Examining Hashtag Co-Occurrence Network on BlueSky: A Multi-Case Study of Protest Movements

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Abstract. The year 2025 has already witnessed numerous protest movements in the U.S. Many people have used social media to coordinate and organize demonstrations aimed at driving societal change and expressing resistance to various government policies. Decentralized social media platforms such as BlueSky have become popular destinations for users migrating from mainstream sites like Facebook and X (formerly Twitter), often due to concerns about censorship and privacy. In this research, we examine the hashtags used to disseminate narratives on BlueSky during five protest movements to understand the platform's role in these events and to identify posting techniques and strategies used by activists. Our results show that BlueSky was utilized not only as a tool for communication and mobilization but also as a space for community building. These protest movements appear to be successful in attracting more participants, as indicated by the increasing number of posts and communities. Activists employed various techniques to achieve this growth and engagement, such as hashtag latching, hashtag reuse, and hashtag misspelling.

Keywords: Protest movements · Networked mobilization · Hashtag activism · Case study · BlueSky.

1 Introduction

Protest movements are defined as "*organized efforts by significant numbers of people to promote social change*" [13]. Today, individuals use the internet, particularly social media, to organize, coordinate, and mobilize people toward specific actions aimed at achieving particular goals, a phenomenon known as "networked mobilization" [5]. In this exploratory research, we examine the hashtags used to disseminate the narratives of multiple protest movements that leveraged network mobilization, namely *#50501*, *#StandUpForScience*, *#TeslaTakedown*, *#HandsOff*, and *#NoKings*. All movements involve a series of protests and actions against Elon Musk (for the *#TeslaTakedown* protest movement) and his influence—particularly his relationship with the current U.S. President, Donald Trump, and his perceived impact on democracy and global affairs. In the other protest movements, many protesters more broadly opposed the current

president's practices and policies, including cuts to the federal grant budget for various science projects. The movements aim to carry out various peaceful demonstrations, boycotts, and efforts to impact Tesla's stock price, Elon Musk involvement in the government, and show some resistance to president Trump's policies. Despite efforts to maintain nonviolence, during the *#TeslaTakedown* protest movements [16] [22] and the protests in Los Angeles, California, some actions have not been entirely peaceful which prompted president Trump to deploy the national guards to control the situation [21].

To conduct our research, we collected data from BlueSky - one of the most used *Decentralized Social Networks* or *Federated Social Networks* that uses the AT Protocol. BlueSky, which has over 30 million users as of January 2025[1], started in 2019 as a project within Twitter/X but then became an independent company in 2021. This decentralized social media app promise its users more control on the content that appear on their timeline, more independence from big social networking corporations, and since its an open network, users can switch from one app to another without losing their content or connections. These features make such platform very attractive to many users, especially those who want more freedom to express their opinion and want to stay online [3] [8] [17] [18] [19]. Hence, we believe this platform is good for studying such events because the data will be more realistic (truly represent what's happening, no content moderation or removal by big corporations) and of high quality (no restrictions on the content/samples collected). Using the data we collected from BlueSky on the five aforementioned protest movements, we aim to answer the following research questions: **RQ1:** What role(s) did BlueSky play in these five protest movements? **RQ2:** What are some of the posting techniques or strategies used in these protest movements? The rest of the paper is organized as follows. In Section 3, we describe our data collection method and dataset size. We then explain the analysis conducted in Section 4 and present our results in Section 5. Finally, in Section 6, we provide our conclusion and highlight our next steps. A literature review section has been omitted due to space limitations, and more emphasis is placed on the methods and results presented here.

2 Literature Review

In this section, we briefly review previous research conducted by various scholars on BlueSky and protest movements. This review is not exhaustive due to space limitations, and greater emphasis is placed on the methods and results presented here. An article by Murphy [12] provides a crucial journalistic account of Bluesky's emergence as a Twitter alternative. Sahneh et al. [17] provide an empirical analysis of the early development of Bluesky - a decentralized alternative to traditional industry standard social media sites. Quelle and Bovet [15] employed network science and political communication techniques to analyze Bluesky's social graph. Arroyo-Machado et al.[3] move to investigate the role

[1] BlueSky https://bsky.social/about/faq

that Bluesky plays as a rising decentralized social network for scholarly communication. Sethi et al. [19] present a practical and community-focused lens to measure how Bluesky is leveraged within a framework for academic medicine. Schukow et al. [18] wrote a literature review to help healthcare professionals - particularly those in pathology - utilize and adopt Bluesky as a social network to further educate and engage peers and laymen. Finally, Carolyn Noble [13] investigates the intersection of political activism and social work in the context of increasingly large-scale protest movements, which gained traction in the post-recession era. Noble's view sees decentralized or federated platforms like Bluesky as modern spaces where these protest movements can develop, organize, and mobilize. Therefore, Noble's work helps position digital decentralization within the long tradition of social resistance and progressive activism.

3 Data Collection

For this research, we collected data from BlueSky for five protest movements: #**50501**[2] (with a national day of action set for February 5, 2025), #**StandUpForScience**[3] (with a national day of action set for March 7, 2025), #**TeslaTakedown**[4] (with a global day of action set for March 29, 2025), #**HandsOff**[5] (with a national day of action set for April 5, 2025) and #**NoKings**[6] (with a national day of action set for June 14, 2025). We used the keywords and hashtags listed in Table 1 to collect public, *unique* posts that contained terms related to each protest movement. Data was gathered using the BlueSky API and our own Python scripts. In the data collection script, we set the "ranking order of results"[7] to *latest* (to sort the results in chronological order) and to *top* (to sort the results by engagement/popularity). This setting was needed to make sure we get both new and popular posts related to our keywords. The data collection script was run multiple times to gather as much data as possible. In each run, we set the number of results per page to the maximum, which is 100 results/posts per page, and only new posts were added to our MySQL database to avoid duplicates. Data collection was stopped when no new data was being added. For all keywords and hashtags, the crawler was set to collect data from January 1, 2025, to June 24, 2025. A trend line of the number of posts obtained per day is shown in Figure 1.

[2] #50501 movement website URL: https://www.fiftyfifty.one
[3] #StandUpforScience movement website URL: https://www.standupforscience.net/
[4] #TeslaTakedown movement website URL: https://www.teslatakedown.com
[5] #HandsOff movement website URL: https://handsoff2025.com
[6] #NoKings movement website URL: https://www.nokings.org
[7] Search Posts Documentation: https://atproto.blue/en/latest/atproto/atproto_client.models.app.bsky.feed.search_posts.html

4 Data Analysis

Using the collected data, we conducted analyses to answer our research questions. We began with a trend analysis, examining the number of posts per day and highlighting the dates on which each protest movement was scheduled to occur. Next, we examined each movement's website to identify the social media platforms used in each protest.

Our subsequent analyses included constructing a hashtag co-occurrence network [1] for each protest movement using the collected data and a five-day window (two days before the protest, the day of the protest, and two days after each protest). This window was chosen to ensure the analysis remained focused on each event and to reduce the amount of unrelated content that may have been collected due to the use of a keyword-based data collection method. We then ran the Louvain community detection algorithm [7], that is provided through the NetworkX Python library[8] to identify hashtag communities. This algorithm detects communities in a network using heuristics based on modularity optimization. Next, we calculated the PageRank[9] of each node in the five hashtag co-occurrences networks of each protest movements to determined the most important hashtag in the overall network and within each community. The nodes (hashtags) with the highest PageRank are the most structurally *important* nodes in the community based on which other hashtags it co-occurs with and how central those co-occurrences are [14]. These hashtags are thematically central to the discourse (i.e., represent the core of the community topic). So, the hashtags with high PageRank might not be the most used globally, but they are structurally important in the co-occurrence network. Finally, we identified common hashtags across the movements. These steps aims to shed light on the similarities and differences in the narratives of these protest movements and to identify techniques or strategies used to attract a large number of participants.

5 Results

To answer the first research questions, we found that BlueSky was used as a platform for *communication and mobilization*. All the protest movements studied have a dedicated website for sharing all things related to the demonstrations. These websites also include a "social" section where organizers communicate with participants and encourage them to share artifacts such as photos and videos of the demonstrations on their social media. The five protest movements primarily used the following social media platforms to communicate and share artifact: BlueSky (5/5), Instagram (5/5), Facebook (3/5), LinkedIn (3/5), TikTok

[8] Louvain algorithm NetworkX reference: https://networkx.org/documentation/stable/reference/algorithms/generated/networkx.algorithms.community.louvain.louvain_communities.html

[9] PageRank NetworkX reference: https://networkx.org/documentation/stable/reference/algorithms/generated/networkx.algorithms.link_analysis.pagerank_alg.pagerank.html

(2/5), YouTube (2/5), WhatsApp (2/5), X/Twitter (2/5), Threads (2/5), Reddit (1/5), and Discord (1/5). This makes BlueSky and Instagram the most used platforms across these five protest movements, with all five movements (5/5) featuring these social media sites on their websites. Based on the post trends shown in Figure 1, most posts were published on the day each event occurred, except for #HandsOff and #NoKings (organized by the 50501 movement, which stands for "50 states, 50 protests, one movement" [6] [20]). For these two events, post volume peaked the following day. These events also generated the highest number of posts, which is expected given that millions of people participated in the demonstrations [6]. The delayed peak may be due to time zone differences among the large number of participants across all 50 states (there is a three-hour time difference between Eastern Standard Time (EST) and Pacific Standard Time (PST)). Additionally, the overall posting trend appears to be gaining momentum, as the peak number of posts grows progressively higher from one protest to the next, possibly indicating increasing success or popularity. For example, the first 50501 protest, held on February 5, 2025, did not generate many posts. However, later demonstrations saw significantly higher number of posts as can be seen in Figure 1.

Another role that BlueSky seems to be playing is serving as a platform for *community building*. For each protest movement, all hashtags co-occurred with others to form a single connected component. We found that in later protest movements, more unique hashtags were used (see Table 2). These hashtags formed more distinct and tightly clustered communities, indicating a more focused use of hashtags (i.e., related hashtags were frequently used together, resulting in the formation of cohesive communities). All the protest movements exhibited a small graph diameter (ranging from 2 to 5)—that is, the longest shortest path between any two hashtags—and an average shortest path close to that of real-world networks [4], suggesting that hashtags were repeatedly used across multiple posts. This frequent co-occurrence created more edges and contributed to a smaller overall graph diameter and average shortest path.

To answer the second research question, we followed the steps described earlier in the Data Analysis section and found that, over time, the protest movements seems to have more *leading communities* of hashtags. We define a leading community as a community of hashtags that co-occurred most frequently (i.e., large communities). In general, the hashtag communities formed during the earlier protest movements were more focused on the protest topic (i.e., more relevant), while later protests seemed to have more unrelated hashtag communities (see Figure 2). This indicates the use of the *hashtag-latching* [2] technique which is used to boost posts visibility by using unrelated but popular/trending hashtags in the posts. Figure 2 shows each hashtag co-occurrence network, with the most important hashtags (i.e., nodes with the highest PageRank scores) in each community shown in red. Another technique that appears to have been used in these protest movements is *hashtag reuse* [10]. This refers to the technique where social media users reuse their own hashtags or those used by their social network. It is widely used in a phenomenon known as *hashtag activism*, where social

Table 1: Keywords used to collect data from BlueSky.

Keyword	Number of Posts	From	To
#50501	1,923	2/5/25 19:20	6/23/25 23:51
#50501movement	8,465	2/1/25 20:45	6/23/25 22:39
#FiftyFiftyOne	9,045	2/2/25 0:35	6/23/25 22:03
#StandUpforScience	7,180	1/23/25 3:28	6/23/25 17:42
#TeslaTakedown	21,256	2/12/25 17:53	6/23/25 23:27
#HandsOff	21,676	2/6/25 10:30	6/23/25 23:47
#LAProtest	6	6/8/25 11:03	6/23/25 1:24
LAProtest	521	1/5/25 23:01	6/22/25 0:13
#MassDeportation	951	1/1/25 21:46	6/23/25 21:47
#LAProtests	1,668	1/20/25 22:45	6/23/25 22:20
#ICE	15,553	1/1/25 11:03	6/23/25 17:25
ICE	19,258	6/15/25 14:44	6/24/25 10:31
#NoKings	24,309	6/12/25 15:27	6/23/25 23:59

Table 2: Hashtag co-occurrence network information.

Protest Movement	# Unique Hashtags	# Communities	Graph Diameter	Avg. Shortest Path
50501	332	9	5	2.2408
StandUpForScience	1,318	20	2	1.991
TeslaTakeDown	3,319	28	3	2.0106
HandsOff	5,359	54	4	2.0409
NoKings	6,079	68	4	2.3408

media users use hashtags to organize content, express their needs and messages, and amplify social and political activism [11]. Figure 3-a shows each protest movement, where each black dot represents a set of hashtags—either unique to that movement (if not connected by a line) or reused across movements (if connected by lines). The number of hashtags is represented in a bar chart above each vertical line of dots. We found that the #NoKings protest had the highest number of unique hashtags, with 4,404, followed by #HandsOff, #TeslaTakeDown, #StandUpForScience, and #50501. Additionally, we found 667 reused hashtags between the #NoKings and #HandsOff protests; 391 reused hashtags among #NoKings, #HandsOff, and #TeslaTakeDown; 141 reused hashtags among #NoKings, #HandsOff, #TeslaTakeDown, and #StandUpForScience; and 78 reused hashtags shared across all five protests. Finally, we found that a *hashtag misspelling* technique was also used in these protest movements. This refers to a practice where social media users creatively write their posts to include more content within BlueSky's 300-character limit by using misspellings and abbreviations. This technique has also been observed on Twitter by other researchers [9], and it can lead to a "feature explosion problem" in machine learning tasks [9]. Figure 3-b shows a word cloud depicting some of the important (with high PageRank) misspelled hashtags.

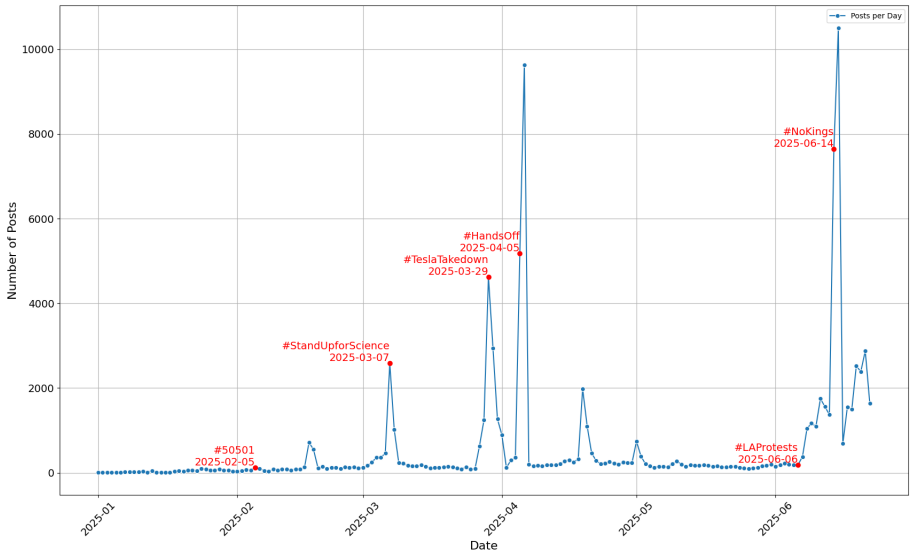
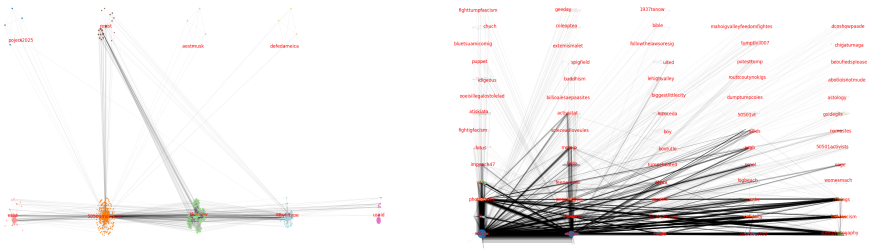


Fig. 1: Trend of the unique posts collected highlighting the protest movements studied.

6 Conclusion and Future Research Directions

Protests have long been a way for people to express their demands, call for change, and voice their grievances. Social media has made it easier to coordinate and organize such events. One of the most successful and well-known examples in our modern time is the Arab Spring movement in 2011, which began in Tunisia and spread to many other countries in the Middle East and North Africa, leading to the fall of the ruling regimes in Tunisia, Egypt, Libya, and Yemen. Major social networking platforms like Facebook and X (Twitter) have established rules and standards for their users and have taken steps to limit the platform's use for such activities; however, these measures often have limited effectiveness. An emerging form of social media, decentralized or federated social networks such as BlueSky or Mastodon, promise users more control over the content they see or share and may have fewer restrictions. This encouraged many people to switch from mainstream social media platforms to decentralized or federated social networks. Hashtag activism is a technique used by social media users that requires them to use a combination of the pound sign (#) and a word, which is called a "hashtag," to share and organize related content, often connected to their social media campaigns or protests. Studying the narratives of protest movements on decentralized social media is an important research problem because these movements can serve as powerful engines for various types of change, including social, economic, and, in some cases, political transformation. Protest movements may lead to major reforms, so understanding the shared narratives helps us examine how power is exercised by different entities and how people resist that power.



(a) (b)

Fig. 2: The hashtag co-occurrence network for: (a) 50501 protest movement, and (b) NoKings. Each word in red represents the most important hashtag in that community, as ranked by the PageRank measure. Co-occurrence is represented using black edges.

This research also sheds light on activist strategies and techniques, helping us assess what has worked and what hasn't. Additionally, it offers insight into collective behavior and can help governments, NGOs, and other stakeholders develop policies that are more responsive to public demands. Finally, the findings of such studies can contribute to building predictive models that detect early signs of unrest, helping to prevent escalation, violence, or even revolution.

In this research, we found that BlueSky was used as a platform for *communication and mobilization* and as a platform for *community building*. The overall posts volume seems to be increasing from one protest to another, indicating success or popularity. The hashtags communities are also increasing, which suggests increasing topics (increasing demand for changes). We also found that the activist used various techniques to gain this popularity and derive more posts, such as *hashtag latching*, *hashtag reuse*, and *hashtag misspelling*. Although we carefully selected keywords and hashtags closely related to the protest movements and used a five-day analysis window (two days before, the day of, and two days after each protest), and we set our crawler to get the latest (results chronologically sorted) and top posts (results sorted by engagement/popularity) one limitation of this research is its keyword-based data collection method. This approach may have introduced sampling bias, or some protest content could have been missed.

One possible direction for future research is to identify the topics discussed before, during, and after each protest; analyze sentiments, toxicity, and other linguistic measures; and classify the types of speech, such as hate speech, violent speech, or harassment. Another promising direction is to examine the types of participants (e.g., humans vs. social bots) and analyze their social networks (friends and followers) to identify similarities and differences and evaluate the effectiveness of each network.

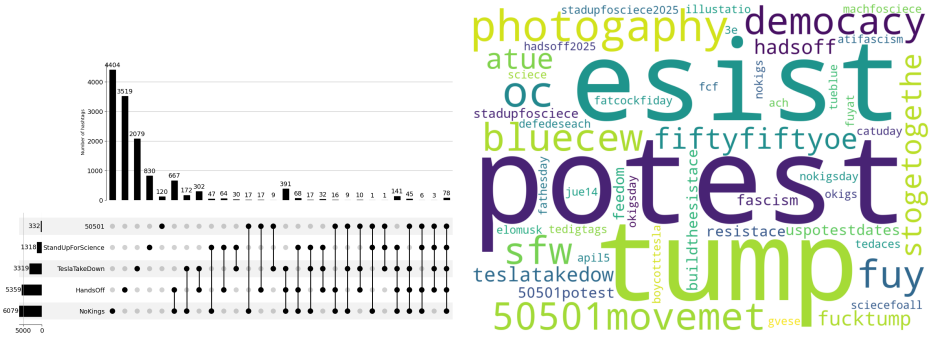


Fig. 3: (a) The number of unique and reused hashtags across five protests. A filled dot indicates a unique set of hashtags, while a line connecting the dots shows a reused set of hashtags from one protest to another. The bars above display the number of unique or reused hashtags shared between connected dots/protests. (b) Word cloud showing some of the misspelled hashtags found in our data.

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References

1. Al-khateeb, S.: Dapping into the fediverse: analyzing what's trending on mastodon social. In: International Conference on Social Computing, Behavioral-Cultural Modeling and Prediction and Behavior Representation in Modeling and Simulation. pp. 101–110. Springer, Springer, Cham, Pittsburgh, Pennsylvania, USA. (2022). https://doi.org/https://doi.org/10.1007/978-3-031-17114-7_10
2. Al-Khateeb, S., Hussain, M.N., Agarwal, N.: Leveraging social network analysis and cyber forensics approaches to study cyber propaganda campaigns. Social networks and surveillance for society **1**, 19–42 (2019). https://doi.org/https://doi.org/10.1007/978-3-319-78256-0_2
3. Arroyo-Machado, W., Robinson-Garcia, N., Torres-Salinas, D.: Are there stars in bluesky? a comparative exploratory analysis of altmetric mentions between x and bluesky. Journal of Informetrics **19**(3), 101700 (2025)
4. Backstrom, L., Boldi, P., Rosa, M., Ugander, J., Vigna, S.: Four degrees of separation. In: Proceedings of the 4th annual ACM Web science conference. pp. 33–42. Association for Computing Machinery, Evanston Illinois, USA. (2012)
5. Badouard, R., Carey-Libbrecht, L.: Networked mobilizations. Réseaux **181**(5), 87–117 (2013)

6. Baumann, L.: What to know about 'no kings' protests against trump's policies (June 2025), https://apnews.com/article/no-kings-protest-things-to-know-trump-8d37f2bb2bf20ab503205b277e92b885, the Associated Press. Updated 2:28 PM CDT, June 12, 2025
7. Blondel, V.D., Guillaume, J.L., Lambiotte, R., Lefebvre, E.: Fast unfolding of communities in large networks. Journal of statistical mechanics: theory and experiment **2008**(10), P10008 (2008)
8. Failla, A., Rossetti, G.: "i'm in the bluesky tonight": Insights from a year worth of social data. PloS one **19**(11), e0310330 (2024)
9. Krokos, E., Samet, H., Sankaranarayanan, J.: A look into twitter hashtag discovery and generation. In: Proceedings of the 7th ACM SIGSPATIAL International Workshop on Location-Based Social Networks. pp. 49–56. Association for Computing Machinery, Dallas/Fort Worth Texas, USA. (2014)
10. Lex, E., Kowald, D.: The impact of time on hashtag reuse in twitter: A cognitive-inspired hashtag recommendation approach (2019), https://arxiv.org/abs/1908.00977
11. Maragh-Lloyd, R.: # hashtagactivism: Networks of race and gender justice. Communication Research Trends **39**(3), 38–40 (2020)
12. Murphy, H.: Dorsey's bluesky emerges as latest challenger to twitter under musk. new social media platform gains momentum as once-friendly tech billionaires go head to head. The Financial Times pp. 9–9 (2023)
13. Noble, C.: Social protest movements and social work practice. International Encyclopedia of the Social & Behavioral Sciences **22**(2), 518–24 (2015)
14. Page, L., Brin, S., Motwani, R., Winograd, T.: The pagerank citation ranking: Bringing order to the web. Tech. rep., Stanford infolab (1999)
15. Quelle, D., Bovet, A.: Bluesky: Network topology, polarization, and algorithmic curation. PloS one **20**(2), e0318034 (2025)
16. Reuters: Two tesla stores spray-painted in sweden by environmentalists (April 2025), https://www.reuters.com/video/watch/idRW329801042025RP1/, accessed: 2025-05-28
17. Sahneh, E.S., Nogara, G., DeVerna, M.R., Liu, N., Luceri, L., Menczer, F., Pierri, F., Giordano, S.: The dawn of decentralized social media: an exploration of bluesky's public opening. In: International Conference on Advances in Social Networks Analysis and Mining. pp. 422–437. Springer (2024)
18. Schukow, C.P., Punjabi, L.S., Khan, E.: A primer on bluesky (and pathsky) for pathologists, trainees, and medical students. Advances in anatomic pathology pp. 10–1097 (2025)
19. Sethi, J., Stauss, M., Mirioglu, S., Floyd, L., Woywodt, A.: Only the bluesky is the limit: ten tips for a trending# skytorial. Clinical kidney journal **18**(2), sfae414 (2025)
20. Together We Will be Indivisible (PAMV): Hands off! march and rally in mountain view (April 2025), https://events.pol-rev.com/events/f2ac86ab-f992-4dfb-960b-77d9eb8a76d6, event held on Saturday, April 5, 2025, from 11:00 AM to 1:00 PM
21. Tsui, K., Park, H., Yeung, J., Radford, A., Chowdhury, M., Ebrahimji, A., Reiss, R., Powell, T.B., Hammond, E., Sangal, A., Musa, A., Tucker, E., Romine, T.: June 10, 2025 – los angeles protest news (6 2025), https://www.cnn.com/us/live-news/la-protests-ice-raids-trump-06-10-25, accessed: September 5, 2025
22. Yoon, J.: What to know about the backlash against tesla (March 2025), https://www.nytimes.com/2025/03/19/business/tesla-musk-trump-backlash.html, accessed: 2025-06-03