#### Uncovering Latent Arguments in Social Media Messaging by Employing LLMs-in-the-Loop Strategy

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**PURDUE** UNIVERSITY.

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# **Public Opinion**

- Responsive governance
- Policy alignment with public interests
- Societal harmony
- Continuous policy refinement (Glynn & Huge, 2008; Price, 1988)



#### **Distributed** Landscape of Social Media



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Users generate and consume a variety of content.

# **Analyzing** Public Opinion

• Automatically analyzing public opinion on social media platforms.



# **Analyzing** Public Opinion

- Automatically analyzing public opinion on social media platforms.
- Argument Mining.
  - automatically extracts the reasons, claims, and talking points/arguments.
  - shedding light on how and why specific opinions are formed.

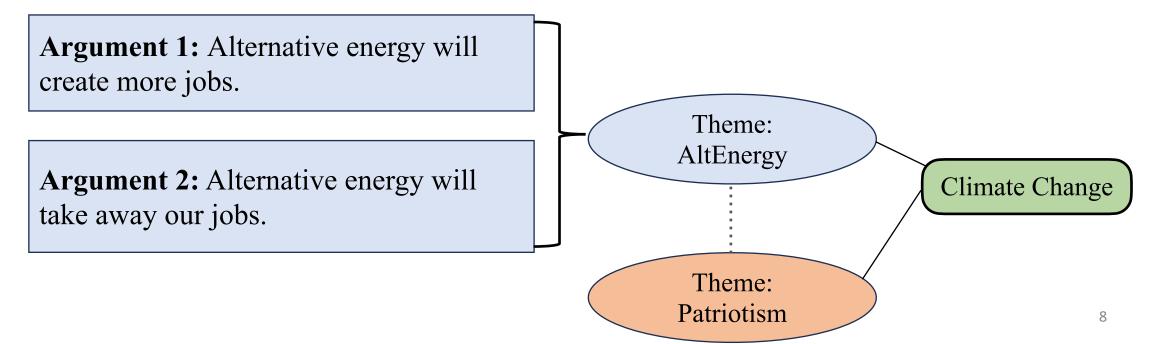


# **Argument Mining - Previous Works**

- Topic Modeling.
  - Shallow Themes.
- Manual and qualitative coding (Hagen et al., 2022; Nguyen et al., 2021; Del Valle et al., 2020).

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- Manual and qualitative coding (Hagen et al., 2022; Nguyen et al., 2021; Del Valle et al., 2020).
- Theme Discovery (Islam & Goldwasser, 2025; Pacheco et al., 2023; Islam et al., 2023b; Islam & Goldwasser, 2022; Pacheco et al., 2022a).
  - Can not to recognize conflicting arguments under same theme, i.e.,



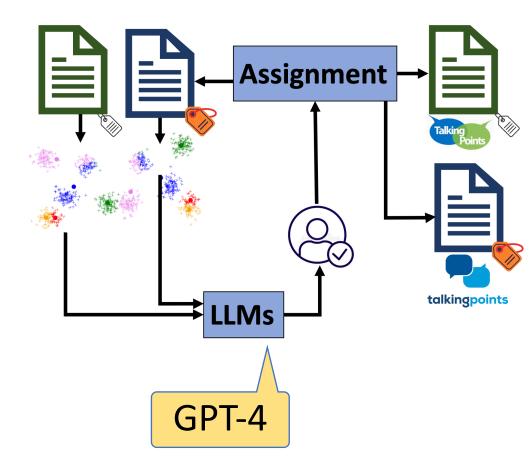
# **Argument Mining - Previous Works**

- Human-in-loop (Pacheco et al. 2022b;a).
  - Costly scalability.
  - Time consuming.

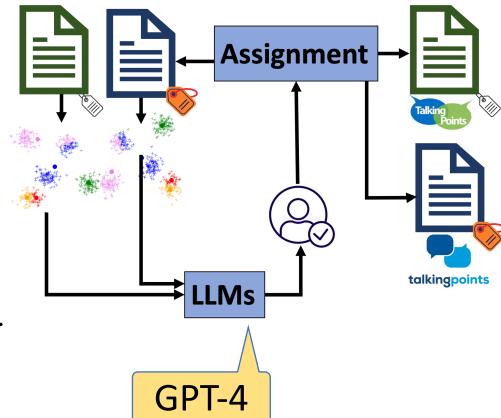
# Machine-in-loop Approach

- Human-in-loop (Pacheco et al. 2022b;a).
  - Costly scalability.
  - Time consuming.
- Machine-in-the-Loop: LLMs-in-the-Loop.
  - LLMs possess extensive domain insights.
  - **Reasoning** capabilities.
  - Accelerate the process of refinement.

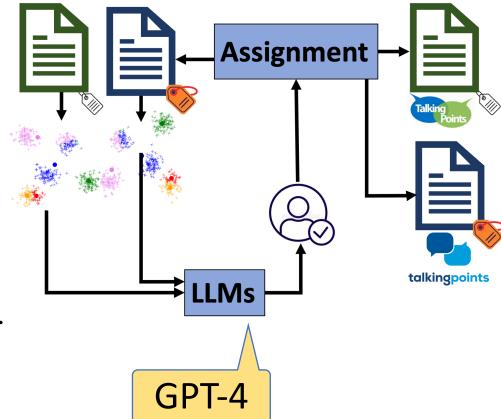
- Themes are pre-defined.
- Theme-specific clustering.
- Summarizing sub-clusters.
  - Zero-shot multi-document summarization using GPT-4 on top-k instances.
- Generating and refining arguments.
  - Implement a redundancy check to identify and merge similar arguments.



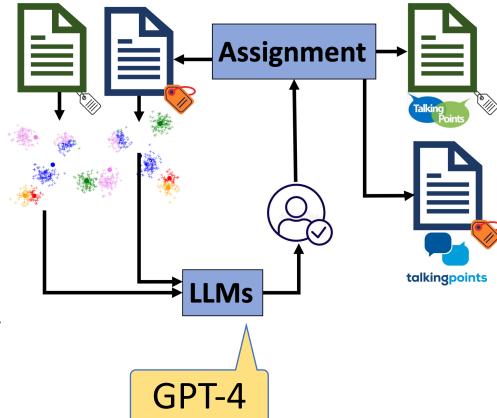
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- Human evaluation.
  - Quality and relevance of the generated arguments.



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- Mapping instances to arguments.
  - Distance-based approach for mapping.



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- **Repeat**: Unassigned ads from iteration1.



#### **Case Studies**

- Climate campaigns.
  - 14k ads (Islam et al. 2023, Islam and Goldwasser 2025), January 2021 to January 2022.
  - Stance (e.g., pro-energy, clean-energy) and theme (e.g., support climate policy).

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  - Stance (e.g., pro-energy, clean-energy) and theme (e.g., support climate policy).
- COVID-19 vaccine campaigns.
  - 9k ads (Islam and Goldwasser 2022), December 2020 to January 2022.
  - Moral foundation (e.g., care/harm) (Haidt and Graham, 2007) and theme (e.g., vaccine equity).

## **Evaluation**

- Sort the ads according to their semantic distance to their assigned arguments.
- Compute the **three** quartiles and sample a set of **12 ads** per theme, such that **3 ads** are randomly sampled from each quartile.
- **300** ads in the 1st iteration and another **300** ads from the 2nd iteration from **climate** case study.
- 168 ads in the 1st iteration and another 168 ads from the 2nd iteration from COVID-19 case study.
- Manually annotate **936 ads** whether the mapping is correct or not.

#### Results

- Better performance in the lower distance between ad and argument.
- Improvement in performance both in coverage and mapping quality after subsequent iterations.

Case Study	Iter.	# Args	Coverage	$\leq Q_1$	$\leq Q_2$	$\leq Q_3$	All
Climate	1	113	37.38%	76.00%	70.67%	58.67%	57.33%
	2	213	44.40%	88.00%	74.67%	70.67%	64.00%
COVID-19	1	47	36.18%	78.57%	61.90%	61.90%	52.38%
	2	78	40.47%	82.93%	73.81%	64.29%	57.14%

Table: Coverage and mapping quality w.r.t. Human Judgments.

# **Ablation Study**

- Comparable results in terms of coverage:
  - Arguments from the top k instances of a cluster without summarizing vs. with summarizing.

Case	Tear	Number of covered ads					
Study	Iter.	thr < 0.6	thr < 0.5	thr < 0.4	thr < 0.3		
	1	13319	10677	5355	1132		
Climate	1-w/o sum.	13394	10613	5189	1164		
Climate	2	13669	11541	6360	1458		
	2-w/o sum.	13759	11592	6143	1384		
	1	7962	6525	3589	850		
	1-w/o sum.	8133	6507	3477	787		
COVID-19	2	8197	6833	4015	1089		
	2-w/o sum.	8426	6767	3710	908		

Table: Ablation study (coverage). sum: summary, thr: threshold.

## **Downstream Task: Stance Prediction**

# Stance prediction task **improves** when **talking points** are **added** with **text**.

MODEL	Acc	F1
$Longformer_{text}$	90.13%	89.89%
$Longformer_{tp}$	83.43%	83.44%
$\mathbf{Longformer}_{\mathbf{text}+\mathbf{tp}}$	93.30%	<b>93.29%</b>
$RoBERTa_{text}$	93.07%	92.96%
$RoBERTa_{tp}$	82.73%	82.81%
$\mathbf{RoBERTa}_{\mathbf{text}+\mathbf{tp}}$	93.65%	93.56%
$llama3_{text}$	92.00%	90.95%
$llama3_{tp}$	81.00%	78.68%
$\mathbf{llama3_{text+tp}}$	92.50%	91.49%

Table: Contribution of talking point (tp) in stance classifier for climate campaigns dataset.

# **Argumentative Cohesion Comparison**

- **COVID-19** vaccine campaigns.
  - Pearson correlation between arguments and moral foundations.
  - Random 15 arguments.
- Climate campaigns.
  - Pearson correlation between arguments and stances.
  - Random 25 arguments.

## **Argumentative Cohesion Comparison: COVID-19**

9 								
2     - 0.1       2     - 0.038     - 0.011     - 0.0096     - 0.042     - 0.0076     0.036	Resistance against federal vaccine mandates, emphasizing personal choice and legal action to uphold individual rights0.036	-0.032	-0.14	-0.0091	-0.034	0.26	0.029	- 0.4
8 - 0.0 2 2 3 - 0.071 0.045 -0.057 -0.012 -0.0025 -0.07 0.083	President Biden's commitment to international accords, public health, economic recovery, and progressive policy achievements to build government trust0.022	-0.02	-0.13		-0.021	-0.032	0.29	- 0.3
S S S S S S S S S S S S S S S S S S S	Donating funds that will be matched to multiply impact, promoting fair global access to vaccines0.027	0.056	-0.086	-0.0067	0.2	0.014	-0.037	- 0.5
©0.025 0.06 -0.0088 0.11 -0.019 0.014 -0.0310.2	Investigating and improving the distribution and administration process to ensure equitable vaccine access in Illinois0.01	-0.0089	-0.058	-0.0025	0.19	-0.014 -	-0.014	- 0.2
0.048 -0.015 -0.055 -0.02 0.0079 0.092 -0.0340.3	COVID-19 vaccine mandates, including recent Supreme Court rulings and public opinion on federal mandates0.032	-0.028	-0.1	-0.008	-0.029	0.26	-0.044	
S0.077 0.026 0.16 0.036 -0.0042 -0.069 -0.14	Against price control legislation, emphasizing its potential to hinder vaccine development and equitable access to life-saving COVID-19 vaccinations0.033	0.034	-0.17	-0.0084	0.03	0.036	0.21	- 0.1
etrayal - e/harm - none - restion - version -	Against COVID vaccine mandates and passports, urging support for personal choice and constitutional rights regarding vaccination0.051	-0.0026	-0.17	-0.013	-0.047	0.38	-0.042	
oyalty/br can intes/cf inty/oppi ity/sub	Awareness and updates on issues related to COVID-19 vaccine mandates and refusals in various states0.033	0.012	-0.08	-0.016		0.16	-0.019	- 0.0
	Global vaccine equity, emphasizing free and universal access to COVID-19 vaccines to end the pandemic for all0.04	-0.036	-0.1	-0.01	0.47	-0.058	-0.056	
<b>Baseline:</b> 10 LDA Topics	Vaccination as an act of love and protection towards neighbors, aligning it with Christian values 0.091	-0.015	-0.049	0.41	-0.016	-0.025	-0.024	0.1
0.4	Overcoming barriers to ensure equitable COVID-19 vaccine access for underserved communities and prioritizing vulnerable populations0.017	-0.015	-0.049	-0.0044	0.22	-0.025	-0.024	
topic-18     -0.049     -0.043     0.014     -0.045     -0.012     -0.066     -0.014       topic-19     -0.052     0.031     -0.033     -0.014     -0.051     0.025     0.0046       topic-14     -0.045     -0.034     -0.053     -0.046     -0.33	Against Biden's vaccine mandate, portraying it as government tyranny and urging resistance and financial support0.017	-0.015	-0.1		-0.016	0.055	0.14	0.2
bpic-13 - 0.022 -0.0005 -0.031 - 0.013 -0.046 -0.072 -0.01 bpic-10 - 0.0072 -0.07 -0.17 -0.01 -0.013 -0.016	Advocates for booster shots to enhance immunity, addressing vaccine safety and mild side effects experienced post-vaccination 0.22	-0.027	-0.026	-0.0076	-0.028	-0.043	-0.042	
topic-6     0.071     0.012     0.012     0.012     0.012     0.02       topic-6     0.071     -0.043     -0.057     -0.012     0.003     -0.2	Against federal COVID-19 vaccine and mask mandates, framing them as overreach and questioning their constitutionality0.035	-0.031	-0.099	-0.0088	-0.032	-0.01	0.24	0.3
topic-15 - 0.037 0.027 0.0045 0.019 -0.0089 0.016 -0.06 -0.1 topic-9 - 0.0011 -0.02 -0.048 -0.016 0.01 0.027 0.058	Using religion as a means to exempt individuals from mandatory COVID-19 vaccination requirements0.017	-0.015	-0.1	0.41	-0.016	0.13	-0.024	0.4
topic-16 - 0.062 0.019 0.068 0.016 0.023 0.0057 0.037 topic-12 - 0.036 0.032 0.037 0.0091 0.14 0.052 0.069	ayal	- E	one -	tion -	ting -	- uois	- uois	0.4
topic-17 - 0.083 0.0072 0.0061 0.017 0.0022 0.053 0.002 topic-1 - 0.051 0.0026 0.0059 0.013 0.035 0.095 0.0710.1	/betra	are/h	C	Jrada	chea	pres	ibver	
topic-11 - 0.042 -0.015 -0.025 -0.015 0.053 -0.011 -0.0054 topic-00.051 -0.0026 -0.06 -0.013 -0.047 -0.017 0.19	yalty	ö		y/deg	'ness/	ty/op	ity/su	
topic-3 - 0.01 -0.035 -0.018 -0.0098 0.016 -0.056 0.094 topic-4 - 0.028 0.1 -0.043 -0.008 -0.029 -0.046 0.046	<u>٩</u>			purit	fair	liber	uthor	
topic-70.036 -0.032 0.087 -0.0091 -0.034 -0.014 -0.050.3							a	

#### **Ours: After 2nd round of iteration**

- -0.4

016 0.0015 -0.055 -0.018 -0.034 -0.017 0.12

0.076 -0.0076 -0.046 -0.019 -0.042 0.069 0.09 0.021 -0.011 0.023 -0.014 0.099 -0.029 -0.051

topic-8 - 0.01 -0.035 -0.042 0.18 0.12 -0.02 -0.017 topic-5 - -0.031 -0.056 0.028 -0.016 -0.058 -0.02 0.082

- 0.3

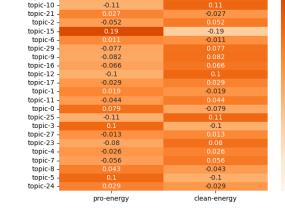
- 0.2

## **Argumentative Cohesion Comparison: Climate**

climate change	-0.11	0.11	- 0.4
ty and freedom	0.12	-0.12	
nd gas industry	0.17	-0.17	
nomic recovery	0.2	-0.2	- 0.3
lership or policy	0.26	-0.26	
hange by 2050	-0.098	0.098	
related policies	0.11	-0.11	- 0.2
e climate action	-0.094	0.094	
uture workforce	0.1	-0.1	
stainable future	-0.11	0.11	- 0.1
inability efforts	0.19	-0.19	
digenous rights. –	0.1	-0.1	
ens on families	0.2	-0.2	- 0.0
mic challenges	0.21	-0.21	
ıgh job creation	-0.092	0.092	
ange mitigation	0.23	-0.23	0.1
ain on residents	0.12	-0.12	
drilling activity	0.1	-0.1	
mental benefits	-0.094	0.094	0.2
es and workers	0.16	-0.16	012
and affordability	0.18	-0.18	
nd job creation	0.25	-0.25	0.3
rising fuel costs	0.16	-0.16	-0.5
l privacy issues	0.1	-0.1	
ed accessibility	-0.098	0.098	0.4
	pro-energy	clean-energy	0.4

**Ours: After 2nd round of iteration** 

Urgent environmental action and policy change to protect future generations from the health impacts of c Supporting natural gas to ensure energy independence and consumer choice, highlighting patriotism through energy securit Pragmatic approach to energy, balancing economic growth and environmental protection through Colorado's oil ar Against new taxes on the natural gas and oil industry, citing concerns over harming ecor Criticizes President Biden's economic policies for significantly increasing gas prices and living costs, urging a shift in leader The cement and concrete industry's commitment to environmental sustainability and carbon neutrality to combat climate ch Preserving oil and gas industry jobs while expressing skepticism towards rapid clean energy transitions and r Exposing and combating the corrupt influence of the fossil fuel industry on politics to promote Recognizing the oil and gas industry's vital role in economic growth, while addressing challenges like automation and training the ful Urgent legislative action on climate change to enhance resiliency against extreme weather events and secure a sus Joining Energy Citizens to support the natural gas and oil industry's economic impact and sustain Halting the Line 3 Pipeline construction to protect the climate, water resources, and Inc Against the implementation of a new gas tax in Connecticut due to its potential financial burde Opposing gas tax increases in Lake and Kane Counties, Illinois, citing high current gas taxes and econor Accelerating the transition to renewable energy to combat climate change and support economic growth through Leveraging innovative technologies and the synergy between natural gas and renewables as key strategies for climate cha The burden of state gas taxes on Californians amid inflation, advocating for measures to ease financial stra Permian Basin's significant contribution to the energy sector's growth and the positive economic impact of increased Embracing wind and nuclear power as key to Illinois' energy strategy, highlighting job creation and environn Against natural gas bans due to their potential economic harm to familie Recognizing and utilizing natural gas as a pragmatic, efficient energy solution for reliability a Acknowledging and supporting the oil and natural gas industry's critical role in economic growth a Maintaining local oil and gas production to ensure California's energy independence and protect consumers from r Against implementing a per-mile tax for drivers, citing concerns over increased burdens and Embracing solar energy for its broad benefits, focusing on economic growth, environmental protection, and enhance



-0.024

-0.023 -0.012

-0.12

-0.059

-0.054

clean-energy

-0.19

-0.049

-0.037

-0.16

**Baseline:** 10 LDA Topics

- 0.3

- 0.2

- 0.1

- 0.0

- -0.1

- -0.2

- -0.3

- -0.4

0.4

- 0.3

- 0.2

- 0.1

- 0.0

- -0.1

- -0.2

- -0.3

- -0.4

topic-1 topic-9 topic-3 topic-0 topic

topic-4 1

topic-7

topic-8 t

topic-5

topic-2

topic-18 -

topic-19

topic-20 -

topic-14

topic-22 -

topic-13

topic-26 topic-28

topic-10

-0.038

-0.12

-0.056

-0.12

pro-energy

-0.059

-0.023

0.16

**Baseline:** 30 LDA Topics

# **Demographic Targeting**

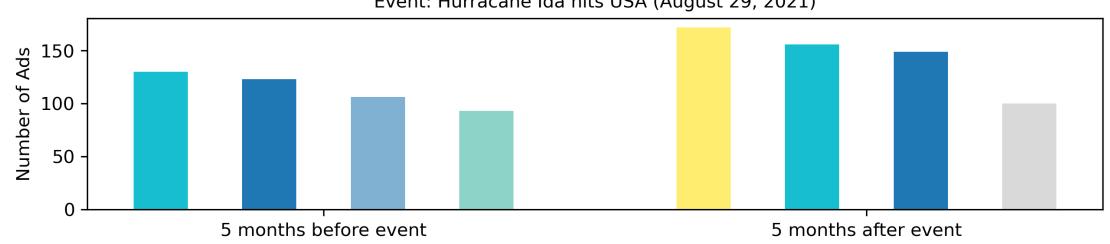
- Three age categories.
  - i.e.,
    - Young people (ages 13-24)
    - Working-age people (ages 25-54)
    - Older population (age 55+)
- Florida and Texas.

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- Florida and Texas.

	Age Group	State	Entity	Talking Points
S	13-24	TX	Children, Parents, reproductive health.	Advocates for the safety of COVID-19 vaccines for children, emphasizing mild side effects and community protection through vaccination.
e	25-54	FL	Ron DeSantis, Dr. Joseph Ladapo, Sur- geon General.	Advocates for building and restoring public trust in the COVID-19 vaccine and the medi- cal community.
		ΤX	seniors, Pfizer, who have passed away or are hospitalized due to Covid, I.	Strongly advocates for COVID-19 vaccination, highlighting its safety, efficacy, and crucial role in preventing severe illness and ending the pan- demic.
	55+	FL	Governor Ron DeSantis, seniors, loved one, Johnson & Johnson.	Efforts and challenges in equitable vaccine dis- tribution and access for seniors across various counties.

• Event1: Hurricane Ida, Date: August 29, 2021.

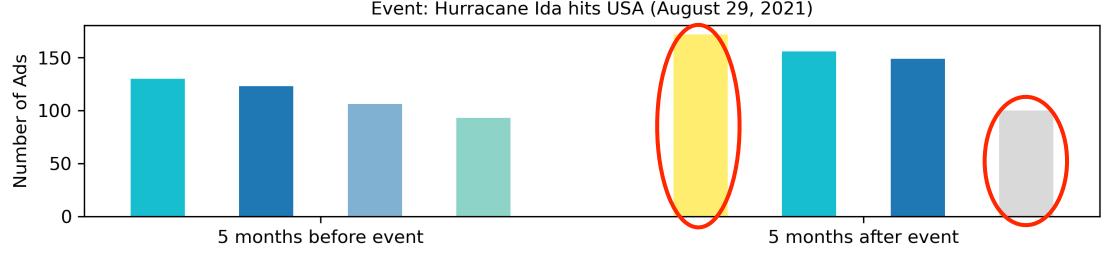


Event: Hurracane Ida hits USA (August 29, 2021)

Joining Energy Citizens to support the natural gas and oil industry's economic impact and sustainability efforts. Collective action and education to combat climate change, emphasizing community involvement and urgent policy measures. Embracing wind and nuclear power as key to Illinois' energy strategy, highlighting job creation and environmental benefits. Supporting the Growing Climate Solutions Act and the senators who champion this bipartisan environmental policy. Embracing solar energy for its broad benefits, focusing on economic growth, environmental protection, and enhanced accessibility. Urgent legislative action on climate change to enhance resiliency against extreme weather events and secure a sustainable future.

**Talking Points** 

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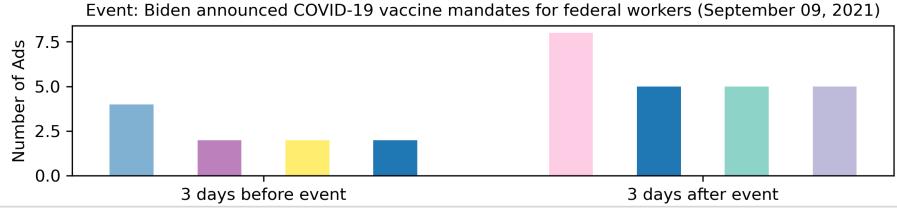


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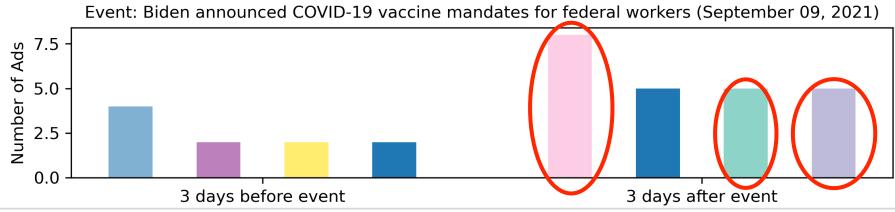
• Event2: Federal COVID-19 vaccine mandate, Date: September 09, 2021.



**Talking Points** 

Importance of COVID-19 vaccination by emphasizing its safety, efficacy, availability, and role in ending the pandemic.
Promoting COVID-19 vaccination for children and the community, emphasizing safety, accessibility, and the benefits of vaccination.
Emphasizes the safety and effectiveness of COVID-19 vaccines despite mild side effects, advocating for vaccination to protect against the virus.
The prioritization strategy for COVID-19 vaccinations in certain highly infected North Carolina counties, addressing vaccine efficacy concerns.
Resistance against federal vaccine mandates, emphasizing personal choice and legal action to uphold individual rights.
COVID-19 vaccine mandates, including recent Supreme Court rulings and public opinion on federal mandates.
Against Biden's vaccine mandate, portraying it as government tyranny and urging resistance and financial support.

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- Quantitative results:
  - Newly discovered arguments can **cover** a **larger portion** of texts.
  - Map texts -> arguments accurately w.r.t. human judgment.
  - Arguments are **more strongly correlated** with specific **stances** or **moral foundations** than the LDA topics.

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- Talking point information **improves** the **stance classifier performance**.
- Talking points are tailored for **demographic targeting**.
- Talking points **dynamically shift** in response to **real world events**.

### References

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#### THANK YOU ③

Slide: <a href="https://tunazislam.github.io/files/LatentArgumentsLLM.pdf">https://tunazislam.github.io/files/LatentArgumentsLLM.pdf</a>

## Questions?

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