Tracing Information Flows in the Hybrid Media System: The Agenda-Setting Role of Dark Platforms Surrounding the Ukraine Invasion Discourse

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The influence of dark platforms on public debate remains understudied. Using a unique multiplatform corpus of news articles, posts from four news-related subreddits, tweets from politicians, and posts from 4chan/pol (N = 1,545,813), we leveraged neural topic modeling and advanced overtime analyses to study discursive information flows dynamically. Focusing on the early stages of the Russian invasion of Ukraine, our results showed limited discursive information flows from the dark platform agenda to other agendas. However, the most influential topics on the dark platform agenda were

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significantly more toxic than those on other agendas. Our approach effectively uncovers the nuanced dynamics of discursive information flows across various platforms, deepening our understanding of the complex interplay between different agendas in shaping public debate in the contemporary media system.

The rise of digital media has paved the way for a "hybrid media system" (Chadwick, 2017), which fosters evolving (political) opportunity structures with diverse information sources, communication spaces, and actors that can "introduce, amplify, and maintain topics, frames, and speakers" (Jungherr, Posegga, & An, 2019, p. 16). Within this complex media system, some information curators include political outsiders (Jungherr, Schroeder, & Stier, 2019) and "dark platforms" (Zeng & Schäfer, 2021), such as the infamous Politically Incorrect board of 4chan (4chan/pol/), that enable the spread of malicious, extremist, and conspiratorial narratives (Tahmasbi et al., 2021). This fuels concerns that problematic information from dark platforms, if powerful enough, can shape the public agenda on news, current affairs, and politics, ultimately steering political discourse "in ways that modify, enable, or disable the agency of others, across and between a range of older and newer media settings" (Chadwick, 2017, p. 285).

Despite widespread concerns and anecdotal evidence that information from dark platforms, like 4chan/pol, is problematic and can influence mainstream media and the public (Lewandowsky et al., 2020), few studies (e.g., Zannettou, 2019) have examined their discursive power and agenda-setting role in cross-platform information flows within the contemporary media system. We argue that the limited studies on the influence of dark platforms, as well as cross-platform and cross-media influence dynamics, stem from the difficulty of capturing these dynamics using conventional social scientific methods. Modeling complex information flows across multiple platforms and information sources requires methodological approaches that can embrace the complexity and fuzziness of these dynamics.

We address this research gap by building on communication and information scientific theories to explore the role of dark platforms and the dynamics of cross-platform information flows. We introduce the concept of "discursive information flows," which aims to extend the scope of (intermedia) agenda-setting research (McCombs & Shaw, 1972) and simultaneously narrow down the scope of information flows by offering a more granular understanding of influence dynamics in the contemporary media system, emphasizing the role of within-agenda dynamics in shaping political discourse.

To this end, we develop a novel methodological approach by leveraging methods borrowed from computational social science and neuroscience to study discursive information flows between (1) the dark platform agenda, (2) the social media agenda of politicians, (3) the social media agenda of the public, (4) the traditional media agenda, and (5) individual entities, such as Twitter accounts, newspapers, or subreddits that constitute these agendas. Specifically, we combine state-of-the-art Natural Language Processing (NLP) approaches on a unique, multiplatform data set with advanced overtime analyses used in—among others—the field of neuroscience (i.e., Hawkes processes) to measure how the studied agendas influenced one another over time by capturing discursive information flows across and within them through

the most influential topics they shared. We apply this method to the first six months of the ongoing Russian invasion of Ukraine, an event that has been central to the public, media, and political agendas since its outbreak in early 2022.

Theoretical Background

The hybrid media system consists of myriad traditional, novel, and digitally born media, as well as other platforms where political discourse occurs. It is characterized by increasing interconnections—and sometimes interdependence—between traditional and more novel digital spaces that produce, distribute, or host news- and politics-related information (Jungherr, Posegga, & An, 2019). This underlines a constant power struggle where contributors to the political discourse continuously adapt, adopt, and become interdependent while trying to keep up with the latest on the grapevine (Langer & Gruber, 2021).

Those entities, platforms, and actors that can successfully steer discursive information flows to align with their objectives hold power over them, and therefore, can influence their ability to act across various traditional and modern media platforms (Chadwick, 2017). Consequently, research aiming to capture these complex interconnections within the hybrid media system must consider all novel entities and types without overlooking traditional outlets (Langer & Gruber, 2021). Despite having access to sophisticated methods and large data sets, obtaining a solid theoretical understanding and suitable empirical insights into "how the media affects and simultaneously is affected by other political forces" (Boydstun, 2013, p. 89) remains challenging.

Information Flows, Agenda Setting, and Discursive Power

Several lines of research have attempted to study connections between different media, platforms, actors, communities, and agendas within the hybrid media system. Scholars often refer to (intermedia) "agenda setting" (Gilardi, Gessler, Kubli, & Müller, 2022), "information flows" (Zannettou, 2019), or "discursive power" (Jungherr, Posegga, & An, 2019) when studying these overtime influence dynamics. These concepts aim to uncover similar patterns across various entities, indicating a high degree of overlap across these concepts and across the disciplines that study them. We briefly outline these concepts, highlighting the elements that form the basis of this study.

The concept of information flows originates from the field of information theory (Shannon & Weaver, 1964), but has since been expanded by other disciplines such as political science, communication studies, and computer science, each offering its own perspectives. Wilkerson, Smith, and Stramp (2015) traced the flow of policy ideas in legislatures by measuring text reuse; Trilling and van Hoof (2020) and Wong and Trilling (2023) investigated "news flows" to uncover patterns of content overlap and information spillover over time across different (news) media outlets. Similarly, Zannettou (2019) studied interconnections and influence patterns across Web communities by investigating the spread of alternative news, memes, and hate speech. These examples highlight the flexibility of this conceptual framework, which can be applied to understand the diverse ways information is propagated, exchanged, and understood across entities, disciplines, and contexts.

Similarly, agenda-setting theory seeks to explain how and why certain issues or topics become salient or prominent in public discourse by uncovering who leads and who follows (Barberá et al., 2019; Gilardi et al., 2022). Intermedia agenda setting, an extension of this theory, examines how different news sources—such as newspapers, blogs, and social media—influence each other and shape the public agenda (i.e., opinions) by determining what issues are given the most attention (Harder, Sevenans, & Van Aelst, 2017). Although intermedia agenda setting is arguably less flexible than the concept of information flows, the two frameworks have been applied to study similar research questions. For instance, the concept of "news flows" has been studied by different disciplines to uncover the complex ways in which different types of media (Wong & Trilling, 2023) and Web communities (Zannettou, 2019) can influence one another and potentially shape the public agenda.

Taking this a step further, Jungherr, Posegga, and An (2019) proposed the concept of "discursive power," which enables and encourages large-scale and comparative empirical research to uncover nuances in the complex "interdependencies and power relationships in contemporary media systems" (p. 404). They argued that to systematically investigate these complex interactions, researchers must acknowledge that interconnections across different entities (e.g., newspapers, social media platforms, or actors)—even between the same types of entities—are subject to variances in the coverage dynamics of certain issues, as well as other external factors.

Therefore, merely aggregating at the agenda level or generalizing to certain typologies of platforms or actors may sidestep these variances within and across entities that hold different levels of discursive power over one another. Moreover, beyond focusing on the transfer of salience of topics, frames, and issues—as posited by intermedia agenda-setting theory—the introduction and sustained presence of topics, frames, and other entities can also serve as powerful indicators of influence dynamics (Jungherr, Posegga, & An, 2019).

We introduce the concept of discursive information flows, defined as the dynamic overtime dissemination of discourse within the hybrid media system, considering connectivity and influence between and within agendas. We aim to extend intermedia agenda-setting research by integrating theoretical and methodological aspects from the three aforementioned frameworks to study the complex patterns of connectivity and influence within the ever-evolving hybrid media system. First, the concept of information flows helps us identify the sources and pathways of information flows to better understand how information spreads within the hybrid media system. Second, our proposed approach incorporates the concept of "agendas" from agenda-setting research, allowing us to conceptually distinguish between information flows across different types of contributors to the communication space on an aggregate level. Finally, the framework of discursive power enables us to gain a more granular understanding of this information flow dynamics across agendas by highlighting that the introduction and maintenance of topics may be just as important as the transfer of their salience, and that these dynamics may well be characterized by unexpected and shifting patterns not only across agendas but also within them. Here, we focus on the first indicator of discursive power: the ability of contributors to political communication arenas to introduce, enhance, and sustain topics.

We scrutinize discursive information flows over time across and within four types of agendas. By "agenda setting," we mean the influence dynamics across the studied agendas that we conceptualize through the discursive power of the topics they introduce, maintain, or amplify over time. Our study centers on the Russian invasion of Ukraine, including the events that led to the invasion on February 24, 2022.

Four Types of Agendas

Dark Platform Agenda

To capture the dark platform agenda amid the Russian invasion of Ukraine, we gathered posts from 4chan's Politically Incorrect (4chan/pol/) board, conceptualized as a "dark platform," because of its reputation as a secluded space (in)famous for, among other things, content liberation and "exile congregation" (Zeng & Schäfer, 2021). In a nutshell, 4chan/pol/ has been studied for its spread of conspiracy theories, misinformation (Zeng & Schäfer, 2021), and hate speech (Rieger, Kümpel, Wich, Kiening, & Groh, 2021). Research found that 4chan/pol/ influences the greater Web by pushing dangerous narratives to other agendas (Zannettou, 2019). For a more in-depth discussion of why 4chan/pol is considered a "dark platform," we refer to Zeng and Schäfer (2021).

Social Media Agenda of the Public

To capture the social media agenda of the public, we turned to Reddit, the self-proclaimed "front page of the Internet." Reddit is a news aggregator where users post, rate, and comment on content within user-moderated topic communities called subreddits. Reddit's diverse communities, user-driven content ranking, focus on discussion and debate, and resilience to algorithmic influence make it a more compelling candidate to study the social media agenda of the public than Twitter or Facebook. Overall, Reddit promotes a nuanced understanding of complex issues, shaping the social media agenda by highlighting important topics and facilitating critical discourse. To illustrate, anecdotal evidence indicates that user behavior on Reddit has led to some real-world events. For instance, Reddit users drove up the share price of GameStop, one of the most shorted stocks on Wall Street, leading to hedge funds losing billions of dollars (Chow, 2023). This coordinated effort caught the attention of politicians who urged Wall Street to democratize the stock market and the media that tried to make sense of the phenomenon (Roose, 2021). This is just one example of the several Reddit events that fostered real-world action (Proferes, Jones, Gilbert, Fiesler, & Zimmer, 2021), proving Reddit's agenda-setting potential.

Social Media Agenda of Politicians

Building on Lewandowsky, Jetter, and Ecker (2020), we considered Twitter an important agenda-setting platform for politicians given that Twitter and similar social media platforms have offered new ways for politicians to influence the public and media agenda—an impact that recent research suggests is increasingly significant. For instance, Donald Trump's Twitter activity contributed to the U.S. Capitol storming by appealing to insurrectionists' emotions (Muhammad & Nirwandy, 2021). Overall, Twitter has proven to be a powerful agenda setter, especially in the hands of powerful politicians. Therefore, we gathered all tweets and retweets from the accounts of G7 leaders and the Ukrainian president to uncover the

information they propagated and prioritized during the ongoing Russian invasion of Ukraine and to assess the extent to which they influenced or were influenced by other agendas.

Traditional Media Agenda

We gathered news articles from two internationally recognized newspapers to capture the traditional media agenda during the study period. The *New York Times* (NYT), one of the largest and most popular newspapers worldwide, has been studied several times for its (intermedia) agenda-setting power (e.g., Golan, 2006). As McCombs and Reynolds (2009) noted, NYT represents an important intermedia agenda setter since front-page coverage on NYT renders a topic newsworthy, thereby legitimizing it. The *Kyiv Independent* (KI) is a recently established, English-language Ukrainian news website that, to the best of our knowledge, has not been studied by academic research thus far. Although KI has been online only since 2021, it has quickly become the world's number 1 news outlet, providing reliable, English-language updates from Ukraine (Abend, 2022). KI has even been quoted by Ursula von der Leyen, the president of the European Commission (Kyiv Independent, 2022), signaling that the content produced by KI is far-reaching and potentially influential from an agenda-setting perspective.

Related Research

Recent studies have explored the complex relationships among various agendas in the hybrid media system. For example, Gilardi et al. (2022) studied the agenda-setting dynamics between the social media agenda of politicians, the social media agenda of parties, and the traditional media agenda across four important issues. Their findings showed that the studied agendas influenced one another, but "no agenda [led] the others more than it [was] led by them" (Gilardi et al., 2022, p. 39).

Research has also found that journalists often draw information from social media platforms like Twitter to inform their news articles (Shapiro & Hemphill, 2017). Similarly, some argue that social media can bypass traditional media gatekeeping and have the power to influence it (Conway-Silva et al., 2018). Vargo, Guo, and Amazeen (2018) found that major traditional new media have lost control over the news agenda, increasingly following online partisan media. This suggests discursive information flows between social media and traditional media, with social media leading and traditional media following. Conversely, James et al. (2019) discerned that the emergence of social media platforms has not weakened the gatekeeping power of traditional media. Langer and Gruber (2021) highlighted that traditional media are still crucial political agenda setters. While evidence on agenda-setting dynamics between traditional and social media is mixed, most studies suggest that social media holds more control over discursive information flows. Thus, we propose the following hypothesis:

H1:   The social media agenda of the public influences the traditional media agenda more than vice versa.

Little is known about the agenda-setting potential of dark platforms, despite findings that information on these sites is often misleading, toxic, and conspiratorial (Rieger et al., 2021; Zeng & Schäfer, 2021). Nevertheless, research quantifying the influence between Web communities on Reddit, 4chan/pol, and Twitter found that communities in obscure online spaces can influence what is shared on mainstream

platforms such as Twitter (Zannettou, 2019). Others have shown that content from the darker corners of the Web can spur real-life action (Bakker et al., 2021). However, because of limited research on dark platforms' influence on mainstream media and politics, evidence remains scarce. Since it is difficult to have clear expectations about understudied influence aspects, we formulate the following research questions:

RQ1:   *How are the discursive information flow dynamics between (1) the dark platform agenda, (2) the social media agenda of politicians, (3) the social media agenda of the public, and the (4) traditional media agenda?*

RQ2:   *What is the role of individual entities (i.e., subreddits, Twitter accounts, newspapers) in shaping the discursive information flows across the studied agendas?*

Data and Methods

Case Study: The Russian Invasion of Ukraine

Following months of intelligence gathering and weeks of media reports concerning a gradual but major Russian military build-up near the borders of Ukraine, on the night of February 23–24, 2022, Russian president Vladimir Putin gave a chilling televised address, where he outlined the Kremlin's decision to carry out an imminent military offensive in Ukraine, violating Ukraine's territorial integrity and sovereignty. Putin claimed that the purpose of this "special military operation" was to demilitarize and "denazify" Ukraine and ultimately stop the increasingly threatening eastward expansion of NATO (The Kremlin, 2022). Since the outbreak of the invasion, news and (dis)information about perceived threats in Ukraine and neighboring regions have spread rapidly, forming a complex, intertwined information ecosystem that reached billions of people worldwide through sources ranging from traditional news media to social media sites.

Data Sets

For all studied agendas, we followed comparable strategies to gather data published between January 17, 2022, and June 16, 2022. Details about data collection can be found in Appendix A.[2] We queried the 4CAT Capture and Analysis Toolkit (Peeters & Hagen, 2022) to gather all posts from 4chan's Politically Incorrect (4chan/pol) board that matched our search query "Russia OR Ukraine." To the best of our knowledge, the only way to collect historical data from 4chan is through keyword matching. Following this approach, we gathered a total of 1,135,025 posts from 4chan/pol/.

We used PSAW (Python Pushshift.io API Wrapper) for comment/submission search to query the Pushshift Reddit API for opening posts on the subreddits. We obtained 405,143 opening posts (submissions) from three major (political) news-related subreddits (Zannettou, 2019): "r/worldnews," "r/news," and "r/politics." Given the context of this study, we also gathered all matching opening posts from "r/Ukraine," the largest topic community dedicated to discussions related to Ukraine.

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[2] https://osf.io/qhb87/?view_only=

We used the Twitter v2 API to gather all tweets and retweets from the leaders of the G7 countries[3] and the Ukrainian president to capture what some of the world's most influential politicians had communicated during the ongoing invasion. In total, we obtained $N = 6,380$ tweets sent by the nine politicians (see Table 1). Then, we excluded all non-English tweets (37.1% of the tweets).[4]

To obtain news articles from both NYT and KI, we first downloaded all article URLs for NYT ($N = 20,647$) via their API and crawled the KI website for URLs ($N = 5,177$). Next, we used "news-please," a generic news website crawler (Hamborg, Meuschke, Breitinger, & Gipp, 2017), to extract article elements—including the full text, author information, and publication date—by crawling the article URLs we collected from both sites.

Table 1. Tweets of G7+ Politicians.

Politician	*n* tweets
Justin Trudeau (CAN)	1,139
President Biden (USA)	1,091
Volodymyr Zelenskyy (UAH)	312
Ursula von der Leyen (EU)	525
Boris Johnson (UK)	521
Emmanuel Macron (FR)	32
Charles Michel (EU)	352
Fumio Kishida (JAP)	37
Olaf Scholz (DE)	4

Note. Tweets posted between January 17, 2022, and June 17, 2022 ($N = 4,013$).

Methods

Previous research tracing the spread of news across platforms clustered them into news events (Trilling & van Hoof, 2020) or news stories (Wang et al., 2021) using word embeddings and various similarity metrics (i.e., cosine and soft cosine) to determine whether articles published by different news outlets described the same news event or news story. Others used predefined issues and employed supervised machine learning to label them across different media, capturing agenda-setting relationships (Gilardi et al., 2022).

Our approach is somewhat comparable to the method of Barberá et al. (2019) who extracted topics from tweets via Latent Dirichlet Allocation (LDA; Blei et al., 2003) and modeled agenda-setting dynamics using Vector Autoregression between the social media agenda of politicians and the social media agenda of the public. We extend this methodological framework in three significant ways. First, instead of extracting topics via LDA, we employ BERTopic, a state-of-the art topic modeling tool known to outperform conventional topic models, such as LDA, in terms of topic coherence and interpretability (Grootendorst,

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[3] Except for the Italian prime minister, who did not have a Twitter account.

[4] Because the multilingual BERtopic model struggled with our unbalanced corpus where non-English documents were scarce.

2022). Second, we use Hawkes processes to detect discursive information flows in continuous time (see Wang et al., 2021; Zannettou, 2019). Finally, we trace discursive information flows across and within agendas (16 individual entities making up agendas).

Topic Modeling With BERTopic

We employed a state-of-the-art topic modeling tool, BERTopic (Grootendorst, 2022), to obtain topics from our corpus. After excluding non-English texts, we used the "all-MiniLM-L6-v2" sentence transformer model, which mapped our full multiplatform corpus onto a 384-dimensional vector space. Instead of setting prior expectations concerning how many topics BERTopic should detect, we set up the model to infer the "ideal" number of topics from the corpus—with the only requirement that a topic should occur at least 200 times to be identified. Since BERTopic modeling is computationally expensive, we implemented several data filtering steps to make our data suitable for the framework and available computational resources, while ensuring that documents from each studied agenda would be comparable. Details about the data preparation decisions are outlined in Appendix B.[5]

Hawkes Processes

Hawkes processes, self-exciting temporal point processes used to model events that occur over time (Hawkes, 1971), can capture nonlinear and dynamic connections across entities by modeling the interdependence between events (in this case, topics) and how they influence one another over time. A Hawkes processes model consists of K self-exciting point processes; each process has a rate of events describing the probability of events being created in the process. We call these point processes self-exciting because the creation of an event increases the rate of events in the same or other processes for a short period. In particular, an event can cause impulse responses to the same or another process, which increases its rate for a short period. The overall rate of events in a process consists of two elements: the background rate of the process and the increases in the rate from impulse responses created by the appearance of events. The background rate describes the base probability of events occurring in the process.

Building on Wang et al. (2021) and Zannettou (2019), we assess the influence between K processes (i.e., agendas and individual entities that make up the agendas) across the 548 different types of events (i.e., topics) over time. We used the pyhawkes Python library (Linderman & Adams, 2015), which employs Gibbs sampling to extract model parameters such as weights, background rates, and impulse response functions between different agendas from the data. We follow the same methodology as Zannettou (2019) and assume that a given event (i.e., post, article, or tweet discussing a topic) can cause other events within a 12-hour time window. We created separate Hawkes models for each validated topic extracted from BERTopic using N processes ($N_{aggaregated} = 4$). To capture the richness of the identified discursive information flows between the studied agendas, we also conducted our analyses on an individual, within-agenda level. Specifically, we modeled 16 processes, each representing an individual entity such as a Twitter account, subreddit, or news outlet. Since 4chan/pol could not be subdivided into

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[5] https://osf.io/qhb87/?view_only=

individual entities,[6] we modeled it as a single entity. We assessed the influence of these processes in an aggregate, agenda-based manner and in an individual, entity-based manner. After fitting the models and obtaining their parameters, we calculated two metrics: Influence (raw influence score) and Efficiency (normalized influence score).

$$\text{Influence}_{A \to B} = \frac{\sum_{t \in \text{topics}}\left(W_{A \to B} \cdot \sum_{t=1}^{T} s_{t,A}\right)}{\sum_{t \in \text{topics}}\left(\sum_{t=1}^{T} s_{t,B}\right)}$$

$$\text{Efficiency}_{A \to B} = \frac{\sum_{t \in \text{topics}}\left(W_{A \to B} \cdot \sum_{t=1}^{T} s_{t,A}\right)}{\sum_{t \in \text{topics}}\left(\sum_{t=1}^{T} s_{t,A}\right)}$$

Where $W_{A \to B}$ is a weight describing the strength of the connection between Process A and B based on all the impulse responses, $\sum_{t=1}^{T} s_{t,A}$ is the number of events created in Process A and $\sum_{t=1}^{T} s_{t,B}$ is the number of events created in Process B. The raw influence score can be interpreted as the expected number of events created in Process B because of previously occurring events in Process A, while the normalized influence score indicates how efficient Process A is in causing the creation of new events in Process B. Taken together, we assess discursive information flows across and within the studied agendas by interpreting normalized influence scores (i.e., efficiency). Raw scores are not interpreted directly as they do not account for the volume of topic appearances across sources, which can vary. Without controlling for this, influence scores might be inflated by frequency rather than by reflecting true efficiency in driving events. See Appendix F[7] for the raw scores.

Advantages of Hawkes Processes Over VAR

Traditionally, Vector Autoregression (VAR) has been used to model (intermedia) agenda setting in the field of political communication (see Barberá et al., 2019). However, we argue that Hawkes processes are more suitable for capturing discursive information flows given that this method is designed to model dynamic processes such as the complex influence patterns across and within agendas over time, which are often nonlinear and may involve feedback loops. In contrast, VAR models are better suited for modeling linear relationships between entities, as assumed by intermedia agenda-setting theory. Additionally, Hawkes processes model events in continuous time, allowing for a more granular understanding of discursive information flows. Hawkes processes also consider background rates, representing event occurrence in the absence of triggers, and can control for external factors beyond a set of predefined covariates. While VAR models are useful for modeling linear relationships between variables across discrete time points, Hawkes processes are better suited for modeling the complex and dynamic nature of discursive information flows in continuous time.

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[6] Users' accounts are anonymous; therefore, there is no simple way to distinguish between individual entities that post on 4chan/pol

[7] https://osf.io/qhb87/?view_only=

Results

Topics

We identified 589 topics using BERTopic, including an outlier cluster that captures elements from raw text that do not fit into any of the identified topics. While our outlier cluster may seem large ($N_{outlier}$ = 744,797), the documents that made up this cluster mostly contained stop words, strange characters, frequently used words, and random noise. Our focus on obtaining interpretable topics led us to avoid further outlier reductions, ensuring topic clarity. The results of an initial word intrusion task (Chang et al., 2009) were acceptable (Appendixes C and D[8]).

However, given the large amount of jargon (predominantly from 4chan/pol) and specialized vocabulary, this task posed significant challenges for human annotators who were not fully immersed in the specific context. To enhance confidence in the validity of the identified topics, we performed a topic intrusion, specifically a document-to-topic matching task (Appendix E[9]) to assess annotators' ability to match topics to documents (i.e., using the output of BERTopic and the raw text we used to infer the topics from). We set up this task in a novel annotation tool called AnnoTinder (Welbers, 2022), which enabled annotators to quickly perform the tasks. While all 589 topics passed the topic intrusion task, we excluded 41 topics that scored low on confidence on the rating across the six annotators.[10]

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[8] https://osf.io/qhb87/?view_only=

[9] https://osf.io/qhb87/?view_only=

[10] On five-point scales, annotators rated their confidence in their classification either very low or low.

	SM agenda pub.	SM agenda pol.	Dark platform	Traditional media	Total	Total Ext.
SM agenda pub.	52.96	0.16	10.19	1.20	64.50	11.55
SM agenda pol.	12.62	47.22	7.64	1.36	68.84	21.62
Dark platform	3.73	0.03	51.97	0.14	55.86	3.89
Traditional media	31.50	0.83	11.33	48.94	92.60	43.67

Source (left axis label) / **Destination** (bottom axis label)
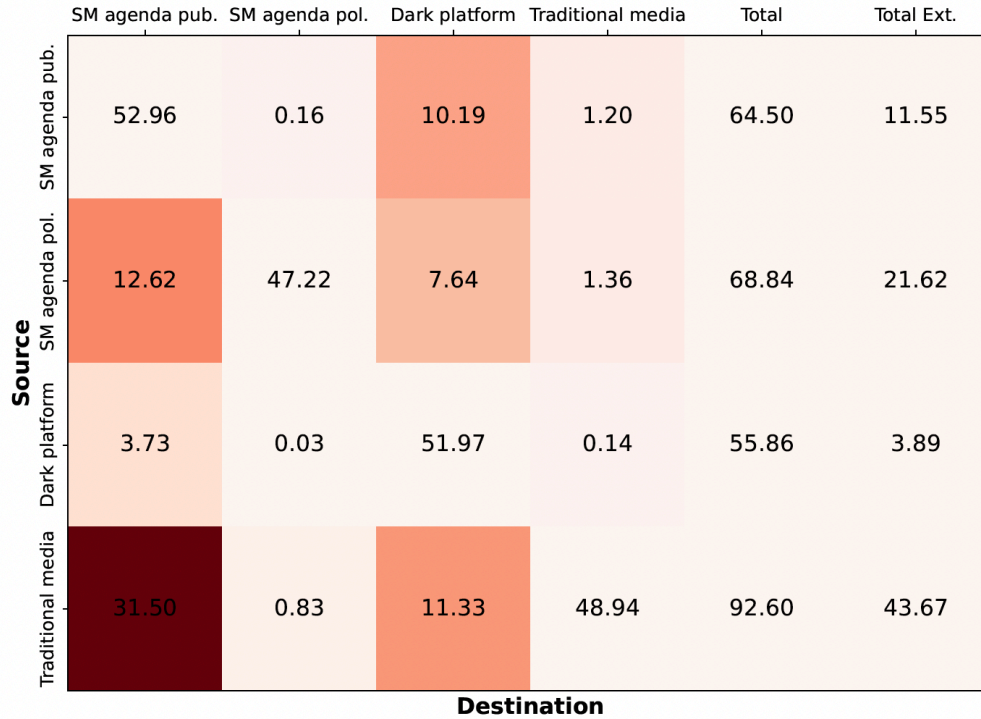
Figure 1. Normalized influence scores (i.e., efficiency) on the agenda level.
Note. Shading not used for self-influence, total influence, and total external influence.

Results of Hawkes Processes

We generated a Hawkes model for each of the validated topics ($N_{validated}$ = 548) both on the aggregate, agenda level, and on the individual, entity level (i.e., Twitter accounts, subreddits, and newspapers). We assumed fully connected models where entities could also influence the rest of the studied agendas as well as themselves. We quantified discursive information flows between agendas using the background rates and impulse responses obtained for each process.

H1: Social Media Agenda and Traditional Media Agenda

To capture discursive information flows across agendas, we turn to efficiency (i.e., normalized influence) scores depicted by Figure 1 (for raw scores, see Appendix F[11]), which indicates each agenda's efficiency in influencing other agendas.

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[11] https://osf.io/qhb87/?view_only=
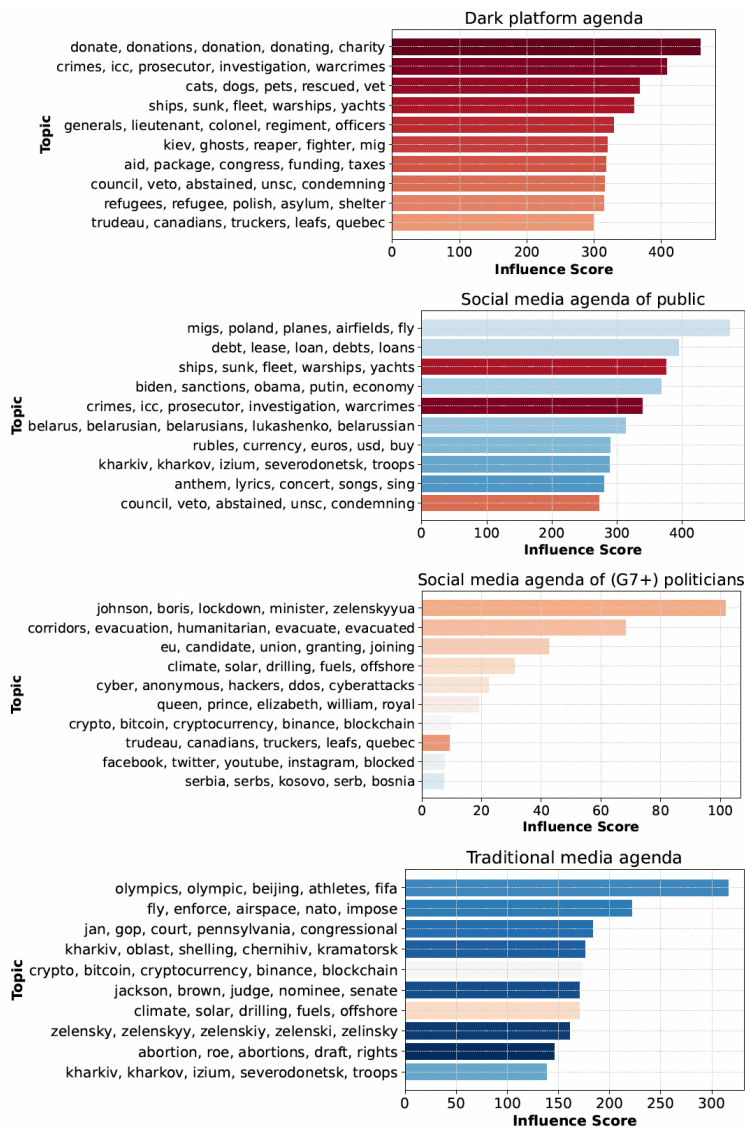
Figure 2. The most influential topics per studied agenda.
Note. Raw scores obtained from Hawkes models per studied agenda.

Scores indicate the expected average number of topics appearing on destination agendas because of topics from source agendas relative to the total number of topics emerging in the source agendas. Higher scores indicate greater discursive information flows from source to destination. The results showed that the traditional media agenda was the most efficient in influencing all other agendas. On average, a topic occurrence on the traditional media agenda led to 43.67 topics occurring on all other studied agendas combined (i.e., *Total Ext.).*

Specifically, the traditional media agenda strongly influenced the social media agenda of the public (31.50 topics), whereas we identified minimal discursive information flows from the social media agenda of the public to the traditional media agenda (1.20). Thus, we found no support for H1, which predicted an inverse relationship between the social media agenda of the public and the traditional media agenda.

RQ1: Discursive Information Flows Across Agendas

The dark platform agenda had the lowest external efficiency score (i.e., Total Ext.: 3.89 topics), exerting minimal influence on the social media agenda of politicians (0.03) and traditional media (0.14). However, we found considerable discursive information flows from the dark platform agenda to the social media agenda of the public (3.73), with nearly four topics emerging there because of previously occurring topics on the dark platform agenda. Overall, the dark platform agenda has some influence on the public's social media agenda but negligible influence on the agendas of politicians and the traditional media. Results showed that 4chan/pol's most influential topics surprisingly align with mainstream agendas. These include discussions on donating, war crimes, aid packages, and refugees (see Figure 2).

The public's social media agenda had a significant impact on the dark platform agenda (10.20) but minimal influence on other agendas. Politicians' social media agendas were the second most influential overall (21.62), notably impacting the public's social media agenda (12.62) and the dark platform agenda (7.64), but less so the traditional media agenda (1.36). Traditional media agenda strongly influenced the public's social media agenda (31.50) and had a moderate impact on the dark platform agenda (11.3), but limited influence on the topics emerging in G7 politicians' social media discourse.
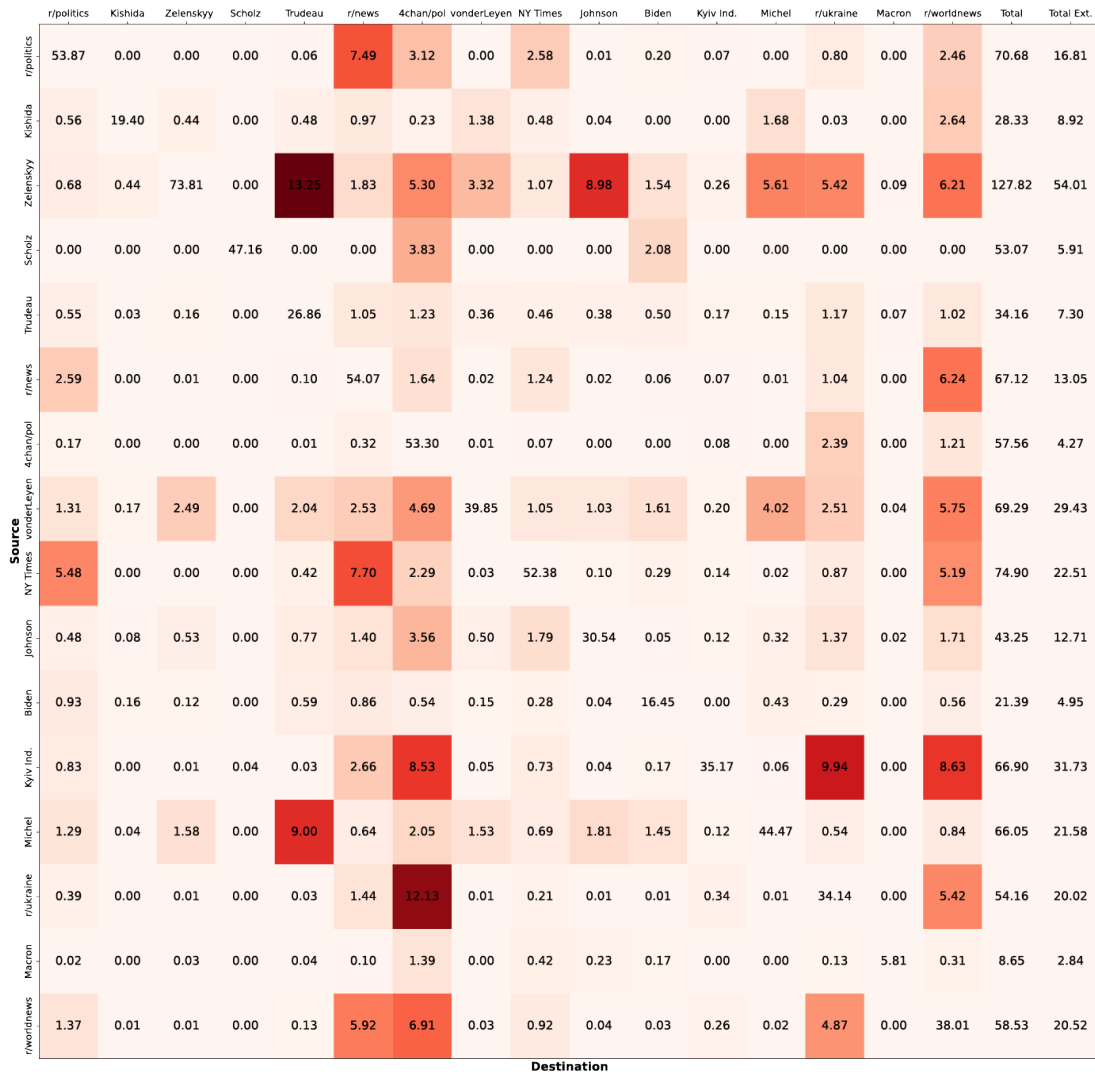
Source	r/politics	Kishida	Zelenskyy	Scholz	Trudeau	r/news	4chan/pol	vonderLeyen	NY Times	Johnson	Biden	Kyiv Ind.	Michel	r/ukraine	Macron	r/worldnews	Total	Total Ext.
r/politics	53.87	0.00	0.00	0.00	0.06	7.49	3.12	0.00	2.58	0.01	0.20	0.07	0.00	0.80	0.00	2.46	70.68	16.81
Kishida	0.56	19.40	0.44	0.00	0.48	0.97	0.23	1.38	0.48	0.04	0.00	0.00	1.68	0.03	0.00	2.64	28.33	8.92
Zelenskyy	0.68	0.44	73.81	0.00	13.25	1.83	5.30	3.32	1.07	8.98	1.54	0.26	5.61	5.42	0.09	6.21	127.82	54.01
Scholz	0.00	0.00	0.00	47.16	0.00	0.00	3.83	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.00	0.00	53.07	5.91
Trudeau	0.55	0.03	0.16	0.00	26.86	1.05	1.23	0.36	0.46	0.38	0.50	0.17	0.15	1.17	0.07	1.02	34.16	7.30
r/news	2.59	0.00	0.01	0.00	0.10	54.07	1.64	0.02	1.24	0.02	0.06	0.07	0.01	1.04	0.00	6.24	67.12	13.05
4chan/pol	0.17	0.00	0.00	0.00	0.01	0.32	53.30	0.01	0.07	0.00	0.00	0.08	0.00	2.39	0.00	1.21	57.56	4.27
vonderLeyen	1.31	0.17	2.49	0.00	2.04	2.53	4.69	39.85	1.05	1.03	1.61	0.20	4.02	2.51	0.04	5.75	69.29	29.43
NY Times	5.48	0.00	0.00	0.00	0.42	7.70	2.29	0.03	52.38	0.10	0.29	0.14	0.02	0.87	0.00	5.19	74.90	22.51
Johnson	0.48	0.08	0.53	0.00	0.77	1.40	3.56	0.50	1.79	30.54	0.05	0.12	0.32	1.37	0.02	1.71	43.25	12.71
Biden	0.93	0.16	0.12	0.00	0.59	0.86	0.54	0.15	0.28	0.04	16.45	0.00	0.43	0.29	0.00	0.56	21.39	4.95
Kyiv Ind.	0.83	0.00	0.01	0.04	0.03	2.66	8.53	0.05	0.73	0.04	0.17	35.17	0.06	9.94	0.00	8.63	66.90	31.73
Michel	1.29	0.04	1.58	0.00	9.00	0.64	2.05	1.53	0.69	1.81	1.45	0.12	44.47	0.54	0.00	0.84	66.05	21.58
r/ukraine	0.39	0.00	0.01	0.00	0.03	1.44	12.13	0.01	0.21	0.01	0.01	0.34	0.01	34.14	0.00	5.42	54.16	20.02
Macron	0.02	0.00	0.03	0.00	0.04	0.10	1.39	0.00	0.42	0.23	0.17	0.00	0.00	0.13	5.81	0.31	8.65	2.84
r/worldnews	1.37	0.01	0.01	0.00	0.13	5.92	6.91	0.03	0.92	0.04	0.03	0.26	0.02	4.87	0.00	38.01	58.53	20.52

Destination

Figure 3. Normalized influence scores: Within-agenda, entity level.
Note. Shading not used for self-influence, total influence, and total external influence.

RQ2: Within-Agenda Discursive Information Flows

To address RQ2, we focused on within-agenda discursive information flows among the 16 entities studied. Volodymyr Zelenskyy's Twitter account emerged as the most influential, driving topic occurrences across various entities (see Figure 3 for within agenda dynamics). His tweets notably influenced the G7 leaders' Twitter accounts, with Justin Trudeau (13.25) and Boris Johnson (8.98) being the most impacted. Zelenskyy's influence extended to r/worldnews and r/ukraine on Reddit but was negligible on NYT and KI. Zelenskyy's strong self-influence (n = 73.81) suggests that his tweets on Ukrainian matters consistently drove subsequent tweets on the same topic.
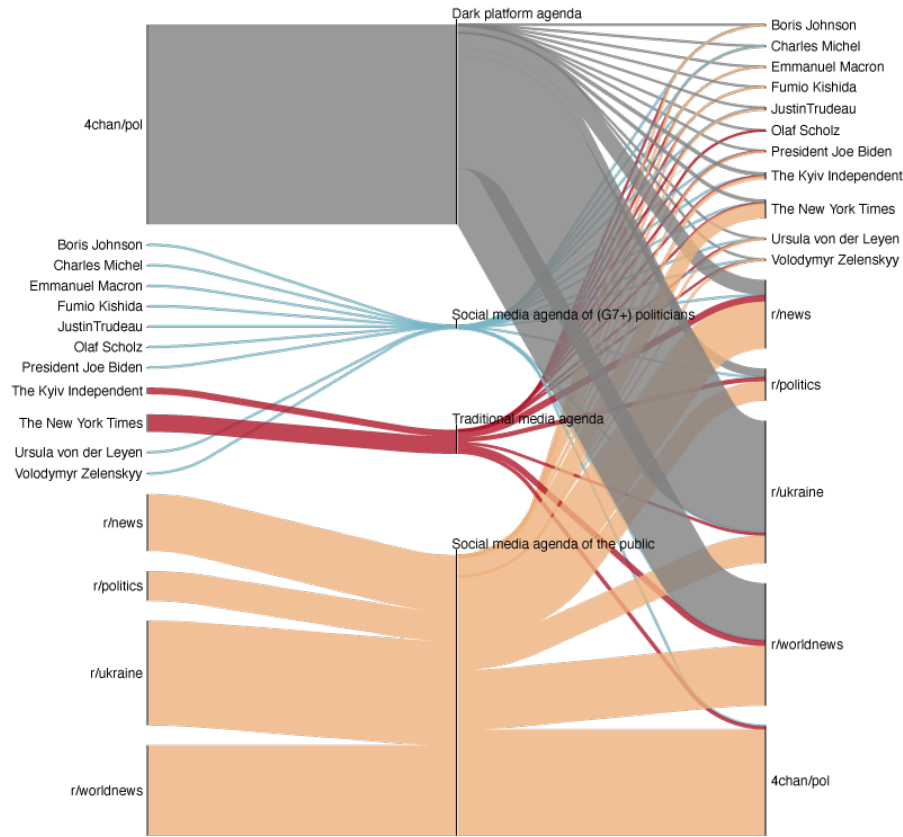
Figure 4. Sankey diagram based on mean influence scores.

Other notable influencers included The *Kyiv Independent* (n = 31.73), The *New York Times* (22.54), prominent Reddit communities ($n_{r/worldnews}$ = 20.52, $n_{r/ukraine}$ = 20.02, $n_{r/politics}$ = 16.81, $n_{r/news}$ = 13.04), and the Twitter accounts of Ursula von der Leyen (29.43) and Charles Michel (n = 21.58). In contrast, 4chan/pol scored high on self-influence (53.3) but had minimal external influence, influencing only news-related subreddits. This suggests that topics on 4chan/pol largely stayed within the platform, reinforcing its own narratives. Figure 4 visualizes the complex dynamics of discursive information flows across and within agendas.

Follow-up Analyses

Since the most influential topics detected on the dark platform agenda seemed harmless, we conducted additional analyses to determine the extent to which the raw text from these influential topics contained harmful language. Using the Perspective API (Perspective API, n.d.) we classified all documents ($N_{classiffied}$ = 32,442) that referred to the top 10 most influential topics on

the studied agendas.[12] The scores for each indicator ranged from 0 to 1, with higher scores indicating a greater likelihood of harmful language use. For instance, a score of 0.8 on the insult indicator means that 8 of 10 people consider the post insulting.

Table 2. The Rate of Harmful Language Indicators per Studied Agenda.

Platform	Toxicity	Severe Toxicity	Identity Attack	Insult	Profanity
Dark platform agenda	22.0%	1.4%	7.9%	15.6%	14.9%
SM agenda of (G7) politicians	0.0%	0.0%	0.0%	0.0%	0.0%
SM agenda of public	6.8%	0.3%	1.2%	4.3%	4.4%
Traditional media agenda	0.4%	0.0%	0.0%	0.3%	0.1%

N = 32,442.

Following best practices, we implemented a threshold-based approach, labeling all scores equal to or above 0.7 as 1 and those below as 0. This enabled us to gauge agenda- and topic-level percentages for each harmful language indicator. In contrast, calculating mean scores alone may inadvertently minimize the impact of the harmful content.

Table 2 shows harmful language indicators across all four agendas. The dark platform agenda exhibited the highest rate of harmful language across all indicators. Using a Kruskal-Wallis test, significant differences were found between the four agendas for toxicity (*teststat* = 7316.163), insult (*teststat* = 9014.841), profanity (*teststat* = 1891.362), severe toxicity (*teststat* = 5098.799), and identity attack (*teststat* = 6520.992), all with *p*-values < 0.001 (Appendix G[13]). Dunn's test confirmed that the dark platform agenda had significantly higher scores on all toxicity-related measures compared with the other agendas. Table 3 depicts the topic-level toxicity-related scores.

Table 3. The Rate of Harmful Language Indicators for Each Topic in the Dark Platform Agenda.

Toxicity	Severe Toxicity	Identity Attack	Insult	Profanity	Topic
26.7%	5.1%	21.3%	17.0%	14.6%	refugees, refugee, polish, asylum, shelter
23.6%	4.9%	13.4%	15.9%	14.7%	donate, donations, donation, donating, charity
24.5%	4.3%	12.2%	16.4%	14.4%	ships, sunk, fleet, warships, yachts
36.5%	9.3%	21.9%	28.4%	23.6%	trudeau, canadians, truckers, leafs, quebec
43.4%	12.0%	29.8%	33.9%	23.9%	cats, dogs, pets, rescued, vet
22.0%	3.7%	10.1%	15.3%	13.5%	aid, package, congress, funding, taxes

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[12] *Note*: *n* = 198 posts of the original data set (*N* = 32,640) could not be classified due to errors related to texts containing languages that are unavailable on the Perspective API.

[13] https://osf.io/qhb87/?view_only=

28.8%	4.5%	17.9%	17.0%	13.3%	crimes, icc, prosecutor, investigation, warcrimes
24.2%	4.2%	11.6%	16.9%	15.1%	council, veto, abstained, unsc, condemning
32.0%	6.8%	18.0%	21.1%	18.1%	kiev, ghosts, reaper, fighter, mig
27.3%	4.7%	13.6%	16.9%	14.0%	generals, lieutenant, colonel, regiment, officers

$N = 14, 341.$

While the most influential topics on the dark platform agenda may seem "innocent," the rate of harmful language provides a more nuanced picture. The language of the posts on all top topics appeared to display substantial rates of harmful language, with some surprisingly high scores for certain topics. For instance, the topic referring to animals had a 43.4% toxicity rate, a 33.9% insult rate, a 29.8% identity attack rate, and a 23.9% profanity rate, which is arguably high. This indicates that these seemingly innocent words may potentially refer to harmful metaphors used to launch attacks on people's identities. Users of 4chan/pol also appeared to discuss fighting in Kyiv in a toxic manner (32.0%).

Conclusion and Discussion

Studying cross-platform and cross-media influence dynamics in the contemporary media system poses a significant challenge to scholars who wish to uncover the extent to which dark platforms influence public debate. Established methodological and theoretical toolkits within communication science are challenged by the complex nature of the hybrid media system, which is characterized by the dynamic interplay across myriad diverse curators of information, from traditional media and social media to the darker corners of the Web. We took a step toward unraveling the complex interplay between various curators of information over time by leveraging theoretical notions and methodological approaches from disciplines with a strong tradition in understanding complex interactions across entities over time. By introducing and testing the concept of discursive information flows, we expanded the scope of intermedia agenda-setting research and gained a more detailed understanding of influence dynamics across and within agendas.

We studied discursive information flows across four agendas and 16 entities during the first six months of the Russian invasion of Ukraine. Using state-of-the-art NLP combined with advanced time-series analysis on a unique multiplatform corpus, we modeled these flows both by topic and by the tone of the original text reflected by toxicity-related scores. Consistent with Langer and Gruber (2021), the traditional media agenda was highly effective in influencing the rest of the studied agendas, demonstrating the continued agenda-setting importance of legacy media. In the context of the early stages of the Russian invasion of Ukraine, the traditional media agenda was leading rather than following.

Our analyses revealed minimal discursive information flows from "darkness to light," and the most influential topics that managed to influence the rest of the studied agendas did not appear immediately harmful. On closer examination, we detected a substantial harmful language rate in the texts that made up the most influential topics on the dark platform agenda. These posts exhibited significantly higher levels of toxicity-related language compared with texts on the other agendas. This is in line with previous work

that emphasized the problematic nature of content emerging on dark platforms, such as 4chan/pol (Rieger et al., 2021).

Echoing Jungherr, Possega, and An (2019), our exploratory findings showed that issue- and topic-level analyses likely sidestep important nuances about language properties such as toxicity, tone, or stance, which can also affect discursive information flows. While it may be a comforting notion that the most influential topics on the dark platform agenda referred to donating, charity, or rescuing pets, it is more concerning that users who encountered these directly on 4chan/pol had a considerable chance of reading or writing about these with harmful undertones. This raises questions about the shareworthiness of these potentially harmful narratives. Are posts with higher toxicity also more influential from the perspective of discursive information flows? Future research should examine whether toxicity-related language features predict the effectiveness of agendas and individual entities in setting the agenda of other entities.

On the bright side, our results highlighted considerable discursive information flows from mainstream agendas to the dark platform agenda, indicating that dark platforms such as 4chan/pol are not necessarily isolated fringe bubbles but are very much connected to the rest of the agendas (Zannettou, 2019) by mostly reacting to topics that first appear on the lighter side of the contemporary media system.

Based on our findings, we believe that rather than creating novel, potentially harmful narratives that may travel beyond the bounds of dark platforms, users who post on 4chan/pol often react to existing topics and narratives from mainstream agendas. These findings speak to the reactive nature of 4chan/pol (Hagen & Venturini, 2023), which may indicate both an innocent "creative vernacular sense" (Rogers & Giorgi, 2023, p. 1) and antagonistic participatory behavior. 4chan/pol's strong self-influence indicates that narratives originating on this platform often remain confined to dark platforms, where they are amplified over time. Future research should identify the tipping point at which these "dark" narratives enter public discourse.

Taken together, we emphasize that expanding the theoretical and methodological toolkit of understanding the hybrid media system through the lens of discursive information flows is crucial to obtaining a more granular understanding of various influence dynamics, not only across agendas but also within them. We must move beyond studying issue, actor, or topic-level influence dynamics (Jungherr Posegga, & An, 2019) to capture not only what different agendas propagate in general, but also how they discuss actors, topics, and issues. As the media landscape continues to evolve, it is imperative to study the influence dynamics of dark platforms on public debate. Platforms that operate outside the traditional understanding of "the public sphere" present unique theoretical and methodological challenges and require specific attention. Uncovering the discursive information flows from dark platforms can reveal narratives and patterns of influence that may otherwise remain hidden.

Expanding on Chadwick's (2017) hybrid media system theory, it becomes evident that understanding the influence dynamics of fringe media, particularly dark platforms like 4chan's /pol/ and Telegram, is essential within the hybrid media system. Although fringe media exist apart from the mainstream, they do not operate in isolation. The interaction between mainstream and fringe platforms creates feedback loops that facilitate the circulation of narratives across the contemporary media system,

influencing public debate. As users increasingly engage with these platforms, their role in influencing narratives and information flows within the broader media system becomes increasingly important.

Limitations and Future Research

The multiplatform nature of our original corpus allowed us to provide unique insights into discursive information flows across very different outlets. However, using multiplatform data from several outlets characterized by very different textual features, publication cycles, and routines resulted in some limitations.

While we successfully extracted valid and interpretable topics from our corpus, our approach had some limitations that may have impacted the results. To account for the mixture of texts in our corpus, we used neural topic modeling. Despite its effectiveness in clustering mainstream content, BERTopic faced challenges when dealing with jargon from darker corners of the Web. A significant portion of documents from 4chan/pol were excluded, indicating that BERTopic is less efficient in clustering jargon coming from the darker corners of the Web together with more mainstream documents from the lighter side of the spectrum, such as established newspapers or tweets of politicians. Future research could treat such jargon as a separate language and train models that "speak this language" to improve the performance of BERTopic in clustering information from the darker corners of the Web together with mainstream content.

Our Hawkes models may have faced challenges because of the slower publication cycles of traditional media compared with the rapid, inconsistent postings on social media. Traditional media's delays, caused by editorial processes and routines, may have led to an underestimation of their influence. The models' assumption of prioritizing closely occurring events could have potentially underestimated the influence of some of the identified influence dynamics involving traditional media. However, we argue that by focusing on topics rather than on finer-grained news events, we were able to somewhat smoothen out such inconsistencies. While this approach may still have introduced some biases in our results about the influence dynamics between the traditional media agenda and the other studied agendas, the alignment of our findings with previous research (Langer & Gruber, 2021) gives us some confidence. Future research should explore models that account for inconsistent publication cycles across media types.

Given limitations in data collection and processing, our study did not incorporate documents from Russian(-language) curators of political information. Future research could expand the scope of our study by incorporating Russian propaganda websites that actively and deliberately spread disinformation. However, this requires overcoming challenges about data collection, processing, and multilingual modeling.

In sum, we set out to integrate theories and methodological approaches from adjacent fields to expand the scope of agenda-setting research by introducing and testing the concept of discursive information flows. The dynamics of the hybrid media system require researchers to borrow methods and theories from other disciplines to reveal complex patterns that would otherwise remain hidden. Using approaches from fields with a tradition of examining dynamic relationships is essential to advancing our understanding of the evolving media landscape. We propose a novel approach to tracing discursive information flows between various curators of political information from darkness to light. This is an important step toward understanding the complex discursive information flows within the hybrid media

system, which play a key role in shaping attitudes, beliefs, and actions on critical issues like the Russian invasion of Ukraine.

Our findings highlight the increasingly important role of alternative media and dark platforms in the contemporary, hybrid media system. Although these platforms exist apart from, or rather as alternatives to, the mainstream, they do not exist in isolation. Studying them independently overlooks their crucial interactions with mainstream media, which are essential to understanding broader media dynamics and opinion formation. Given the growing popularity of dark platforms, along with their increasing integration into the wider media ecosystem, it may be time to reconsider categorizing them as purely "fringe." As these platforms become more connected to mainstream media, revisiting and updating our theoretical frameworks will become crucial to reflecting the evolving dynamics of the media landscape.

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