



Department of Computer Science
UNIVERSITY OF COLORADO **BOULDER**



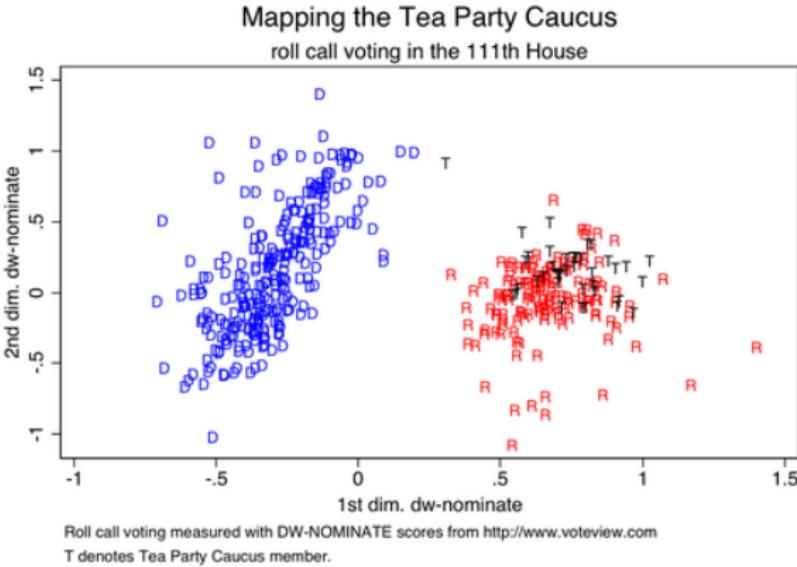
Supervised Topic Models

Advanced Machine Learning for NLP

Jordan Boyd-Graber

OVERVIEW

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

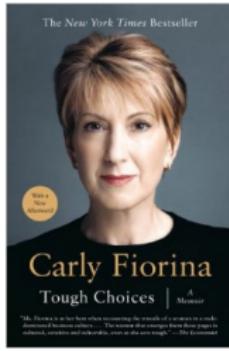
- American political movement for freedom, small government, lower tax
- Disrupting Republican Party and recent elections
- Organizations:
 - Institutional: Tea Party Caucus
 - Other: Tea Party Express, Tea Party Patriots, Freedom Works
- **“Conventional views of ideology as a single-dimensional, left–right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

(?, ARPS)

Goal

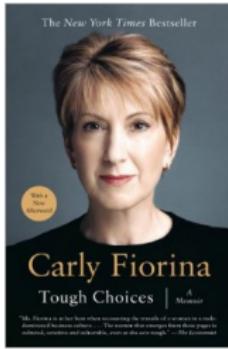
- Explain Tea Partiers in terms of issues and votes
- Identify Tea Partiers from their rhetoric

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

 Dr. Ben Carson @RealBenCarson · May 7

I'm pleased the Senate just passed the Corker-Menendez bill requiring Congressional review of the administration's proposed treaty with Iran

  333  662  ...

 Dr. Ben Carson @RealBenCarson · May 7

Met with some Pastors & community leaders from the inner city #OneBaltimore

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

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A single model that uses:

- Bill text
- Votes
- Commentary

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

Outline

① Ideal Point Review

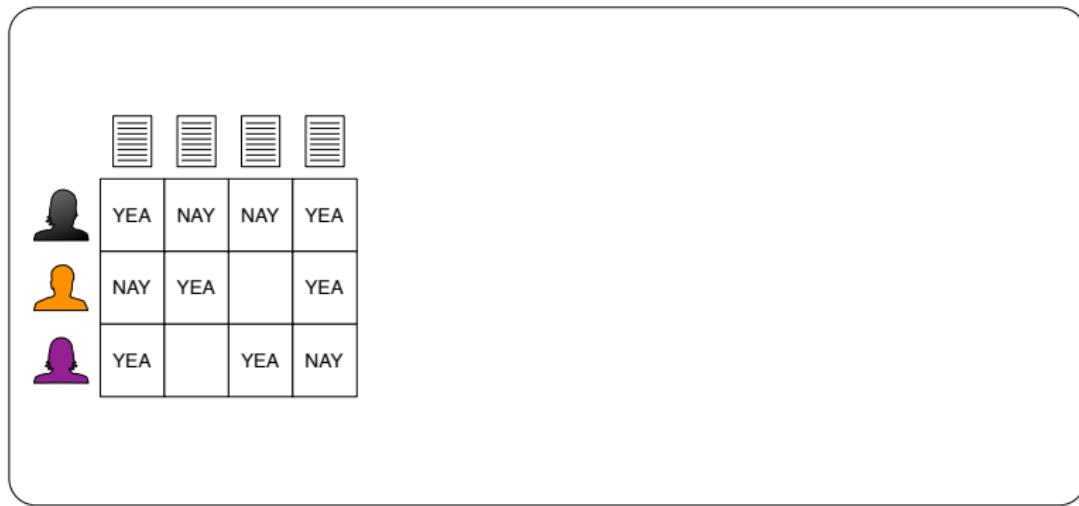
② Hierarchical Ideal Point Topic Model

③ Predicting Membership

④ How They Vote

⑤ How They Talk

One-dimensional Ideal Point using Votes



	YEA	NAY	NAY
	NAY	YEA	
	YEA		YEA

?

One-dimensional Ideal Point using Votes

Legislator a votes 'Yea' on bill b with probability



	YEA	NAY	NAY	YEA
	NAY	YEA		YEA
	YEA		YEA	NAY

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

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

?

One-dimensional Ideal Point using Votes

Legislator a votes 'Yea' on bill b with probability

	YEA	NAY	NAY	YEA
YEA		YEA		YEA
NAY				
PURPLE	YEA		YEA	NAY

One-dimensional ideal point
of legislator a

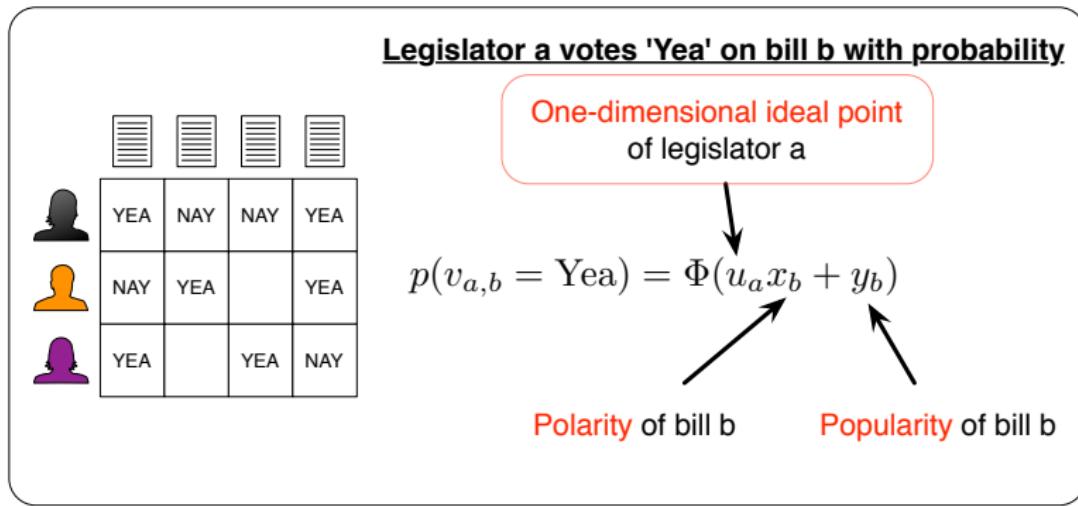
$p(v_{a,b} = \text{Yea}) = \Phi(u_a x_b + y_b)$

Polarity of bill b Popularity of bill b

The diagram illustrates the formula for the probability of a legislator voting 'Yea' on a specific bill. It features three icons representing different individuals above a 4x5 grid of YEA/NAY votes. To the right, a red arrow points down from the formula to the grid, indicating the legislator's ideal point. Two other red arrows point from the words 'Polarity of bill b' and 'Popularity of bill b' to the first and last columns of the grid respectively, representing the bill's characteristics.

?

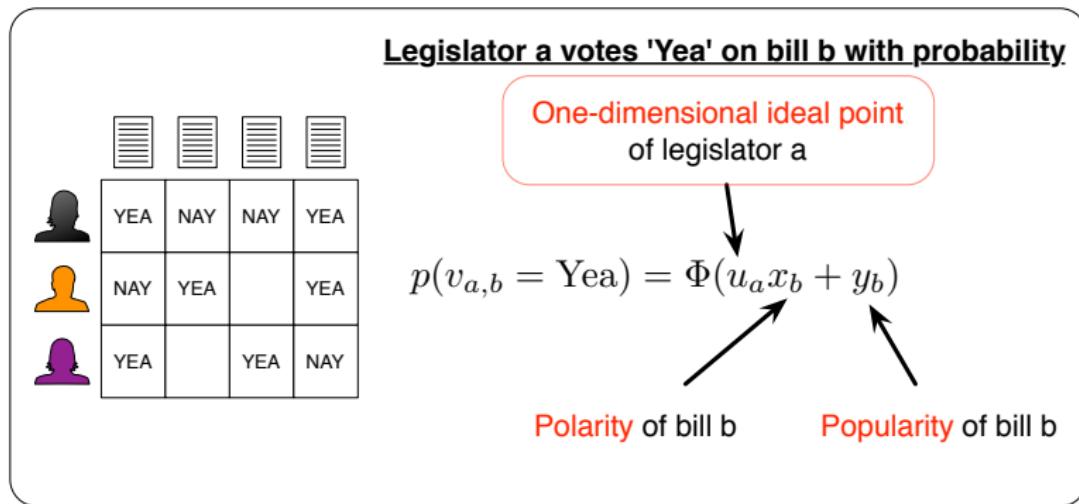
One-dimensional Ideal Point using Votes



?



One-dimensional Ideal Point using Votes



?



Multi-dimensional Ideal Point using Votes

Legislator a votes 'Yea' on bill b with probability

	YEA	NAY	NAY	YEA
	NAY	YEA		YEA
	YEA		YEA	NAY

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

???

Multi-dimensional Ideal Point using Votes

Legislator a votes 'Yea' on bill b with probability

	YEA	NAY	NAY	YEA
YEA		YEA		YEA
NAY				
YEA		YEA	YEA	NAY

Multi-dimensional ideal point
of legislator a

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

??? K dimensions

Multi-dimensional Ideal Point using Votes

Legislator a votes 'Yea' on bill b with probability

	YEA	NAY	NAY	YEA
	NAY	YEA		YEA
	YEA		YEA	NAY

Multi-dimensional ideal point
of legislator a

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

K dimensions

???



Multi-dimensional Ideal Point using Votes

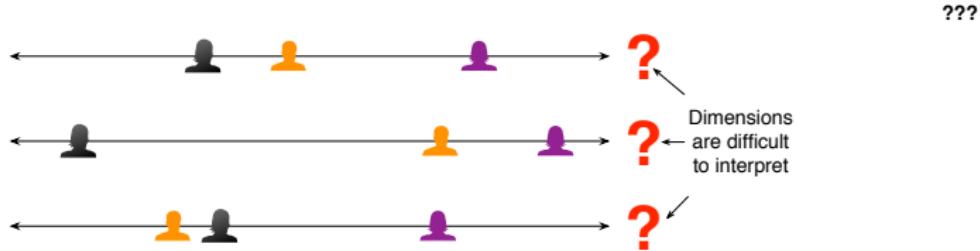
Legislator a votes 'Yea' on bill b with probability

	YEA	NAY	NAY	YEA
YEA		YEA		
NAY				YEA
	YEA		YEA	NAY

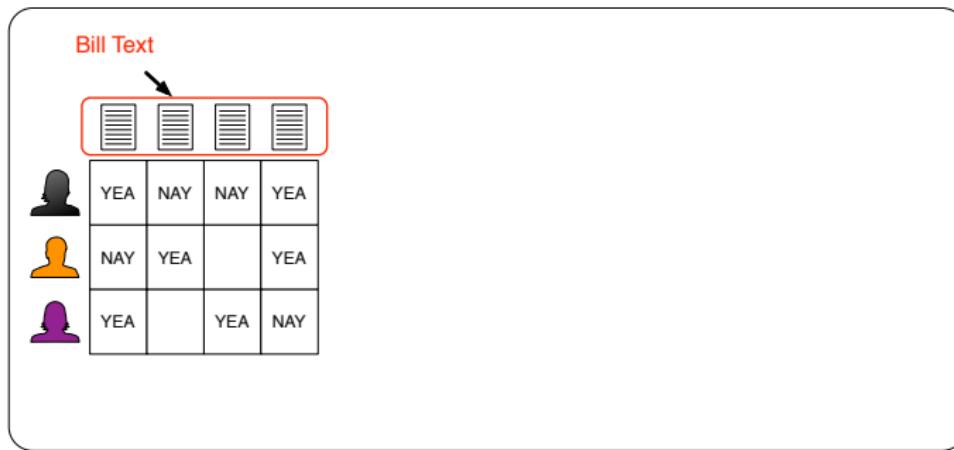
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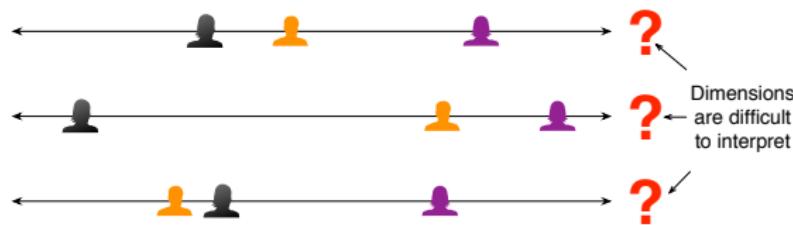
K dimensions



Multi-dimensional Ideal Point using Votes & Text



????



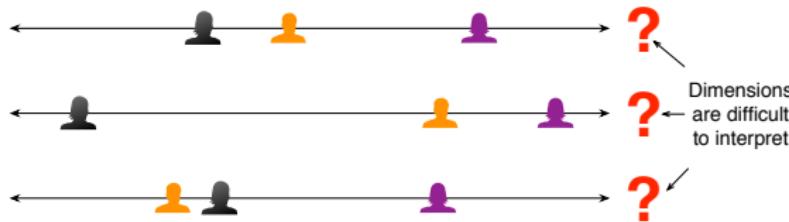
Multi-dimensional Ideal Point using Votes & Text

Legislator a votes 'Yea' on bill b with probability

	YEA	NAY	NAY	YEA
	NAY	YEA		YEA
	YEA		YEA	NAY

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

????



Multi-dimensional Ideal Point using Votes & Text

Legislator a votes 'Yea' on bill b with probability

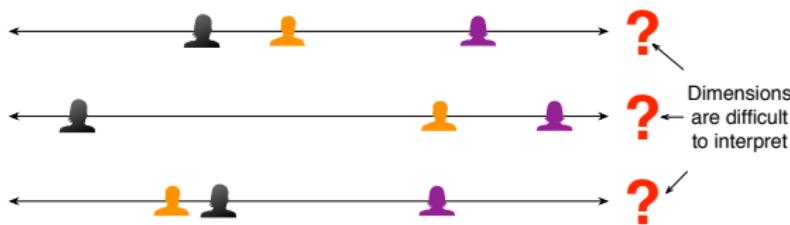
	YEA	NAY	NAY	YEA
YEA				
NAY	YEA			YEA
	YEA		YEA	NAY

Multi-dimensional ideal point
of legislator a

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

Topic proportion of bill b
estimated from its text

????



Multi-dimensional Ideal Point using Votes & Text

Legislator a votes 'Yea' on bill b with probability

	YEA	NAY	NAY	YEA
YEA				
NAY	YEA			YEA
	YEA		YEA	NAY

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Outline

- ① Ideal Point Review
- ② Hierarchical Ideal Point Topic Model
- ③ Predicting Membership
- ④ How They Vote
- ⑤ How They Talk

Hierarchical Ideal Point Topic Model: Intuition

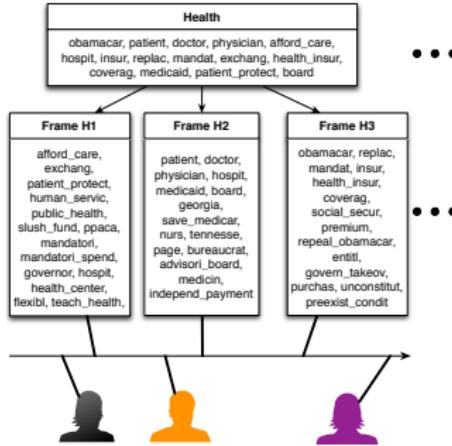
What are your thoughts on the issue of **immigration**?



Hierarchical Ideal Point Topic Model: Overview

Using both votes and text to learn

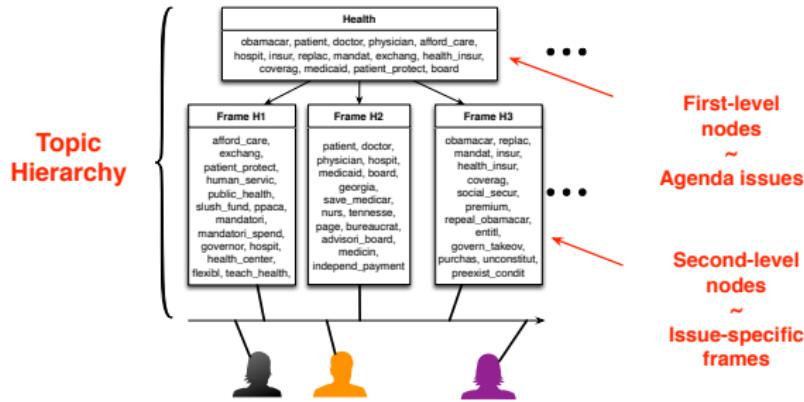
- Two-level topic hierarchy:
- Ideal points in multiple interpretable dimensions



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

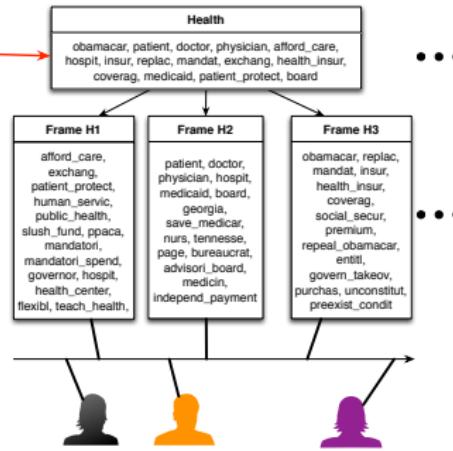


Hierarchical Ideal Point Topic Model: Overview

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

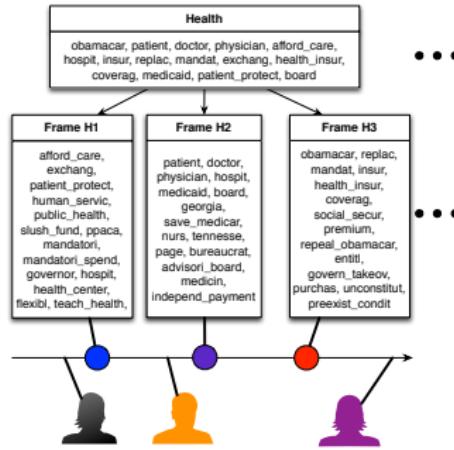
Use prior to learn
interpretable
issue topics



Hierarchical Ideal Point Topic Model: Overview

Using both votes and text to learn

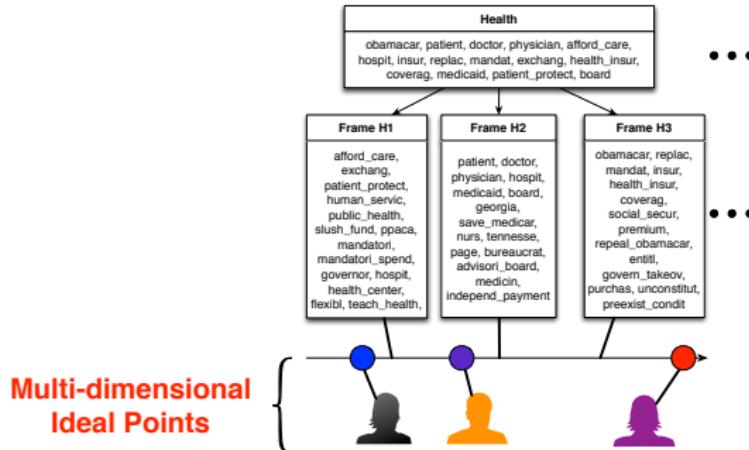
- Two-level topic hierarchy: Ideal points for frames for predictions using text only
- Ideal points in multiple interpretable dimensions



Hierarchical Ideal Point Topic Model: Overview

Using both votes and text to learn

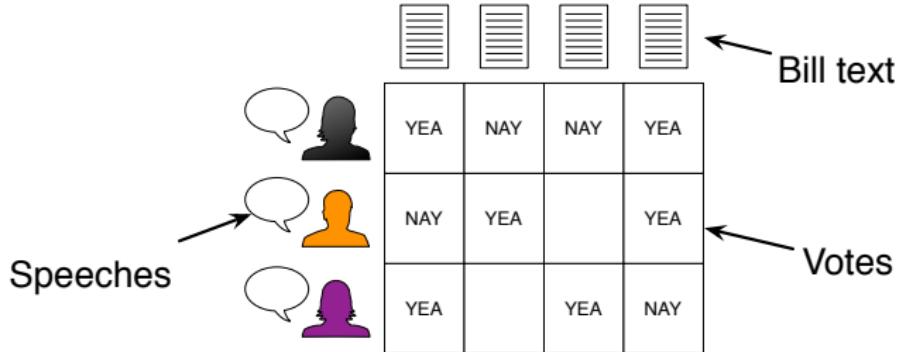
- Two-level topic hierarchy:
- Ideal points in multiple interpretable dimensions



Hierarchical Ideal Point Topic Model: Overview

Hierarchical Ideal Point Topic Model: Inputs

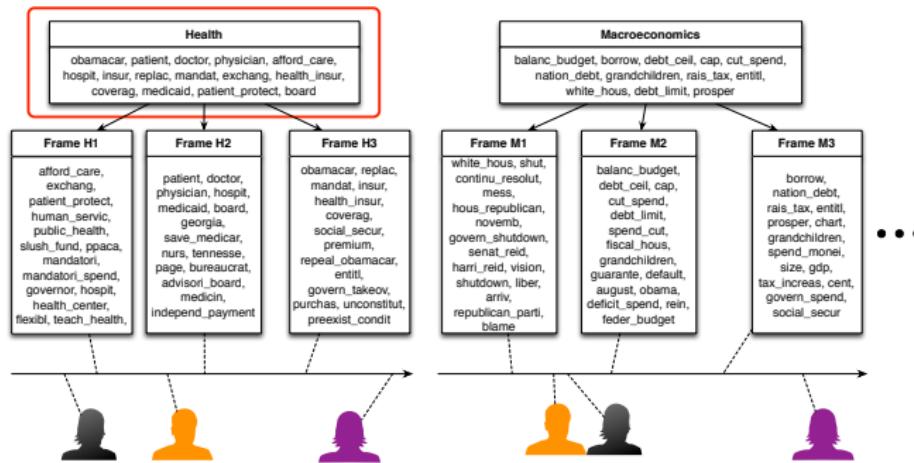
- A collection of votes $\{v_{a,b}\}$
- A collection of D speeches $\{\mathbf{w}_d\}$, each of which is given by legislator a_d
- A collection of B bill text $\{\mathbf{w}'_b\}$



Hierarchical Ideal Point Topic Model

Modeling bill text

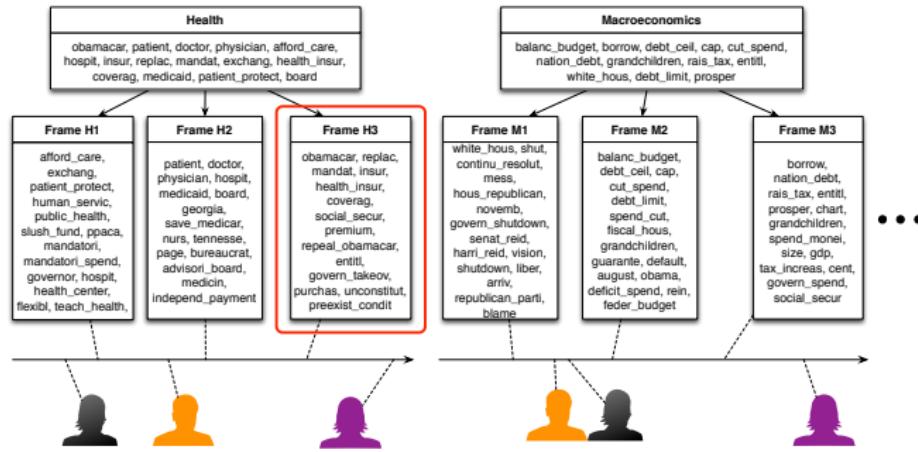
- Each bill text b is a mixture over K issues ϑ_b
- Each bill token generated from topic at **first-level issue node**



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**

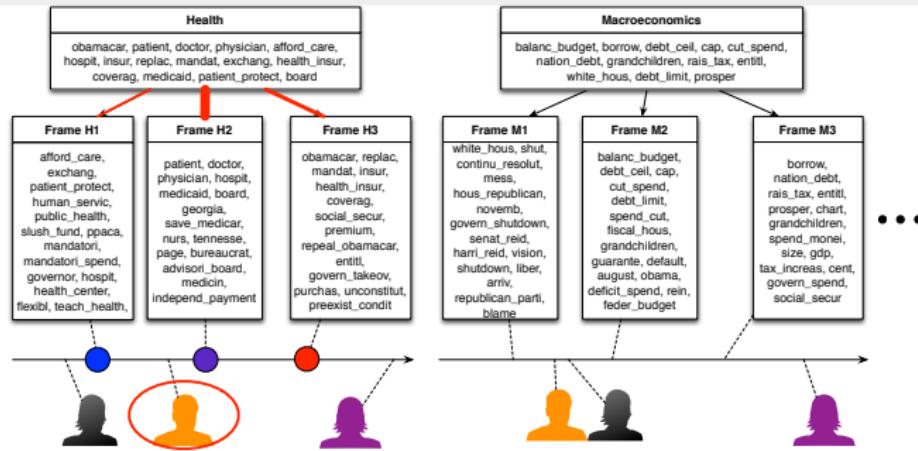


Hierarchical Ideal Point Topic Model

Hierarchical Ideal Point Topic Model: Modeling votes

- Legislator a votes ‘Yea’ on bill b with probability

$$p(v_{a,b} = \text{Yea}) = \Phi(x_b \sum_{k=1}^K \vartheta_{b,k} u_{a,k} + y_b)$$
- Ideal point $u_{a,k} \sim \mathcal{N}(\sum_{j=1}^{J_k} \eta_{k,j} \psi_{a,k,j}, \rho)$

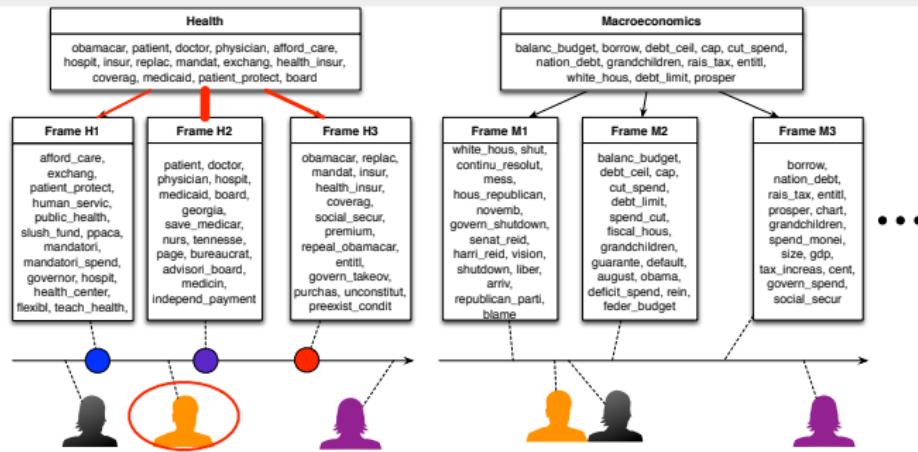


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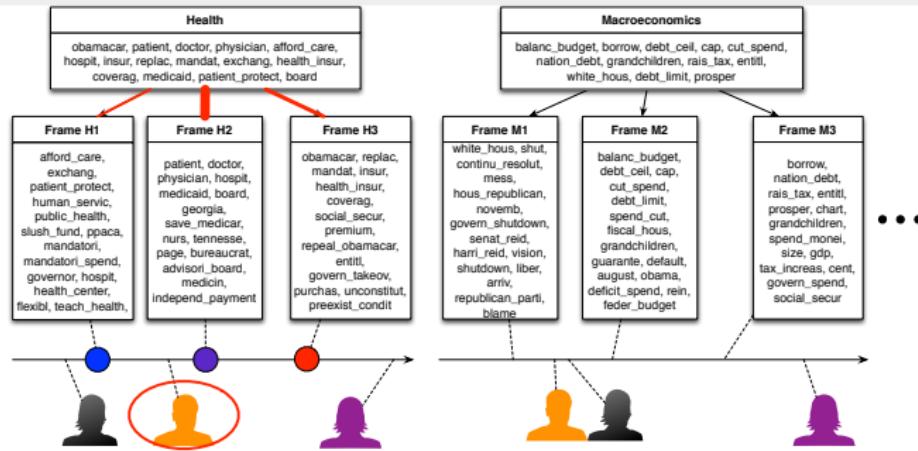


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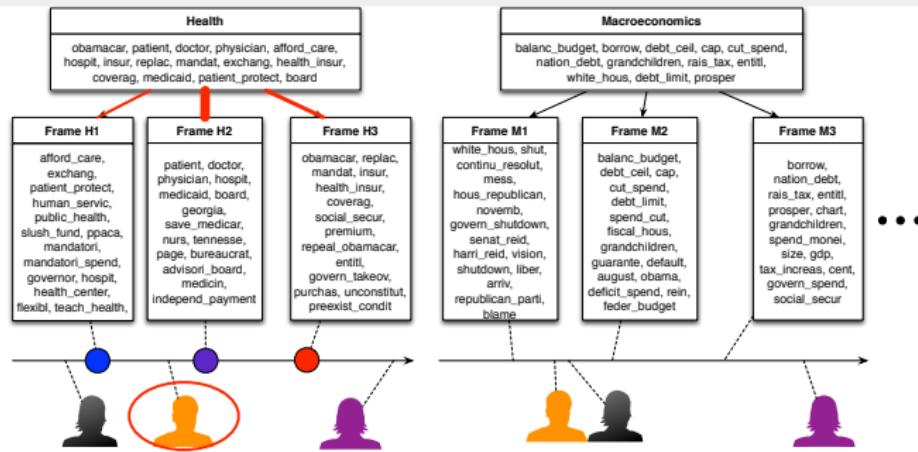


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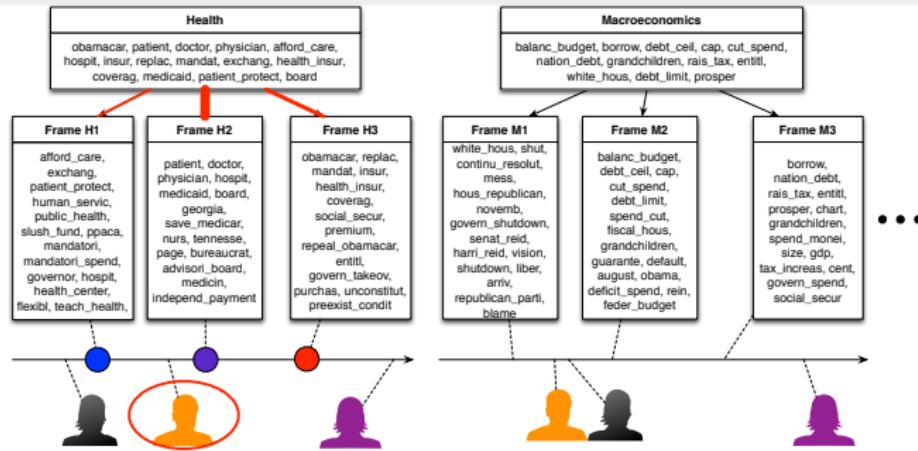


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Hierarchical Ideal Point Topic Model: Modeling votes

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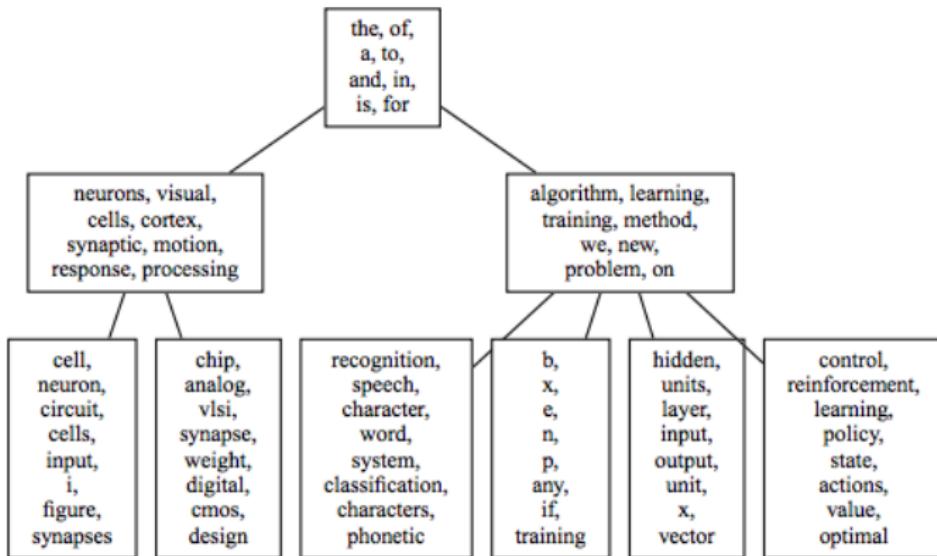
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- Ideal point $u_{a,k} \sim \mathcal{N}(\sum_{j=1}^{J_k} \eta_{k,j} \psi_{a,k,j}, \rho)$



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

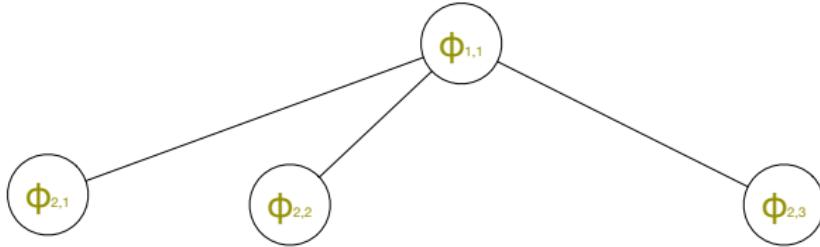


Generative Process



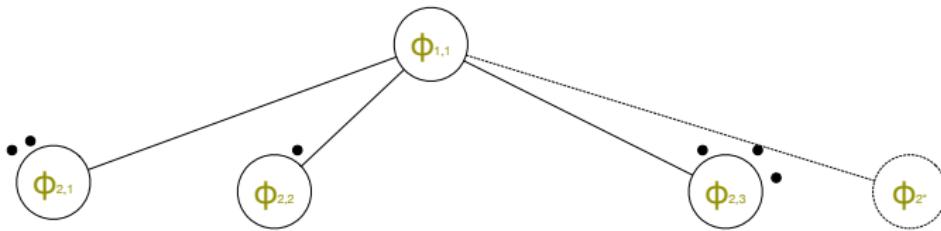
Start at the root node

Generative Process



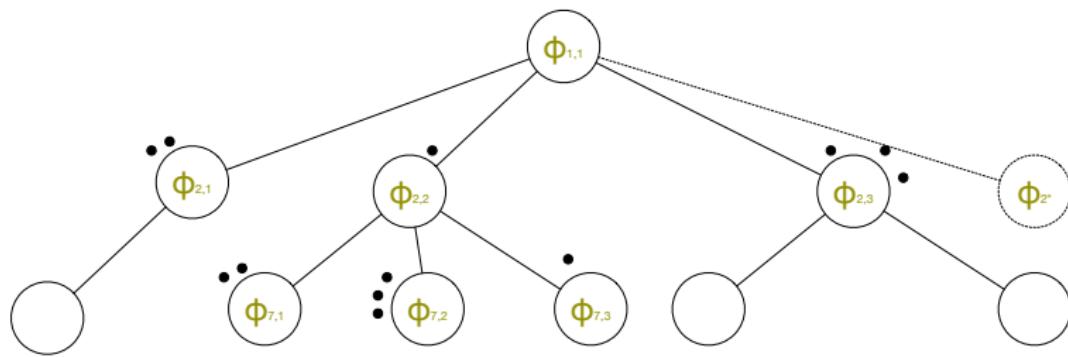
Need to choose which table to sit at

Generative Process



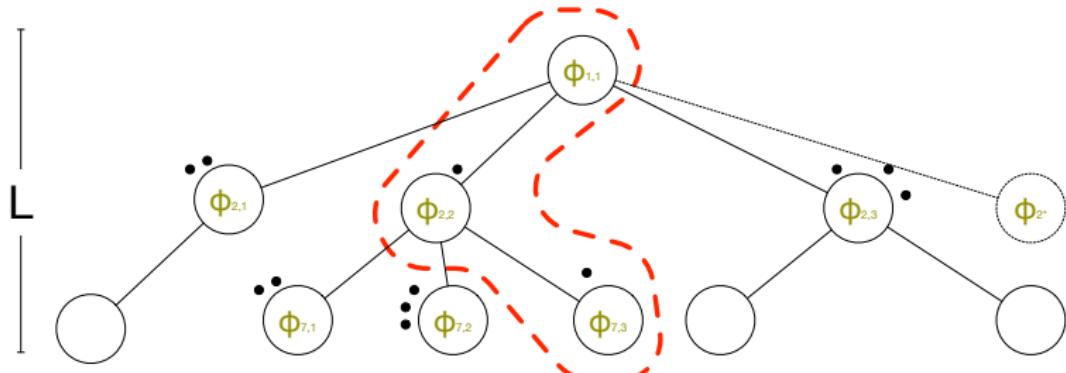
This is a CRP! (Can create new table too.)

Generative Process



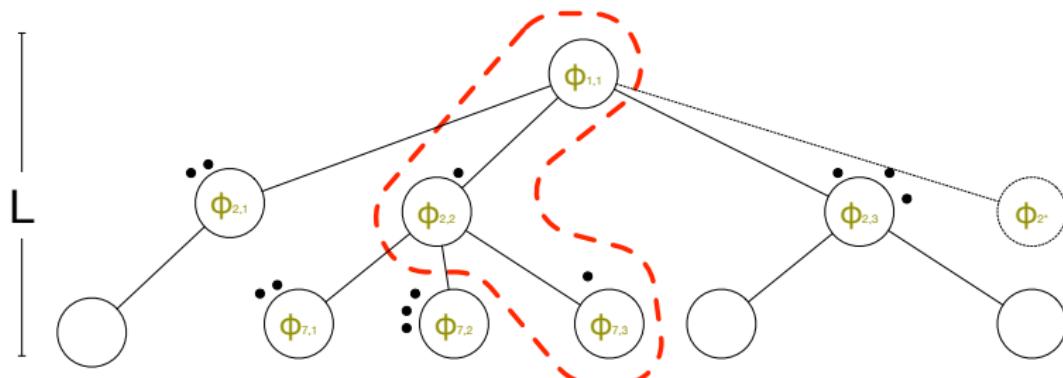
Repeat

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

Evaluation: Tea Party in the House

The Tea Party

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

Data

- 240 Republican Representatives in the 112th 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

- 1 Ideal Point Review
- 2 Hierarchical Ideal Point Topic Model
- 3 Predicting Membership
- 4 How They Vote
- 5 How They Talk

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

Tea Party Caucus Membership Prediction

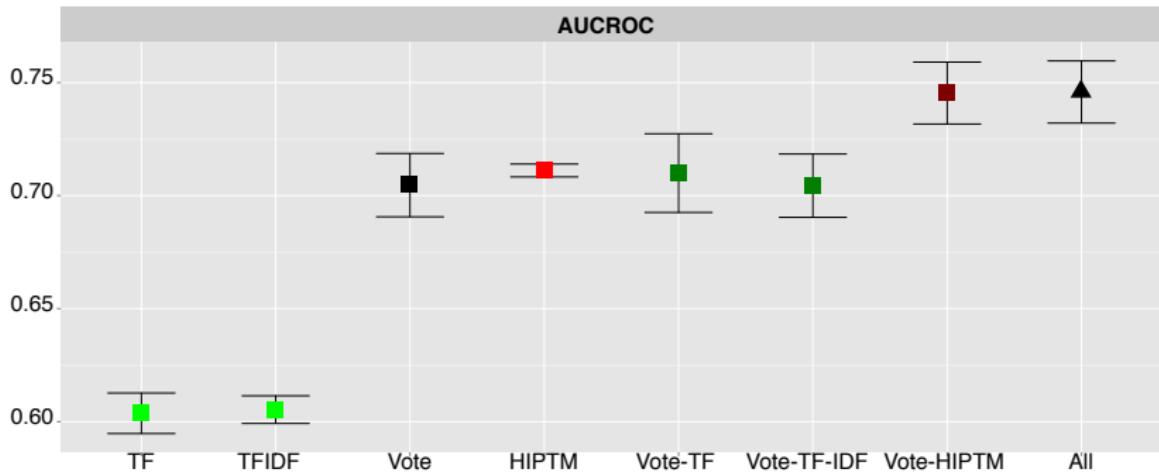
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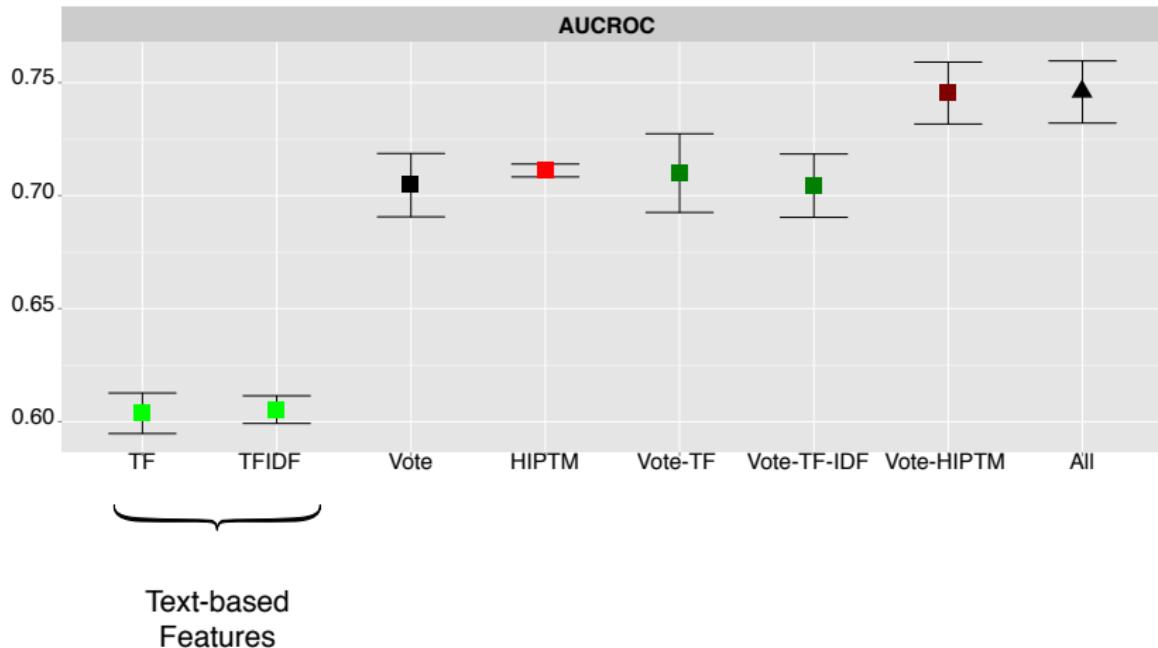
Features

- 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 $\Phi(x_b \sum_{k=1}^K \vartheta_{b,k} u_{a,k} + y_b)$

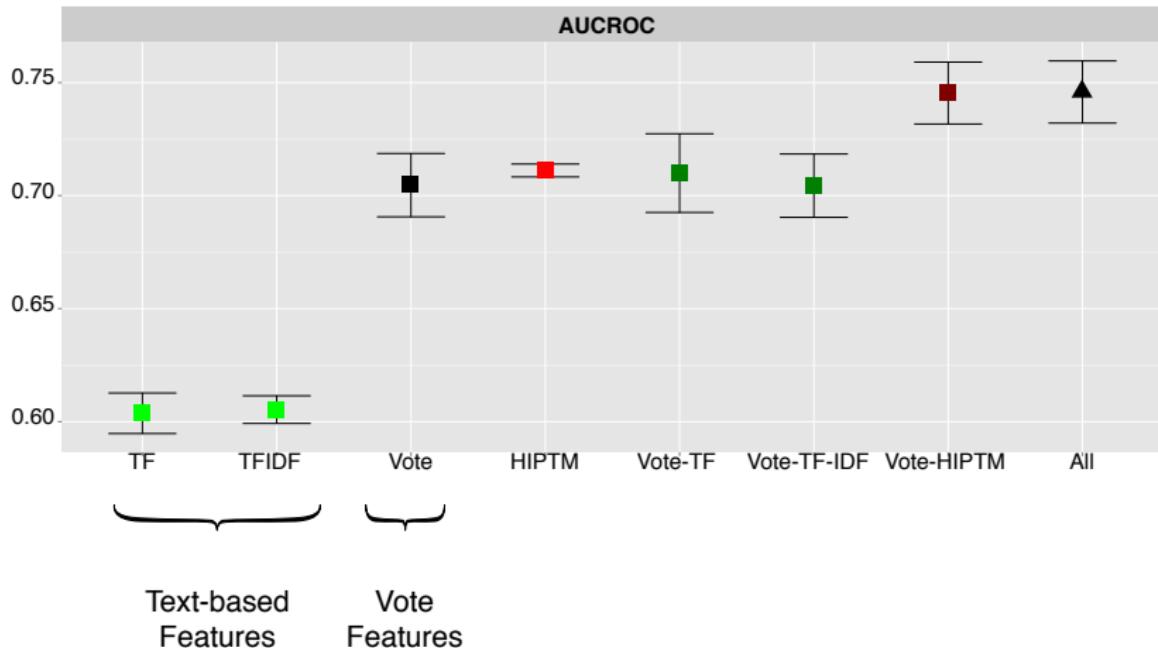
Tea Party Caucus Membership Prediction: Votes & Text



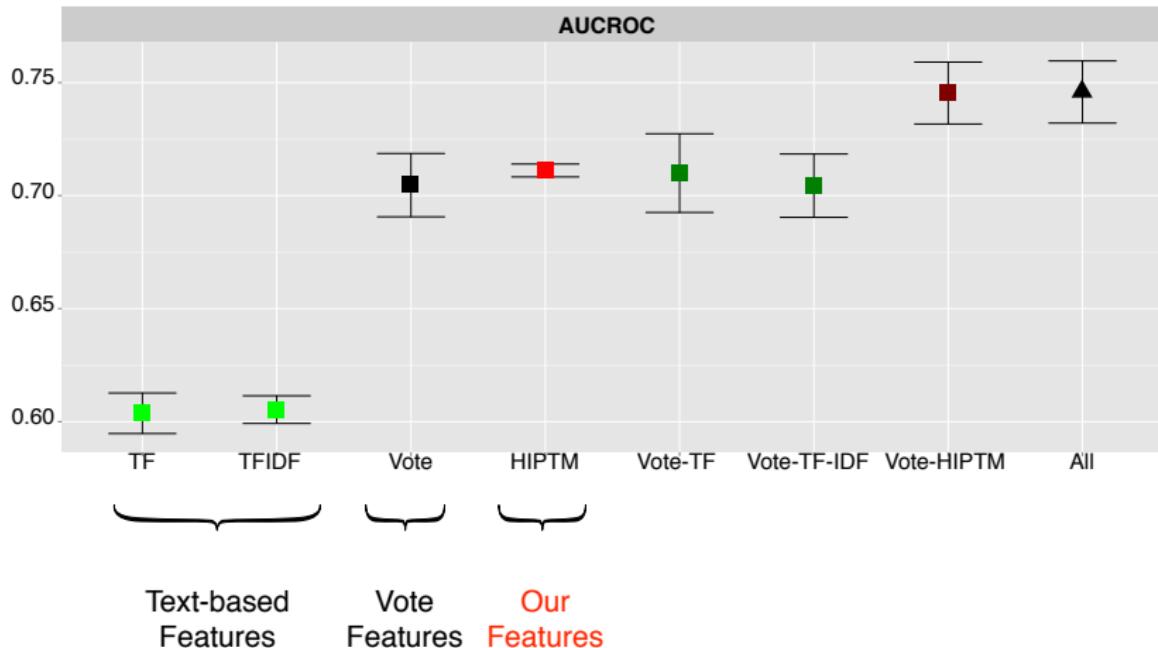
Tea Party Caucus Membership Prediction: Votes & Text



Tea Party Caucus Membership Prediction: Votes & Text



Tea Party Caucus Membership Prediction: Votes & Text

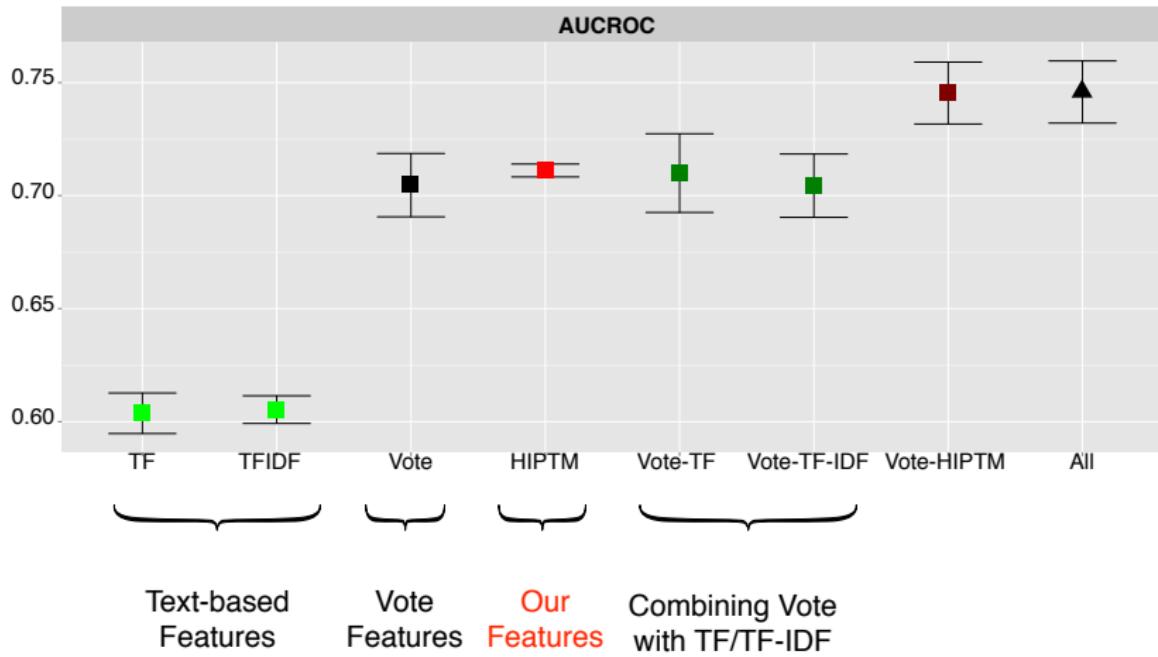


Text-based
Features

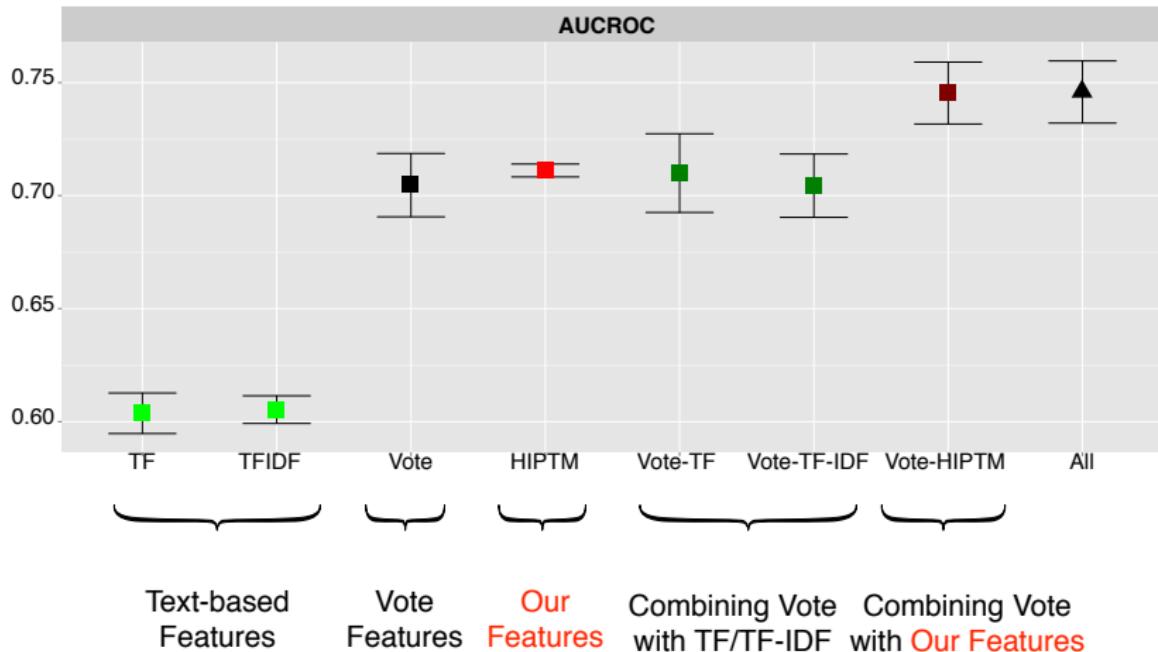
Vote
Features

Our
Features

Tea Party Caucus Membership Prediction: Votes & Text



Tea Party Caucus Membership Prediction: Votes & Text

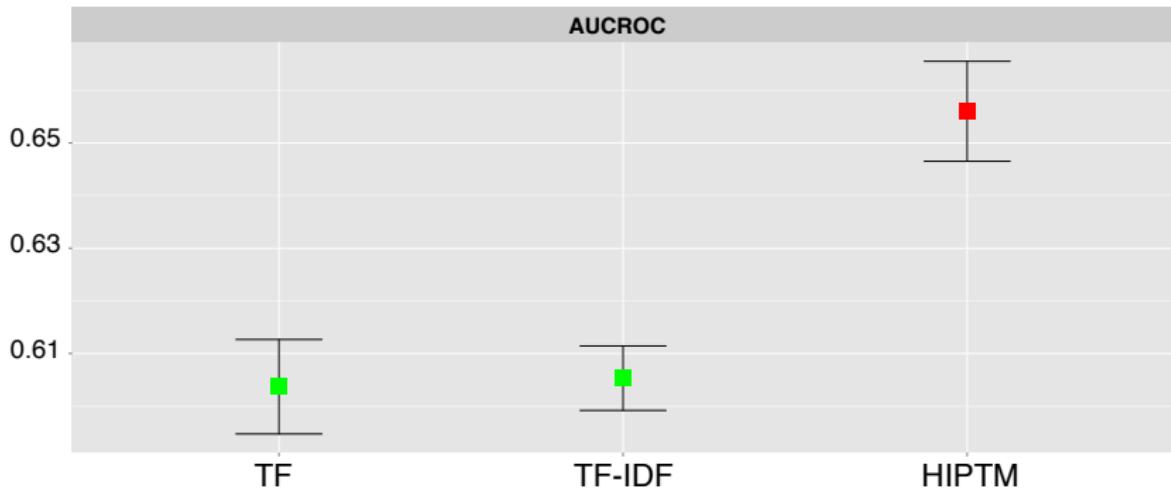
Text-based
FeaturesVote
FeaturesOur
Features

Combining Vote

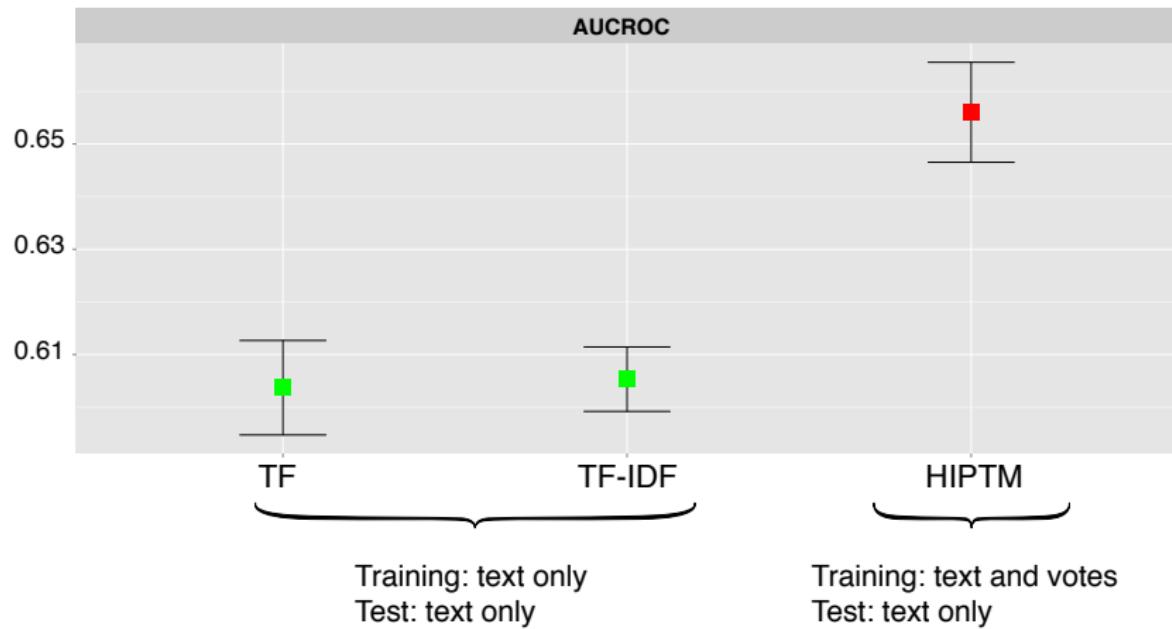
with TF/TF-IDF

Combining Vote
with Our Features

Tea Party Caucus Membership Prediction: Text Only



Tea Party Caucus Membership Prediction: Text Only



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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

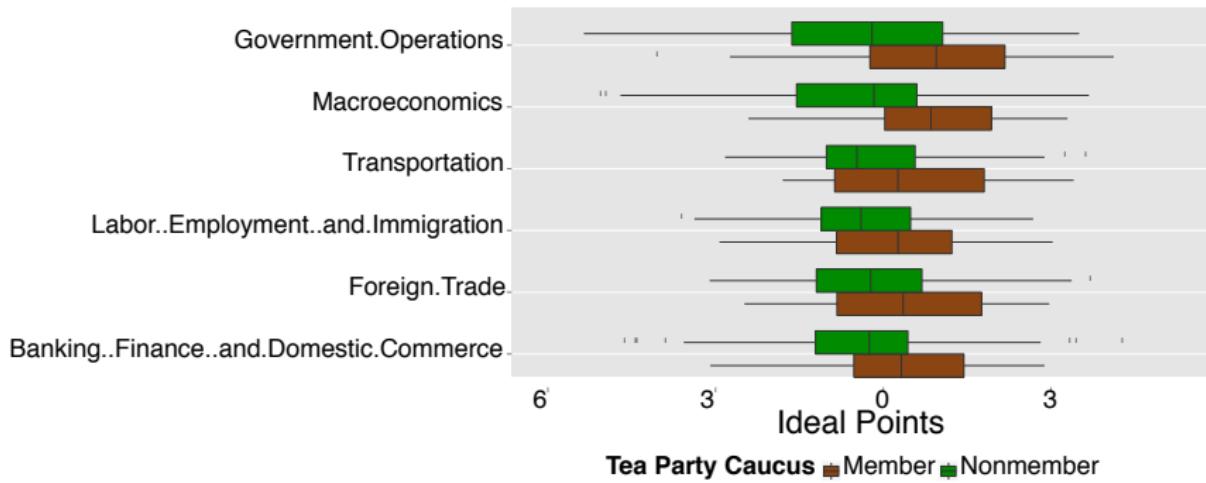
NEW REPUBLIC

"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."



Tea Party Caucus ■ Member ▲ Nonmember

Multi-dimensional Ideal Points

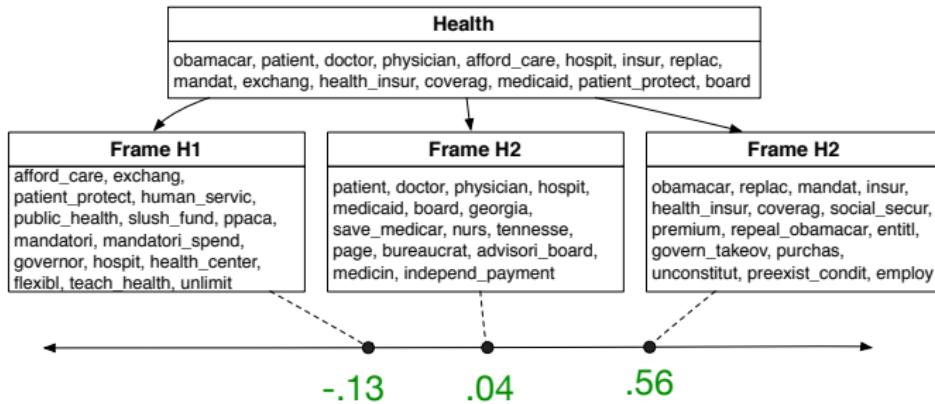


Freedom Works' key votes on most highly polarized dimensions are about government spending

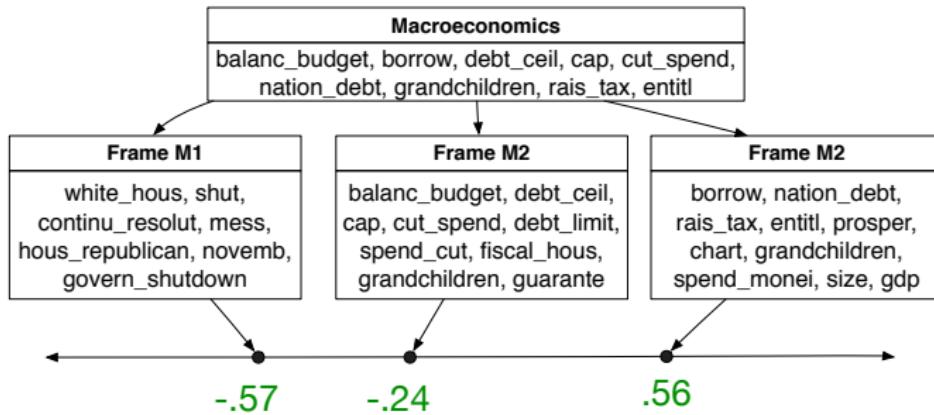
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- ⑤ How They Talk

Framing Healthcare

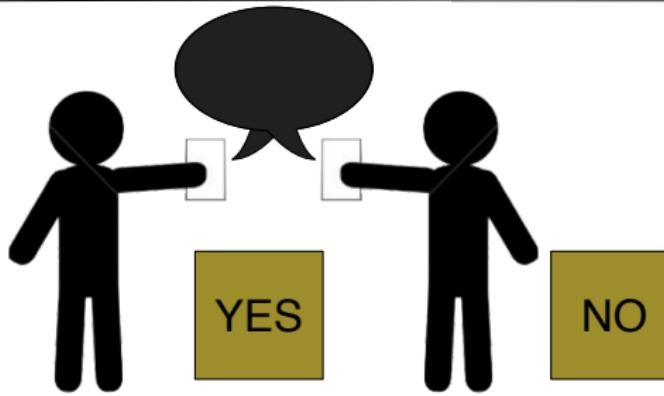


Framing Macroeconomics



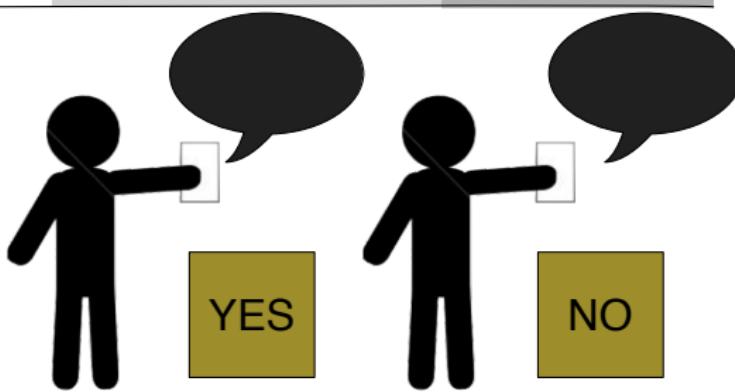
Polarization

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



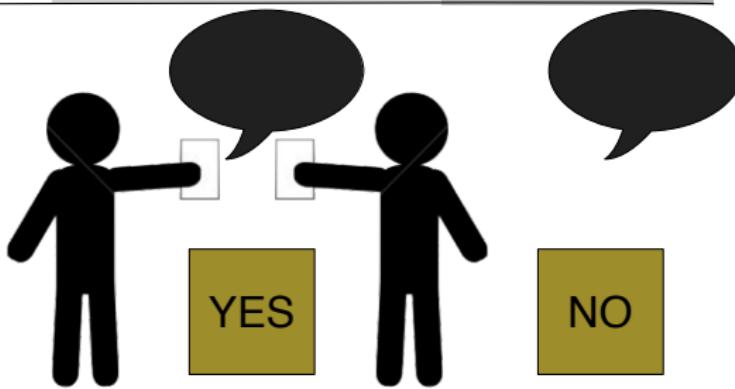
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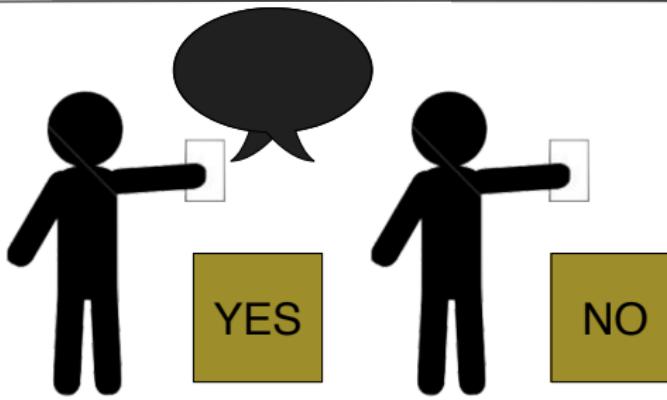
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Ideal Point Distributions		Not	Polarized
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Hierarchies are Cool

- 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