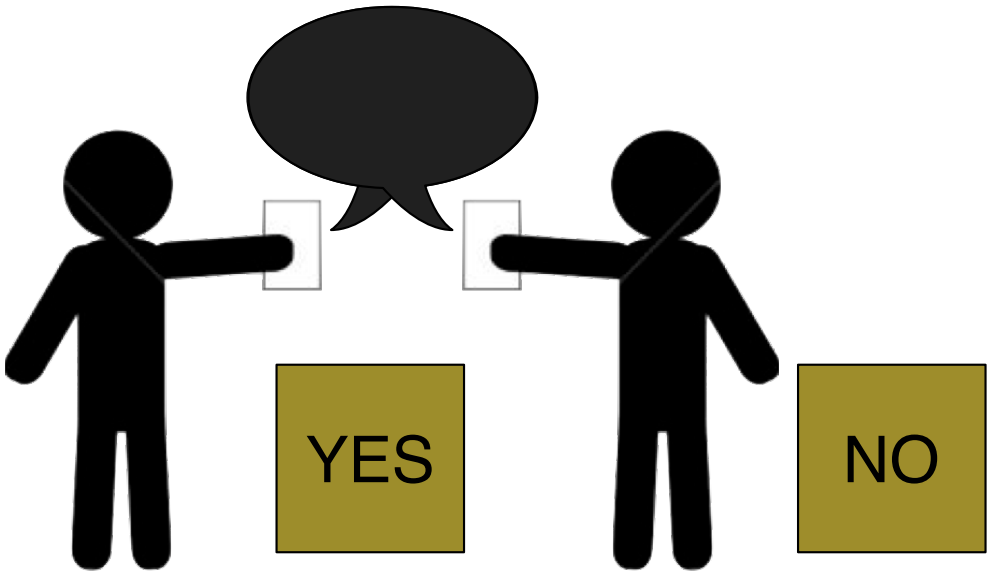


Framing Macroeconomics



Polarization

Ideal Point Distributions		Not	Polarized
Distribution of Issue Frames	Not	**Civil Rights, Minority Issues, Civil Liberties**	Banking and Finance; Transportation
	Polarized	Health; Public Lands and Water Management	Macroeconomics; Government Operations



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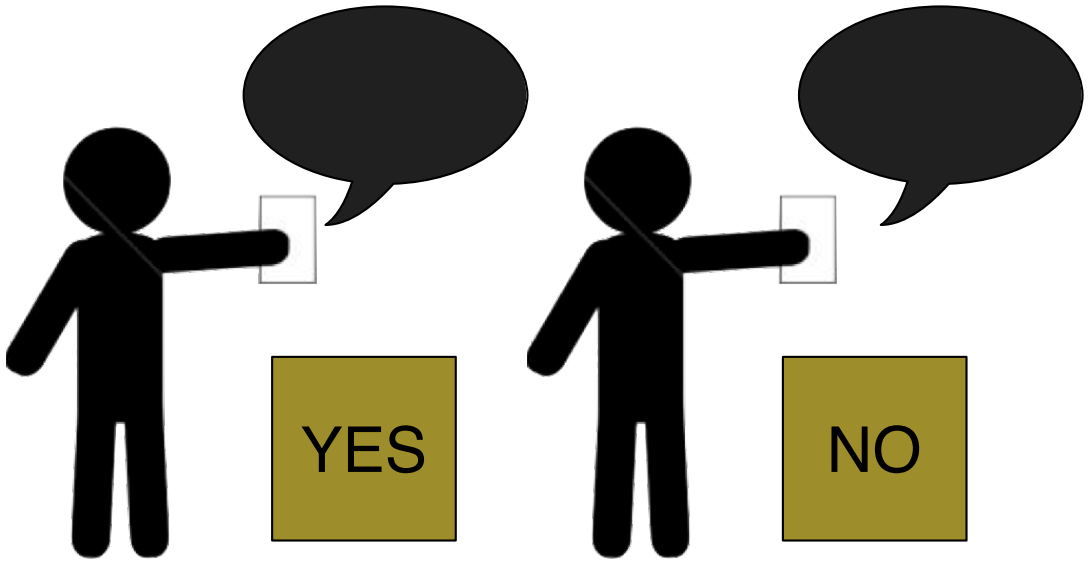
	Polarized	Health; Public Lands and Water Management	**Macroeconomics; Government Operations**



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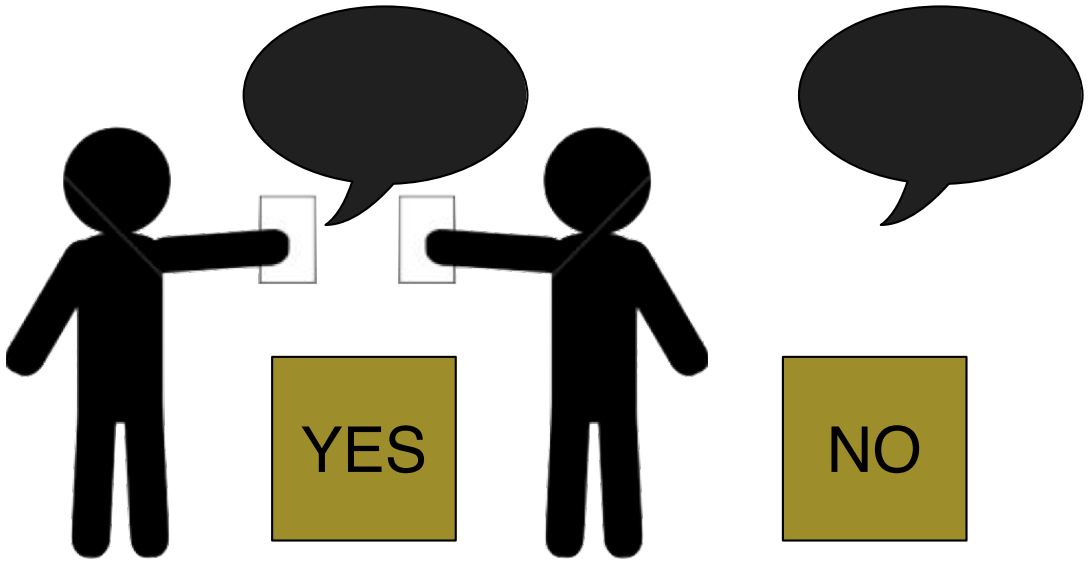

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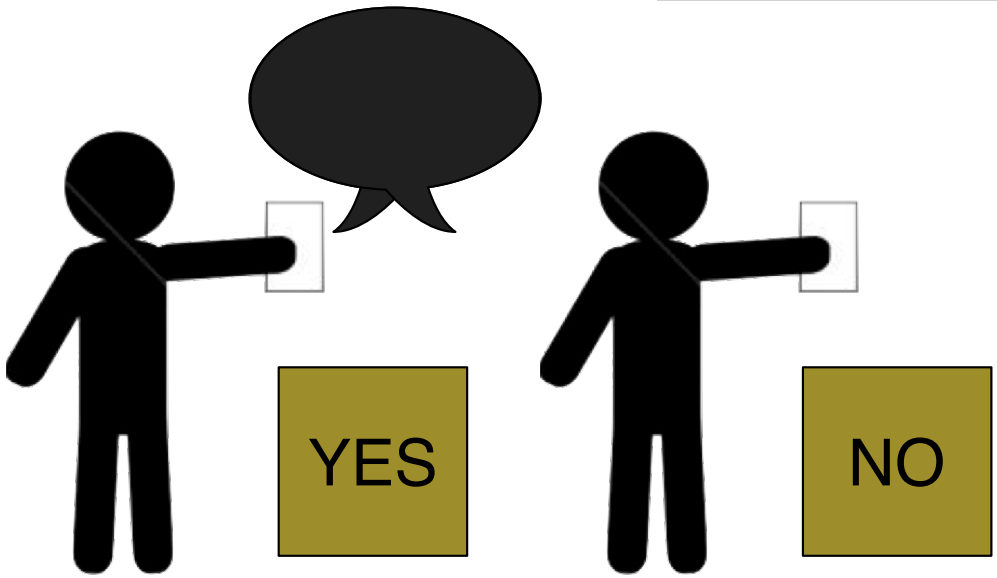

Hierarchies are Cool

- For a sweep of single parameter, BNP not that useful
- Complex structures are more realistic applications
- Combining with supervised objective
- Unsolved problem: good prediction with interpretable structure