

Echo Tunnels: Polarized News Sharing Online Runs Narrow but Deep

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Abstract

Online social platforms afford users vast digital spaces to share and discuss current events. However, scholars have concerns both over their role in segregating information exchange into ideological echo chambers, and over evidence that these echo chambers are nonetheless over-stated. In this work, we investigate news-sharing patterns across the entirety of Reddit and find that the platform appears polarized macroscopically, especially in politically right-leaning spaces. On closer examination, however, we observe that the majority of this effect originates from small, hyper-partisan segments of the platform accounting for a minority of news shared. We further map the temporal evolution of polarized news sharing and uncover evidence that, in addition to having grown drastically over time, polarization in hyper-partisan communities also began much earlier than 2016 and is resistant to Reddit's largest moderation event. Our results therefore suggest that social polarized news sharing runs narrow but deep online. Rather than being guided by the general prevalence or absence of echo chambers, we argue that platform policies are better served by measuring and targeting the communities in which ideological segregation is strongest.

Introduction

The rapid adoption of online platforms has helped people connect, converse, and share information with each other across social and geographical boundaries (Bakshy et al. 2012; Ellison et al. 2014). At the same time, these platforms have also become a key means of disseminating and consuming news from traditional media sources in different social contexts. A majority of people in the USA obtain news from some form of social media (Shearer and Gottfried 2017); 31% of adults in the USA, for example, regularly get their news from Facebook (Walker and Matsa 2021). More broadly, social media platforms allow users to generally be exposed to more and wider sources of news than non-users (Fletcher and Nielsen 2018).

However, online platforms are increasingly scrutinized for potentially causing or exacerbating societal problems surrounding the news consumption cycle. There are concerns that online news is largely hyper-partisan and filled with polarizing political biases (Budak, Goel, and Rao 2016;

Bakshy, Messing, and Adamic 2015; Weld, Glenski, and Althoff 2021). Many have argued that this leads to “echo chambers” (Flaxman, Goel, and Rao 2016; Boutyline and Willer 2017) that reinforce existing social silos (Stroud 2008) and limit the extent to which conflicting viewpoints can be reconciled (Sunstein 2018; Pariser 2011). Indeed, news presenting congruent, “co-partisan” attitudes with the reader’s own political affiliation (Hasell and Weeks 2016) and hostile sentiment against opposing groups (Rathje, Van Bavel, and van der Linden 2021; Schmitz, Burghardt, and Muric 2022) is associated with both antagonistic affect and elevated engagement online.

Despite this widespread public apprehension around echo chambers (Sunstein 2018; Pariser 2011), however, large-scale evidence for their existence in and impact on organic news sharing patterns remains mixed. On the one hand, some studies have shown that people tend to be selectively exposed to co-partisan, offline news sources (Stroud 2008) and interact more with politically like-minded individuals (Boutyline and Willer 2017). Others, however, suggest that the effects of selective exposure to news sources are either moderate (Flaxman, Goel, and Rao 2016) or overridden by other social determinants (Messing and Westwood 2014), and that people generally consume cross-cutting news content online (Dubois and Blank 2018; Nelson and Webster 2017; Barberá et al. 2015; Guess et al. 2018; Cinelli et al. 2021; Gentzkow and Shapiro 2011). Indeed, it even remains unclear whether cross-cutting content would alleviate (Bakshy, Messing, and Adamic 2015; Pariser 2011; Sunstein 2018) or worsen (Bail et al. 2018; Rathje, Van Bavel, and van der Linden 2021) polarized behaviors online.

Thus, to what extent does the sharing of news on online platforms fall within partisan, ideologically-isolated social contexts? To address this research question, we quantify the relationship between the partisan biases present in both news producers, for which we study articles from Allsides-rated news sources, and news consumers, for which we investigate users of the Reddit platform. Our work presents a large-scale analysis of how partisanship in social news-sharing has evolved over 8.5 million articles shared on Reddit leading up to June 2021, for which we combine measures of partisan ideologies across established media organizations provided by Allsides (Rathje, Van Bavel, and van der Linden 2021; Ribeiro et al. 2018; Robertson et al. 2018; Baly et al.

2020) and Reddit’s user communities derived from a neural embedding technique (Waller and Anderson 2021). To our knowledge, this is the first complete, longitudinal study of news consumption on the platform that considers every community’s partisan affiliation, both explicitly stated and implicitly imputed via the embedding method.

Overview of results. We observe three key characteristics of polarized news sharing. From a macroscopic perspective, we find that news is shared in asymmetrically co-partisan social contexts, with right-leaning news being shared disproportionately more in right-leaning communities. This is consistent with existing findings of asymmetric polarization in online news, both real and fake (González-Bailón et al. 2022; Rao et al. 2021; Rao, Morstatter, and Lerman 2022). However, at a more granular level, these behaviors are concentrated in a small fraction of the platform. A handful of explicitly hyper-partisan communities accounts for the majority of segregated news sharing, suggesting that the most extreme echo chambers are likely narrow and deep (Guess, Nyhan, and Reifler 2018, 2020). Furthermore, we map the process of polarization, i.e. how co-partisanship has evolved over time, and find that it rose sharply in late 2015 to a peak in 2017. There is evidence that polarization began earlier in 2012 for right-leaning news and is unaffected by platform moderation events. Nonetheless, like our findings on hyper-partisan communities, this also occurs mainly for the most hyper-partisan news sources.

Our work thus supports claims that the aggregate effects of echo chambers on online platforms are limited. However, it also provides crucial context that polarization runs deep within narrow, hyper-partisan spaces, to the extent that political news sharing on the platform appears deceptively polarized at the macroscopic level. Thus, although Reddit does not consist of a singular echo chamber (c.f. De Francisci Morales, Monti, and Starnini 2021), ideologically-similar news is still echoed within hyper-partisan tunnels running under the platform’s surface. Taken together, our findings suggest that platform policies may be better informed by the existence of these strands of deeply polarized news-sharing patterns, rather than the absence of universally co-partisan behaviors.

Background

Our work builds on a growing body of research on the societal implications of online news sharing. For instance, there is widespread concern that hyper-partisan news sharing may lead to polarized communities and ideological echo chambers (Bakshy, Messing, and Adamic 2015; Weld, Glenski, and Althoff 2021; Flaxman, Goel, and Rao 2016; Boutyline and Willer 2017; Sunstein 2018; Pariser 2011). However, evidence for the prevalence of echo chambers is inconsistent, with the maxim that they threaten societal cohesion punctuated by claims that they are actually over-stated (Dubois and Blank 2018; Nelson and Webster 2017; Cinelli et al. 2021; De Francisci Morales, Monti, and Starnini 2021). In parallel to this inconsistent descriptive evidence of echo chambers online, there is also no general consensus on whether promoting cross-cutting content – i.e. opposing ideologies – is

normatively desirable. While some assume that exposure to diverse viewpoints may help reduce extreme attitudes (Bakshy, Messing, and Adamic 2015; Pariser 2011; Sunstein 2018), other studies also show that cross-cutting and out-group content may actually increase polarization (Bail et al. 2018; Rathje, Van Bavel, and van der Linden 2021).

Furthermore, concerns about news sharing online extend beyond political and ideological segregation. For instance, research has also highlighted the threats of online misinformation (Grinberg et al. 2019; Allcott, Gentzkow, and Yu 2019) and provided evidence for negative effects on well-being (Boukes and Vliegenthart 2017; Allcott et al. 2020). And yet, while reducing social media usage can help moderate polarization and well-being, it does so at the expense of factual knowledge about political issues (Allcott et al. 2020).

Together, this literature on the societal implications of online news highlights the need to form a clearer understanding of how people read and share news *in situ* on social platforms. On the one hand, we have an imperfect understanding of whether echo chambers are widespread online. On the other, it is unknown whether this is a result of limited generalizability in existing work. For example, phenomena observed in self-reported news readership habits at small scales often do not align with what people actually consume online in general (Konitzer et al. 2021).

We therefore measure partisanship in news sharing on the *entire* Reddit platform, described as the “Front Page” of the Internet (Singer et al. 2014). On Reddit, millions of users organize themselves into thousands of discrete online communities sharing common interests and moderation norms (Chandrasekharan et al. 2018). Here, we quantify the *implicit* partisanship of communities by how much they share similar user-bases with political communities (Waller and Anderson 2021). This contrasts with other methods considering only explicit partisanship via community names like *r/democrats* and their “About” information (Soliman, Hafer, and Lemmerich 2019; An et al. 2019; Cinelli et al. 2021; De Francisci Morales, Monti, and Starnini 2021). Similarly, partisanship on Twitter is often quantified by networks formed by sampling followers of political figures (Boutyline and Willer 2017) and retweets of on- and off-platform content (Barberá et al. 2015). On Facebook, partisanship can be inferred from samples of users’ self-reported affiliation (Bakshy, Messing, and Adamic 2015).

Method

We obtained all user activity on Reddit between January 2008 and June 2021 via Pushshift.io. Users interact with the platform by posting top-level content (“*submissions*”) into individual communities (“*subreddits*”), on which users can post shorter “*comments*” in threads of discussion. To identify news-sharing behaviors, we obtained a list of news sources labelled by Allsides.com, an organization that provides fact-checking and ideological bias ratings for common media sources (Rathje, Van Bavel, and van der Linden 2021; Ribeiro et al. 2018; Robertson et al. 2018; Baly et al. 2020). We match Allsides-rated Web domains to Reddit submissions linking directly to external websites, such as *nytimes.com*, *mobile.nytimes.com*, and *nytimes.com* for New

Left (-2)	Lean Left (-1)	Center (0)	Lean Right (+1)	Right (+2)
Alternet	ABC News	Associated Press	The Epoch Times	The Blaze
Buzzfeed	The Atlantic	Axios	New York Post	Breitbart News
CNN	Bloomberg	The BBC	Newsmax	The Daily Caller
The Daily Beast	CBS News	CS Monitor	Reason	The Daily Mail
Democracy Now	The Economist	Forbes	Washington Examiner	The Daily Wire
HuffPost	The Guardian	The Hill	Washington Times	The Federalist
The Intercept	NBC News	Newsweek		Fox News
Jacobin	The New York Times	NPR		Fox News Insider
Mother Jones	Politico	Reuters		National Review
MSN	Time	Wall Street Journal		One America News
The New Yorker	USA Today			The Spectator
Slate	Washington Post			
Vox				

Table 1: Overview of news sources submitted to Reddit and their Allsides ratings at time of analysis (2022).

York Times articles. In total, we considered 177 websites that matched to 53 news organizations.

We further attenuate automated activity in two steps. We first under-sample commenting activity of users whose comment frequencies are in the top 0.1% of Redditors so that they remain within the remaining 99.99% (in our data, sampling up to 141 comments each month from users with > 141 comments per month). We then discard submissions with fewer than 2 comments and a upvote-to-downvote score of 2. This ignores posters who comment on and upvote their own posts, further limiting our dataset to news articles that have been exposed to other Reddit users. Altogether, our resulting dataset contains 4.97M unique URLs from Allsides-rated sources across 8.50M submissions.

Community embedding. We further use a community embedding developed to model community relationships from user behaviors in a high-dimensional space (Waller and Anderson 2021; Kumar et al. 2018; Martin 2017). While existing work often focuses solely on explicitly political communities (An et al. 2019; Rajadesingan, Resnick, and Budak 2020; De Francisci Morales, Monti, and Starnini 2021), this embedding method applies to the entirety of Reddit and enables us to characterize the political biases of seemingly apolitical communities like *r/technology* and mildly right-leaning subreddits like *r/malelifestyle*. This embedding is also granular, whereas existing work often can only binarize *if* a subreddit is right- or left-leaning, and not measure *how* right- or left-leaning it is. Thus, to this end, we use a modified version of word2vec for word embeddings that allows for arbitrary word contexts, instead of only a fixed-sized window (Levy and Goldberg 2014). Conceptually, textual documents in word2vec are replaced with user commenting traces such that users are “sentences” forming contexts for subreddits as “words”. Thus, two communities are closer in this embedding if they share more users who participate in both of them by posting comments.

Hyper-parameters are then tuned using community analogies, specifically sports teams to their respective sports, teams to their cities, and universities to cities; e.g. querying

r/columbia:r/nyc::USC:? should yield *r/LosAngeles*. This follows established work on community embeddings adapting analogy-based tuning methods from language models, which are known to effectively capture semantic relations between communities (Martin 2017; Waller and Anderson 2021). The training process led to an alpha of 0.18, a negative-sampling parameter of 35, sampling rate of 0.0043, dimensionality of 150 with shuffled comment ordering. Note that the embedding is trained using *all* Reddit comments in the 10k communities with the most activity, and not just the submission histories linking to Allsides mentioned above. This allows the embedding to more holistically capture behavioral patterns beyond those containing news links.

Measuring Ideological Biases

We consider two aspects of ideological biases in news sharing: partisanship in the sources from which news is produced, and partisanship in the social communities in which news is consumed. We use Allsides ratings and embedding partisanship scores respectively to measure these biases in news articles shared on Reddit.

Media partisanship. To operationalize ideological partisanship in news coverage – or *producer-side* news contexts – we directly use the bias labels l_A from Allsides for each featured news association A , which ranges from -2 to $+2$ for the US political left to the US political right (Table 1). For an article $a \in A$, its media partisanship l_a is therefore defined directly by the Allsides rating of its publishing organization A . This has been used throughout existing work on ideological biases in sociotechnical systems (Ribeiro et al. 2018; Robertson et al. 2018), and recent evidence suggests that different choices of news labels generally yield similar results for fact-checking tasks¹ (Bozarth, Saraf, and Budak

¹We also ran a secondary set of analyses using Media Bias Fact Check ratings (<https://mediabiasfactcheck.com>) and found qualitatively almost identical results. The main differences were in smaller news sources on Reddit (Figure 1) being labelled as more partisan by MBFC than Allsides. Newsmax, the Epoch Times, the Washington Examiner are rated +1 by Allsides but +2 by MBFC; Forbes,

2020; Weld, Glenski, and Althoff 2021).

Social partisanship. To operationalize ideological biases in social settings – or *consumer-side* news contexts – we additionally compute a social “partisanship” score for each community by using the community embedding. We first compute the cosine similarity between each community’s embedded vector and an “index” vector between polar opposite partisan communities, specifically *r/progressive* and *r/Conservative*. This pair was chosen as they have identical interests (American politics) but differ only in one aspect (partisanship), and the resulting cosine similarities are highly correlated to cosine similarities when using other pairs like *r/askhillarysupporters* and *r/AskTrumpSupporters* (Waller and Anderson 2021).

Formally, given a community c in the set of 10k communities C , its embedded vector \vec{c} , and the partisan vector \vec{v} , c ’s partisanship z -score is given by $z_c = \frac{\gamma_c - \bar{\gamma}}{\sigma(\gamma)}$ where $\gamma_c = \text{cossim}(\vec{c}, \vec{v})$, and $\bar{\gamma}$ and $\sigma(\gamma)$ are respectively the mean and standard deviation of the cosine similarities across C . This is equivalent to answering: how many standard deviations to the political left or right is community c , relative to the mean subreddit? For context, the three closest communities to $z = 0$ are respectively *r/UWMadison*, *r/matt* (a subreddit dedicated to mentions of Matt or Matthew), and *r/ukulele*. In comparison, *r/Conservative* ($z = 5.82$) and *r/democrats* ($z = -4.67$) are the most partisan communities on either side of the spectrum.

A news article’s social partisanship is therefore given by a weighted mean over the partisanship scores of the embedded communities in which it appears. Given an article a from a news source A appearing $n_{a,c}$ times in a community c with score z_c , its *article-level* social partisanship is given by $\phi_a = \frac{1}{N_a} \sum_{c \in C} n_{a,c} z_c$ where $N_a = \sum_{c \in C} n_{a,c}$. Correspondingly, we also measure the *source-level* social partisanship ϕ_A of each news association A as a sum over its articles $\phi_A = \frac{1}{N} \sum_{c \in C} \sum_{a \in A} n_{a,c} z_c$, where $N = \sum_{c \in C} \sum_{a \in A} n_{a,c}$. The interpretation of ϕ_a and ϕ_A , respectively, is therefore: how many standard deviations to the political left or right are the communities c in which a (or A) appears, on expectation?

Temporal metrics. In addition to these static measures of news and social partisanship, we also trialled dynamic versions for temporal analyses. For social partisanship, we compute individual partisan scores $\phi_{A,t}$ per news source, per month, by re-weighting using $n_{a,c,t}$ each t th month, which replaces $n_{a,c}$ in the definition of ϕ_a . Note that we use the same z -scores from the single embedding generated by all Reddit comments described above, rather than methods like diachronic embeddings that embed individual timeslices separately (Hamilton, Leskovec, and Jurafsky 2016). This enables us to quantify the partisanship of articles at each t relative to all of Reddit at all times, rather than relative to Reddit at the t th month only. Additionally, a single em-

bedding using all data will be less susceptible than temporal embeddings to confounders in, for example, transient activity surges in topical subreddits. For news partisanship, we experimented with yearly Allsides ratings to capture fluctuations in how, e.g., CNN shifted towards the political left in recent years. This led to qualitatively very similar results to using static news labels, so for ease of interpretation we present findings with static labels².

Results

Before considering the individual subreddits in which articles appear, we first characterize the distribution of different news sources on Reddit as a single community. How do news-sharing behaviors on Reddit *overall* differ between time frames and news sources? Figure 1(a) depicts the distribution of submissions across months on the platform, the cumulative fractions for which are shown in (b). We find several general patterns. Firstly, after rapid activity growth ending in mid-2017, news articles on Reddit from Allsides-rated sources have been submitted at a stable, consistent rate on aggregate. Secondly, centrist and moderately left-leaning sources make up the bulk of news sharing on Reddit, together accounting for more than 60% of articles on Reddit. Thirdly, despite making up fewer than 10% of news prior to 2016, moderately and explicitly right-leaning news sources grew to 20% of news shared on Reddit between 2016 and 2020. Although they still form a much smaller fraction than the grey and light-blue area in Figure 1, the growth in the light-red and red area diluted the presence of explicitly left-leaning, blue news sources.

These observations about news on Reddit provide a baseline for the amount of news shared on the platform that are generated by different news producers and, therefore, are published in different media contexts. Based purely on the *amount* of partisan news from left-leaning sources shared on Reddit, the platform appears to be moderately left-leaning. Considering Reddit’s generally liberal demographics as measured by recent surveys (Walker and Matsa 2021; Vogels, Auxier, and Anderson 2020), this suggests that news-sharing by Redditors – as a singular left-leaning population – is co-partisan. Nonetheless, such a conclusion ignores the vast diaspora of political ideologies housed by the platform, especially when subreddits can be explicitly antithetical (e.g. *r/The_Donald* and *r/hillaryclinton*).

Partisan News in Partisan Social Contexts

Thus, how are news articles from different established media organizations shared across the *different social contexts*

²See <https://www.allsides.com/blog/how-allsides-media-bias-ratings-have-changed-over-time>. The main noticeable difference in our experiments is that the +2 line in Figure 5(a) does not recede as much after late 2017, which we find is because the Epoch Times, Newsmax, the New York Post, and Washington Examiner dropped from +2 to +1, leaving more extreme sources in the +2 group. Additionally, Fox News was considered +1 between 2017 and 2020, removing another source of decline in the +2 line (see Fox line in Figure 5(b)). Beyond this, however, our results and their interpretation do not change substantially.

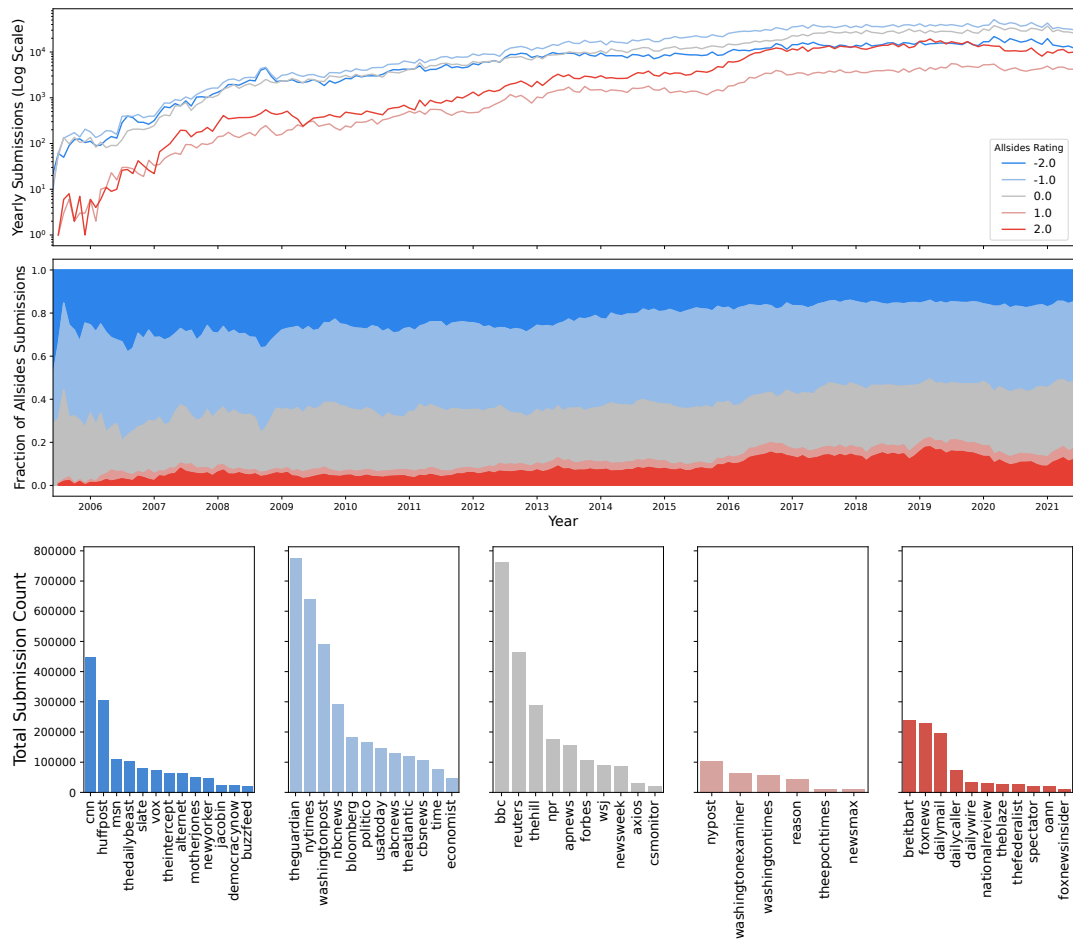


Figure 1: *Top (a)*: Number of articles (non-unique) from Allsides-rated sources shared to Reddit each month. *Middle (b)*: Monthly share of news articles on Reddit by sources under each Allsides label. *Bottom (c)*: Total number of submissions linking directly to an Allsides source grouped by Allsides label.

on Reddit? We turn to our main analysis: the relationship between news producer and news consumer ideological biases on Reddit. Figure 2 depicts each news source’s ideological biases, measured by Allsides, and social biases, measured by the partisanship of the communities in which they appear.

We find two consistent patterns. Firstly, with media partisanship measured through Allsides ratings l_a being strongly correlated to the embedding social partisanship metric ϕ_a ($r = 0.92$), there is a substantial amount of *co-partisan* news sharing globally across all of Reddit. In other words, biases in news sources l_a and biases in online communities ϕ_A agree – left-leaning news is more likely to be consumed by left-leaning communities, and likewise for right-leaning news. Visually, this is evident by the split of red and blue dots respectively to the right and left of $\phi = 0$. Note that this does not account for actual content, i.e. *what* is written directly in articles. Nonetheless, assuming that both news sources and online laypeople frame current events within their partisan viewpoints, our results suggest that *where* news is produced and consumed may form echo chambers on the basis of co-partisan discursive norms.

A second pattern in Figure 2 is that co-partisan news consumption is heavily asymmetrical between the political left and right on Reddit. While left-leaning news sources all appear in contexts that are within one standard deviation to the left of center (except Mother Jones, $\phi = -1.04$), right-leaning news sources are consumed in extremely right-leaning social contexts. Only New York Post ($\phi = 0.66$), Reason ($\phi = 0.80$), and The Daily Mail ($\phi = 0.82$) fall within one standard deviation to the right of center. Because z -scores are calculated relative to all of Reddit (such that if a specific community’s score were $z = 1$, then it is one standard deviation to the right of all communities’ mean partisanship score), this demonstrates the extreme skew in right-leaning co-partisan news-sharing contexts. In other words, the consumption of news from moderately right- and far right-leaning outlets occurs within right-leaning social contexts that are relatively extreme compared to the rest of Reddit. There is *no left-leaning equivalent of Breitbart and The Daily Wire* on this account of producer-consumer, traditional-social media co-partisanship. These results suggest that purely producer-side partisanship ratings that label,

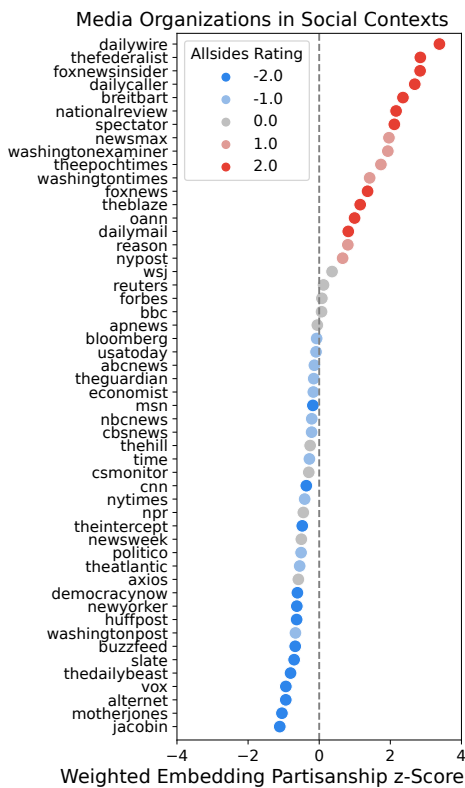


Figure 2: Traditional media organizations by the aggregated partisanship scores of the communities in which they are shared. Communities are given individual z -scores normalized over all of Reddit before aggregating by news source.

say, The Huffington Post as the polar opposite of Breitbart may not sufficiently capture skewed ideological biases in actual news consumer contexts.

How do these two patterns of news consumption on Reddit relate to existing evidence about potential ideological echo chambers on online platforms more broadly? Our work provides additional large-scale, empirical support both to existing work on co-partisan consumption of news (Flaxman, Goel, and Rao 2016; Boutyline and Willer 2017; Hasell and Weeks 2016) and to recent studies on asymmetric online behaviors among the political right (Eady et al. 2019; Soliman, Hafer, and Lemmerich 2019; Rao et al. 2021). In this sense, the news consumption patterns we uncover are therefore consistent with echo chambers formed by people discussing news with similar ideological biases.

However, this co-partisanship may not apply evenly across the entire online platform beyond its explicitly political spaces. If ideological echo chambers were to exist, do they arise homogeneously across Reddit as a whole? While Figure 2 corroborates existing evidence of co-partisan news-sharing behaviors, it does not distinguish, for instance, between posting behaviors in partisan and non-partisan communities. We therefore disaggregate our co-partisanship analysis by separating explicitly partisan communities from non-partisan communities. We considered the

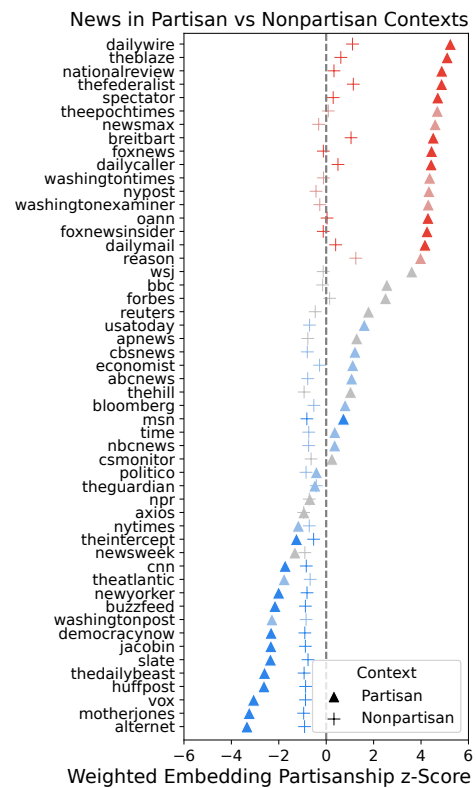


Figure 3: Disaggregation of Figure 2 by news sources shared in explicitly partisan versus nonpartisan communities.

50 communities with the highest and lowest partisanship scores, and manually checked whether their Reddit descriptions contain either explicit support for or rejection of either 1. the Republican or Democrat parties, or 2. Republican or Democrat politicians (including affiliated individuals like Bernie Sanders). This yielded 32 explicitly left-wing subreddits, e.g. *r/hillaryclinton* ($z = -4.09$) and *r/RussiaLago* ($z = -1.65$), and 18 explicitly right-wing subreddits, e.g. *r/HillaryMeltdown* ($z = 2.74$) and *r/The_Donald* ($z = 4.37$). Together, these partisan communities account for 10.4% of Allsides-linked submissions on Reddit.

Figure 3 illustrates the social biases of news sources, split by whether communities are explicitly partisan (triangles) or not (crosses). Although we still find co-partisan media-social ideological alignment in non-partisan communities, the range of scores is substantially curtailed with Reason ($\phi = 1.25$) and Mother Jones ($\phi = -0.95$) being the furthest poles. However, partisan news sharing is drastically amplified in partisan communities, with every right-leaning source scoring above $\phi = 4$ and The Daily Wire reaching $\phi = 5.24$. Of all news sources, only 9 out of 48 had partisanship scores within 1 standard deviation of the center when only considering partisan communities. In non-partisan communities, all sources except Breitbart ($\phi = 1.04$), The Daily Wire ($\phi = 1.11$), The Federalist ($\phi = 1.14$), and Reason ($\phi = 1.25$) fell within 1 standard deviation.

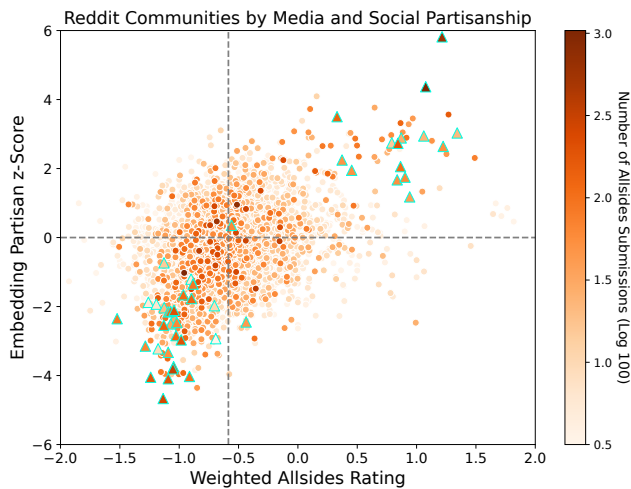


Figure 4: Communities with at least 10 submissions linking to Allsides news articles, scattered by their Allsides media partisanship (x -axis) and embedded social partisanship (y -axis). Partisan communities shown as blue triangles; means shown in dotted grey.

Thus, while news sharing on the platform appears to be partisan and polarized from the bird’s eye view of Figure 2, this is largely mild in the majority of communities without obvious partisan affiliation. However, co-partisan news sharing is pervasive within the narrower space of hyper-partisan communities, to the extent that they distort Reddit from a macroscopic perspective. This occurs despite partisan communities only accounting for 10.4% of all news shared, and is asymmetrically larger for right-leaning media organizations and social contexts.

Communities by partisan news sharing. Our analyses thus far highlight the asymmetric, co-partisan relationship in the ideological biases surrounding each news source on Reddit, both with respect to the publishing organization and to the communities of news readers. Nonetheless, these results only measure media and social partisan biases for *news publishers*. One may expect that *news consumers* would also share co-partisan news articles. A complementary question is therefore: to what extent do different communities of news readers share co-partisan news sources?

In order to address this question, we consider communities, instead of news sources, by their media and social partisanship metrics. To measure *media partisanship* for a given community c , we use a mean over the Allsides labels l_a of each article a posted in the community weighted by number of submissions. In other words, for each community c , its media partisanship is $l_c = \frac{1}{N_c} \sum_a l_a n_{a,c}$, where $N_c = \sum_a n_{a,c}$ ³. To measure *social partisanship* we directly use the embedding partisan scores z_c for each community c .

³Note that media partisanship in communities is measured analogously to social partisanship of news sources, i.e. ϕ_a , but with embedding scores z_c swapped for Allsides labels l_a and news sources a swapped for subreddits c .

Figure 4 illustrates communities with at least 10 submissions linking to Allsides-rated news sources ($N = 4409$) scattered according to both of these partisanship measures. We find there to be a vast amount of variance in the weighted Allsides metric and embedding scores, leading to only a slight correlation *at the community level* ($r = 0.36$). However, this relationship is significantly closer ($r = 0.86$) for the 50 explicitly partisan communities previously identified. This again reinforces our previous findings: there is substantial co-partisan, polarized sharing of news online, but co-partisanship is only concentrated within a minority of political communities.

Furthermore, we find additional evidence of asymmetric co-partisanship between the political left and right at the community level. Consider *r/Conservative* and *r/progressive*, the polar communities used to determine the partisanship vector in the Reddit embedding, which respectively score $z = 5.82$ and $z = -4.05$ on the social partisanship score. Here, they respectively obtain $l = 1.21$ and $l = -1.24$ on the media partisanship measure. Against a mean media partisanship of $l = -0.59$, *r/Conservative* lies 2.76 standard deviations to the right of the mean compared to and *r/progressive*’s -1.09 standard deviations. This further highlights the skewed media co-partisanship for the right-most community. Similarly, *r/The_Donald* and *r/hillaryclinton* respectively have media partisanship scores of $l = 1.08$ and $l = -0.86$, representing 2.62 and -0.78 standard deviations respectively. Thus, co-partisan news consumption is most prevalent among both strongly right-leaning news sources and strongly right-leaning communities, relative to left-leaning sources and communities.

This is reflected in the likelihood of exposure to sources with similar ideologies in the most partisan communities. For example, the probability of a random news article drawn from *r/Conservative* being from a far-right source is 0.61, whereas the probability of a random far-left article drawn from *r/progressive* is 0.43. Indeed, the odds of sharing extreme co-partisan news is generally asymmetric, with news in right-wing communities being more likely to be far-right (odds of 0.45) than news in left-wing communities being far-left (odds of 0.33; $p = 0.002$ in an unpaired t -test).

Together, these findings of co-partisanship based on individual online communities reinforce our results for individual news sources. Co-partisanship patterns are, again, more evident in right-leaning social contexts. Outside of the hyper-partisan segments of Reddit, however, co-partisanship is mild. This provides further evidence that echo chambers are unlikely to be pervasive, and instead run deep in narrower, hyper-partisan spaces of the platform.

The Evolution of Polarization

Our results so far paint a static picture of how traditional media sharing in online social contexts can be colored by co-partisan ideological biases. News-sharing behaviors, however, are dynamic and often change in complex ways over time. To investigate the evolution of partisan social contexts around news sharing, we compute monthly partisanship scores $\phi_{A,t}$ for news source on the platform. The resulting temporal scores indexed by month are shown in Figure 5,

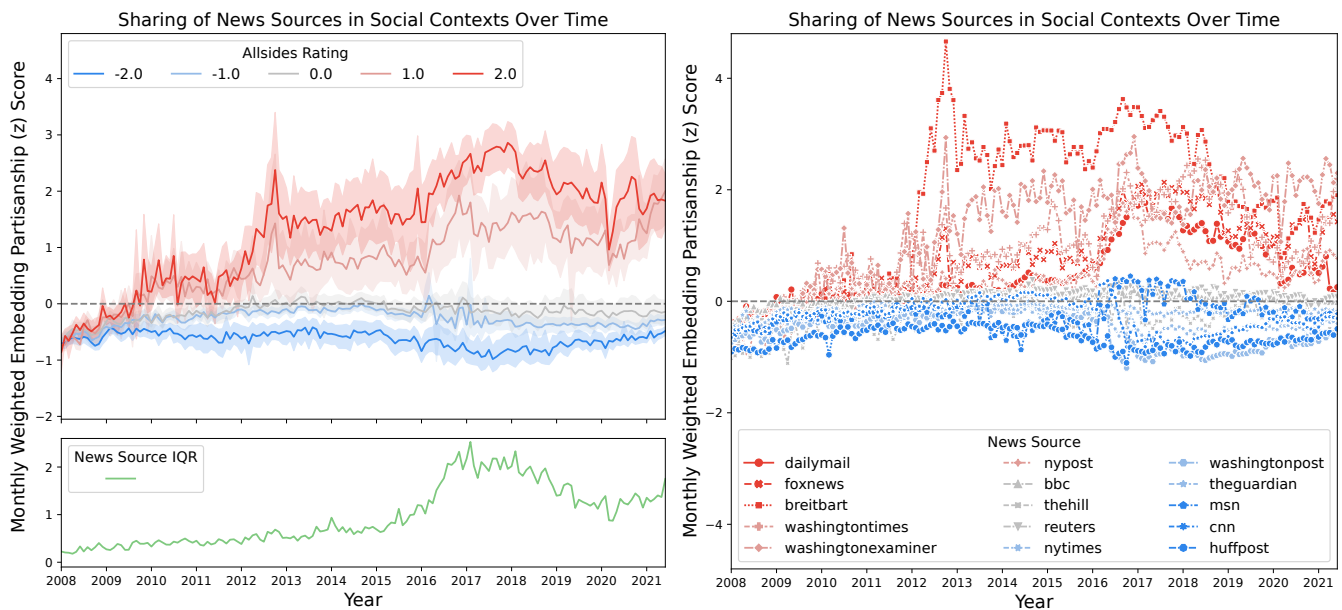


Figure 5: *Left (a)*: Temporal patterns in news sharing contexts. Monthly embedding partisanship scores are aggregated by news organizations under the same Allsides label with a 95% CI. *Right (b)*: The same patterns disaggregated into the three most shared news sources within each Allsides label.

split respectively by Allsides rating (a) and the top 3 news sources per Allsides rating by appearances (b). We again observe skewed co-partisan news-sharing behaviors that persist over time, with right-leaning news sources being asymmetrically shared in more right-leaning social contexts. However, we find three additional dynamics in these patterns.

Increasing and asymmetric polarization. Firstly, co-partisan news consumption increases across our trace, indicating that the platform *became polarized* over time. In Figure 5, each group of news sources with an Allsides-labelled partisan bias shifts outwards over time, culminating in maximal displacement from $y = 0$ in late 2017 and early 2018. Very left-leaning news sources were, at the most extreme, consumed by people in communities scoring $\phi = -0.99$ to the left of center on Reddit in August 2017, compared to $\phi = -0.77$ and $\phi = -0.62$ a year and two years before respectively. Very right-leaning sources similarly, but asymmetrically, peaked at $\phi = 2.81$ in December 2017 compared to $\phi = 2.58$ and $\phi = 1.67$ the two Decembers before.

As an aggregate measure of polarization, consider the inter-quartile range (IQR) of the partisan scores between individual news sources (green line in Figure 5, represented as a delta between ϕ). Until December 2015, the partisanship IQR remained within $\Delta\phi = 1.00$, indicating that most news sources were shared in communities that fall within a narrow ideological band. In contrast, the IQR peaks at $\Delta\phi = 2.44$ in February 2017 coinciding with then-President Donald Trump’s assumption of office and the formation of his cabinet. This indicates a dramatic partisan widening of media organizations over time: 50% of sources were shared in contexts separated by a partisanship gap of more than 2 standard deviations. Right-wing news sources contribute most to this

polarization, with outlets like Breitbart being consumed in *very* right-leaning communities across most of this period in Figure 5(b). Thus, we find that the news-sharing behaviors in Figure 2 become increasingly co-partisan and asymmetric on the political right when they are broken down by time frames.

2016-17 as a (misleading) focal point. It would therefore appear that 2016 is a focal point for polarization in news consumption because co-partisanship increases sharply leading up to the US Presidential Election. And yet, Figure 5(a) provides some evidence that far-right sources already began appearing in seemingly polarized co-partisan contexts in late 2012. We find that this is likely due to the early growth of the *r/Conservative* community, illustrated as the uppermost, most socially right-leaning point at $x = 1.21, y = 5.82$ in Figure 2(b). From January to October 2012, links to Allsides-rated news sources in the subreddit grew almost monotonically from 402 to 3950, with Breitbart links specifically jumping from 3 to 206 per month. In comparison, Breitbart articles were only shared 19 times in *r/POLITIC* in October, at the time the subreddit with the second most Breitbart submissions.

Thus, the role of *r/Conservative* as the community with both the most right-leaning partisan score and most of the shares of Breitbart articles in 2012 drove the sharp spike visible in Figure 5(b). These observations show that polarization of news consumption may significantly predate the 2016 election (Moody and Mucha 2013), which may otherwise be seen as a catalyzing point for ideological division in US politics. However, they again show that early polarization is not broadly prevalent across the platform, and is instead driven by skewed sharing of (at the time) fringe news

sources in a relatively fringe subreddit with extreme partisanship. Like our results about the *heterogeneously partisan* news sharing on Reddit in Figures 2 and 3, our current findings also illustrate that polarized news sharing occurs *heterogeneously early* in those communities.

In spite of this, however, our results in Figure 5(a) also suggest that the polarized, partisanship gap in news sharing has receded since its peak in February 2017. We tested this using piece-wise regressions between partisan scores and month indices around February 2017. Positive regression coefficients indicate that social partisanship scores grew with the same sign as news sources' Allsides ratings – i.e., that they became shared in increasingly polarized social contexts. For example, if $\beta = 0.1$ for a news source, then that news source was shared in increasingly co-partisan subreddits at the rate of 0.1 standard deviations each month.

As expected, co-partisan sharing of far-right news sources became more polarized leading up to February ($\beta = 0.02$, $p < 0.001$), and then decreased afterwards ($\beta = -0.02$, $p < 0.001$). Co-partisan sharing of far-left news sources also followed similar patterns but with a much smaller effect size ($\beta = 0.003$, $p < 0.001$ before and $\beta = -0.008$, $p < 0.001$ after February 2017). Indeed, the partisanship IQR metric for polarization also decreased to below $\Delta z = 1.5$ after May 2019 from its peak of $\Delta z = 2.44$ in February 2017. These patterns thus suggest that, in addition to being restricted to a small subset of the platform, polarized news-sharing behaviors may have already reached a peak on the Reddit platform.

Behavioral fluctuations around platform moderation. Finally, polarized news sharing appears to be surprisingly robust to platform moderation efforts. Consider the *r/The_Donald* community, which accounts for a plurality of all far right-leaning news links on Reddit from January 2016 to January 2020 (34.0% vs 6.9% in *r/Conservative*, which has the second highest share). Having started in June 2015 after Donald Trump announced his Presidential candidacy, the community was quarantined in June 2019 with a disclaimer on its landing page for repeatedly violating Reddit's content policies. It was subsequently restricted in February 2020 and fully banned in June 2020 (Horta Ribeiro et al. 2021; Chandrasekharan et al. 2022).

We find that the resulting abandonment of *r/The_Donald* and its role as the largest community of right-wing news sharers led to a reduction of 30% of right-wing news between February and March 2020. However, despite being an obvious visual drop in Figure 5(a), the red line for far-right news recovered almost immediately in May 2020 to post-2016 levels after this point ($z = 0.51$ before 2016, $z = 2.34$ between 2016 and February 2020, and $z = 2.04$ from May 2020 onward). Furthermore, far-right news also remained present across the *entirety* of Reddit, as shown in Figure 1 (6.5% of all news on Reddit before 2016, 14.0% between 2016 and February 2020, and 10.4% after May 2020). Thus, sharing of e.g. Breitbart and Fox News returned to hyper partisan contexts on Reddit almost immediately after the banning of *r/The_Donald*, as shown in Figure 5(b).

To what may the robustness of polarized news sharing be

attributed to? Although speculative, we find evidence that sharing of far-right news simply shifted from *r/The_Donald* to *r/Conservative*. While news naturally disappeared from the former when it was banned, the percentage of far-right news appearing in the latter jumped from 15% in February 2020 to 39% in May. Furthermore, *r/Conservative* is the only subreddit that is socially even more right-wing than *r/The_Donald* – it is the uppermost triangle in Figure 2(b). This facilitates the reappearance of far right news in hyper partisan contexts in May 2020. Thus, the polarized sharing of right-wing news on Reddit, in this case, appears nearly unaffected by the deplatforming of *r/The_Donald*. Our findings indicate that more work into causal mechanisms and generalizability to other interventions is needed to understand how polarized news consumption on online platforms is affected by moderation strategies.

In summary, our temporal results illustrate the growing co-partisan consumption of traditional news in social contexts, across the history of the Reddit platform. They also suggest that news-sharing polarization on Reddit began before salient events like the 2016 Election, but is skewed heavily towards and restricted mostly within hyper-partisan, right-wing news publishers and right-wing online communities. Despite being narrow, however, this polarization also appears deep – to the extent that the banning of Reddit's largest far-right community had little long-term effect on the sharing of far-right news.

Discussion

Together, our results paint a picture of polarized news-sharing behaviors that are narrow but deep on Reddit. On the one hand, co-partisan patterns of news consumption occur largely within the hyper-partisan spaces of the platform, which accounts only for 10.4% of articles overall, and is skewed especially towards right-leaning news publishers and social contexts. On the other, the effects of this partisanship are very strong – to the extent that the entire platform appears macroscopically polarized at a bird's eye view. Furthermore, polarization of far-right news sources appears to have started much earlier than the 2016 Election, and is further only mildly affected by platform moderation.

Our findings are therefore consistent with claims that the pervasiveness of online echo chambers is overstated (Dubois and Blank 2018; Nelson and Webster 2017; Barberá et al. 2015; Guess et al. 2018; Cinelli et al. 2021; Gentzkow and Shapiro 2011; Muise et al. 2022). Nonetheless, our work also suggests that these claims need to be contextualized by the extreme partisanship in the smaller spaces that are most likely to contain echo chambers. While narratives positing that online interactions occur largely in echo chambers may risk over-regulation, arguments against their existence risk overlooking the subspaces in which they *are* a concern. If fringe news (KhudaBukhsh et al. 2022) and communities (Armaly, Buckley, and Enders 2022) can drive tumultuous events like the January 2021 US Capitol riot, then platform policies may be better informed by the presence of narrow and deep echo tunnels on online platforms rather than the absence of a singular, broad echo chamber.

What could potential policies look like? Our results hint at two concrete opportunities for further investigation. Firstly, the apparent polarization of right-wing news in 2012 indicates that heterogeneous and heterogeneously early partisan activity on online platforms may contain information about the health of political interactions. Secondly, the seeming resistance of polarized news-sharing to Reddit’s largest deplatforming intervention, which itself led to increased radicalization (Horta Ribeiro et al. 2021), indicates that alternative ways of moderating the platform need to be explored before hyper-partisan behaviors become difficult to mitigate. Both suggest paths of research into pro-actively regulating platforms using behavioral news sharing patterns, i.e. from which sources and to which communities news is shared, alongside lingual information (Cheng et al. 2017). Nonetheless, these approaches also need to be balanced against the risk of driving polarized news-sharing to even more extreme websites (Johnson et al. 2019). Another possibility could be that moderation moves article-level anti-partisan content around the platform, such as articles criticizing opposing politicians, while reducing source-level co-partisanship.

Limitations. As with all studies that observe user behaviors online, these findings need to be interpreted with several caveats. Firstly, our claims are correlational; much more work remains to understand the mechanisms underpinning, for example, the asymmetric polarization of news between different political poles. Furthermore, we intentionally studied metadata, i.e. from and to where news is shared, allowing us to quantify behavioral polarization. However, more research is needed to understand how this impacts the relationship between article *content* and readers’ affective polarization. For instance, although we find news is shared in co-partisan communities, the actual news articles may be heavily *anti*-partisan by being antagonistic against opposing political figures. This could, in turn, drive animosity when in-group news readers share articles about and discuss the political out-group (Rathje, Van Bavel, and van der Linden 2021; Schmitz, Burghardt, and Muric 2022).

Ethics Statement

Because of the political nature of our work, we recognize the need to protect the privacy of users engaged with partisan content on the platform. We used publicly available, pseudonymous Reddit data from PushShift, through which individuals may request to delete their Reddit histories at any time. In addition, we used additional measures to protect user privacy: our study presents only aggregated results, does not identify nor analyze individual histories, and stored data in a secure server to which only members of our research team had access.

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