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Inter- and intra-community commenting behavior in NFL team fan forums on Reddit.com

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1. INTRODUCTION

Reddit.com is an online forum organized into content-specific communities referred to as subreddits. Users create posts on individual subreddits containing either user-generated content or links to external content. Each post is submitted to a specific subreddit and is accompanied by a page where users can discuss the content by submitting comments, referred to as comments sections.

Each subreddit is dedicated to a topic or set of topics. These can range from broad – like the /r/sports subreddit for any content related to athletics – or more specific – like /r/nfl – which is devoted to posts and discussions related to the National Football League (NFL).[1] Both posts and comments are ranked by a voting system which allows users to vote items either up or down the ranking. Every post and comment is associated with a username persistent across any subreddits a user interacts with, and users must be signed into an account associated with a username in order to vote. Additionally, each subreddit allows users accompany their username with a text label or image that appears on all posts and comments they make. These are commonly referred to as 'flairs'. In some communities, like /r/nfl, these flairs are restricted to predetermined strings identifying teams participating in the league, allowing community members to self-identify as fans of a particular team.

In addition to the /r/nfl subreddit, all 32 NFL teams have their own subreddit where fans gather to discuss, speculate, praise, and bemoan their teams (/u/Bahamas_is_relevant 2021). Generally, it is frowned upon for fans of one team to make negative comments in another teams subreddit, and moderators of some team subreddits officially discourage such behavior(/u/jshanley16 2022), sometimes referred to as "brigading".

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[1] Throughout this work, subreddits will be prepended by "/r/" according to the convention on Reddit.com that assigns a subreddit **X** the url "Reddit.com/r/**X**"

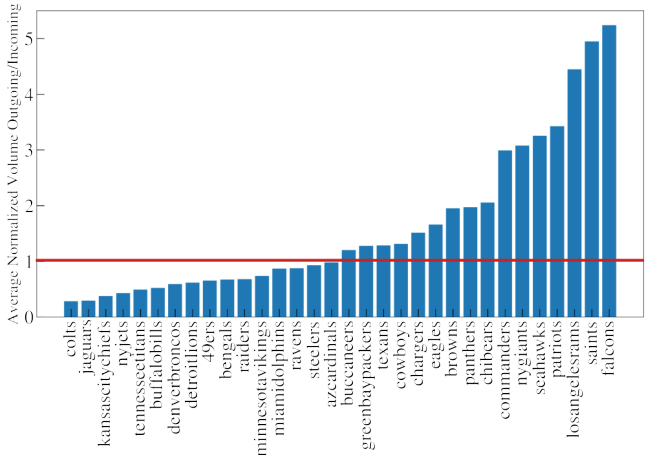

Figure 1. We plot the ratio $\langle v_A \rangle^B / \langle v^A \rangle_B$ for each subreddit. This can be seen as a metric of the amount of engagement of members of subreddit A in all other subreddits relative to the engagement of members of all other subreddits in subreddit A. Members of subreddits above the red line engage with other NFL subreddits more than members of those subreddits do with their subreddit.

In this work, we analyze the commenting behavior of members of team subreddits, both within their own subreddit community and those of other teams. We keep track of the volume of internal and external comments, their distribution among the 32 NFL subreddits, and perform a basic sentiment analysis of their content. We also look at how commenting behavior evolves with time over the course of the 2022/2023 NFL off season, regular season, and playoffs.

2. CORPUS

We perform this analysis on a corpus of 1.15 million comments across all 32 NFL team subreddits, collected using `PRAW` python wrapper for the reddit.com API ("praw dev" 2013). Taking post authorship on a team subreddit as a first approximation of a user's membership to that community, we start by scraping the 1000 [2] most recent posts on each team subreddit and recording their author's usernames. For each unique

[2] the maximum listing length allowed by reddit.com's API

Subreddit	%Flaired Authors	%NFL	%Team Comments	% Other-Team Comments	N Comments
49ers	0.380	0.418	0.611	0.018	38948
azcardinals	0.338	0.347	0.635	0.011	24240
bengals	0.372	0.412	0.563	0.028	40052
browns	0.386	0.460	0.647	0.011	33690
buccaneers	0.419	0.450	0.628	0.016	33236
buffalobills	0.357	0.446	0.607	0.023	44088
chargers	0.395	0.454	0.597	0.018	41655
chibears	0.470	0.485	0.651	0.011	51564
colts	0.343	0.431	0.737	0.008	33729
commanders	0.349	0.439	0.757	0.013	40696
cowboys	0.364	0.373	0.588	0.017	36616
denverbroncos	0.396	0.489	0.645	0.010	29390
detroitlions	0.399	0.473	0.655	0.020	49428
eagles	0.407	0.346	0.468	0.017	26238
falcons	0.386	0.272	0.575	0.027	15844
greenbaypackers	0.385	0.445	0.573	0.011	39576
jaguars	0.440	0.466	0.705	0.013	50646
kansascitychiefs	0.361	0.460	0.565	0.014	46138
losangelesrams	0.365	0.352	0.590	0.020	29780
miamidolphins	0.430	0.433	0.549	0.011	34217
minnesotavikings	0.389	0.460	0.660	0.011	37352
nygiants	0.414	0.378	0.597	0.023	30642
nyjets	0.371	0.441	0.745	0.011	18068
panthers	0.384	0.409	0.609	0.020	33665
patriots	0.405	0.321	0.408	0.016	19619
raiders	0.387	0.495	0.713	0.011	45221
ravens	0.400	0.514	0.634	0.015	42925
saints	0.357	0.330	0.520	0.026	22738
seahawks	0.402	0.348	0.583	0.022	32408
steelers	0.384	0.453	0.644	0.015	45336
tennesseetitans	0.398	0.512	0.745	0.009	55309
texans	0.376	0.385	0.683	0.016	32026

Table 1. Here we summarize the filtered database of comments on which we base our analysis. From left to right, we list the team subreddit, the percentage of posting members that were found to self-identify with that subreddit's team via flair on an /r/nfl comment, the percentage of those members' comments that were made on an nfl-related subreddit, the percentage of those nfl-related comments that were made on their own teams' subreddit, the percentage of said comments that were made on another team's subreddit, and finally the total number of comments sourced from that subreddit's members after filtering as described in Section 2.

user obtained, we then scrape (up to) their 1000 most recent comments, recording which subreddit they were made on, the author's flair on that subreddit, the date of posting, and the raw comment text itself. We then filter the database to save only comments made on nfl team subreddits and /r/nfl itself.

Finally, in order ensure that each comment is accurately associated with a subreddit community member (i.e. a self-identified fan of that subreddit's team) and not just a user authoring posts on another team's subreddit, we perform one final filter by leveraging author flair. While the flairs on many team subreddits are unrestricted and often inconsistently used, the flairs on /r/nfl are limited to a curated subset of strings, mostly consisting of team names. Taking advantage of this, search the comment history of each author for a comment on /r/nfl, and only retain comments authored by users who have commented on /r/nfl under a flair matching the team of the subreddit that their username was scraped from.

We give a surface summary of the database in Table 1. We find that, on average, 41% of post authors on a team subreddit have commented on /r/nfl under a flair

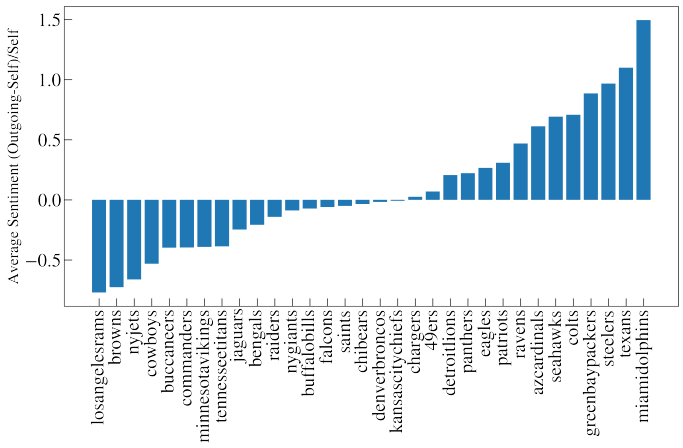

Figure 2. Here we plot the outgoing sentiment minus the internal community sentiment normalized by the internal community sentiment $(\langle s_A \rangle^B - s_A^A)/s_A^A$ as a measure of the sentiment of comments left in other subreddits relative to the internal community sentiment. Members of subreddits to the left tend to comment with more negative sentiment in other teams' subreddits than they do their own, and members of subreddits to the right speak more positively in other teams' subreddits.

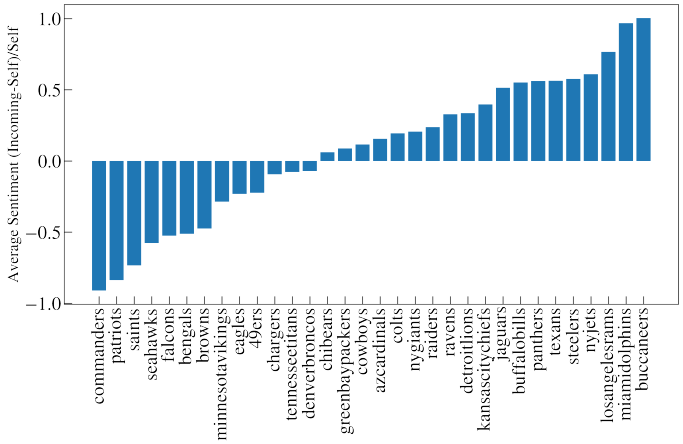

Figure 3. We plot $(\langle s_A \rangle^B - s_A^A)/s_A^A$ as a measure of the sentiment of comments made in subreddit A by members of other team subreddits, relative to the internal community sentiment in subreddit A. The external community tends to speak with more negative sentiment in subreddits to the left than members of those subreddits, and vice-versa for subreddits on the right.

matching that teams' subreddit. We find that on average 44% of those flaired authors' 1000 most recent comments were made on either /r/nfl or an nfl team subreddit, and that 62% of *those* comments were made on their own team's subreddit, while 1.6% were made on another team's subreddit. While comments on /r/nfl were used for affiliating users with a team community, the analysis that follows is restricted to comments made on individual team subreddits, totaling 1.15 million comments.

3. ANALYSIS

We now analyze the comments in our database, with a focus on the communities where they are made in relation to the communities that their authors identify as members of, as well as their overall sentiment and distribution throughout the life cycle of an NFL season.

We start with a rudimentary sentiment analysis, assigning score between -1 and 1 to each comment. To do this we employ `VADER`, an open-source, rule-based language model designed for sentiment analysis of social media text (Hutto & Gilbert 2014). The model is trained on short-form social media posts including tweets, New York Times editorial snippets, and Amazon product reviews. While the training data isn't sports or reddit-specific, `VADER` accounts for negation, punctuation, and use of emoticons as well as all-caps as sentiment modifiers, making it a useful first pass at extracting sentiment from reddit comments. Since `VADER` is designed for short-form content, and since reddit comments vary greatly in length, we analyse a comment's sentiment by first breaking it into sentences using the Natural Language Processing Tool-kit (`NLTK`, Bird (2016)), passing each sentence to `VADER`, and then averaging the resulting compound sentiment scores. `VADER`'s compound scores range between -1 and 1 where –roughly speaking – scores < -0.05 indicate negative sentiment, scores between -0.05 and 0.05 indicate neutral sentiment, and scores > 0.05 indicate positive sentiment. As examples, the comments "Our front office is completely incompetent", "Offseason!", and "I'm in such a good mood watching this game I just caught myself laughing at one of Aikman's jokes." rate a -0.5, 0.0, and 0.79, respectively. Overall, we find that the distribution of comments in our corpus has a mean of 0.08 with a standard deviation of 0.3.

With each comment assigned a sentiment score, we now structure our data according to where comments are made and the community affiliation of their authors. For each pair of subreddits (A,B), we count the number of comments made by users self-identifying with subreddit A that are posted in subreddit B, and divide that number by the number of comments made by members of subreddit A subreddit A itself. We call this the outgoing (from A)/incoming (to B) normalized volume v_A^B and use it as metric of the engagement of a community's members with external (possibly-rival) communities relative to engagement with their own community. Similarly, we define the average sentiment of the comments made in subreddit B by members of subreddit A

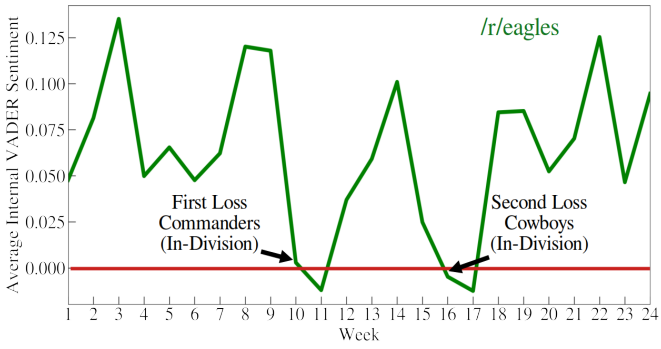

Figure 4. Average weekly internal sentiment on /r/eagles across the 2022/2023 NFL season and postseason. The red line separates positive and negative `VADER` sentiment scores. We highlight the weeks coinciding with divisional losses to rival teams.

as the outgoing/incoming sentiment s_A^B. We present the results of this analysis in the next section.

4. RESULTS

We start with a summary of subreddit member behavior in *all* other subreddits relative their own. Then proceed to break down this behavior over time and specific incoming/outgoing subreddits.

4.1. *Global summary*

In Table 2 we present averages over the metrics defined in the last section. For a given subreddit A, we list the average of the normalized outgoing volume $\langle v_A \rangle^B$ over all other subreddits B. This can be interpreted as the average number of comments made by members of A externally per subreddit B, in units of the number of comments made internally. Likewise we list the average normalized incoming volume $\langle v^A \rangle_B$.

In Figure 1, we plot the ratio $\langle v_A \rangle^B / \langle v^A \rangle_B$ for each subreddit. This can be seen as a metric of the amount of engagement of members of subreddit A in all other subreddits relative to the engagement of members of all other subreddits in subreddit A. Informally, members of subreddits above the red line "do more talking" in other subreddits than other members of other subreddits do in theirs. We find that members of /r/falcons do "the most talking" – relatively speaking – while members of /r/colts do the least.

In Table 2 we also list sentiment metrics. As a measure of overall community sentiment, we list the average sentiment of comments left in subreddit A by members of subreddit A s_A^A. We also list the average sentiment of comments left in other team subreddits by members of subreddit A in other subreddits $\langle s_A \rangle^B$, and the average sentiment of comments left in subredit A by members of all other team subreddits $\langle s^A \rangle_B$.

In Figure 2, we plot $(\langle s_A \rangle^B - s_A^A)/s_A^A$ as a measure of the sentiment of comments left in other subreddits relative to the internal community sentiment. Here we summarize the global behavior of members of individual team subreddits in other team subreddits as well as their own. From left to right we list the subreddit A in question, the average of its normalized outgoing volume over other subreddits B $\langle v_A \rangle^B$, the average of its normalized incoming volume over other subreddits B $\langle v^A \rangle_B$, the average sentiment of user comments in subreddit A itself s_A^A, the average outgoing sentiment over other subreddits B $\langle s_A \rangle^B$, and the average incoming sentiment over subreddits B $\langle s^A \rangle_B$. We find that members of /r/miamidolphins comment with more positive sentiment in other subreddits than they do in their own, with the most positive relative swing overall. On the other hand, we find that members of /r/losangelasrams comment more negatively in other subreddits then they do in their own, with the most negative relative swing overall.

Similarly, in Figure 3 we plot $(\langle s_A \rangle^B - s_A^A)/s_A^A$ as a measure of the sentiment of comments made in subreddit A by members of other team subreddits, relative to the internal community sentiment in subreddit A. We find that in most subreddits, external commenters speak with more positive sentiment than members of that subreddit, with largest positive internal-to-external swings in /r/miamidolphins and /r/buccaneers. Meanwhile, external commenters speak more negatively in /r/commanders and /r/patriots than members of those subreddits.

While we can not draw a causative relationship between team performance in the NFL season and the behavior of users on reddit, there are some apparent correlations. To examine these, we bin just under one year of time into the 2022 off-season (3/1/2022 - 9/07/2022), the 2022/2023 regular season (9/8/2022 - 1/13/2023) and the 2022/23 NFL playoffs (1/13/2023-2/13/2023). As expected, teams that made the playoffs had a higher average normalized volume in the playoffs than the off-season or regular season, with volume tripling compared to the former, and doubling compared to the latter. Also as expected, teams that didn't make the playoffs saw a drop of about 10% in normalized volume and sentiment from the regular season to the playoffs. Additionally, teams that missed the playoffs also saw a drop in regular season normalized volume and sentiment relative to the offseason, suggesting that the online discourse may be efficient at concentrating around teams that are expected to do well.

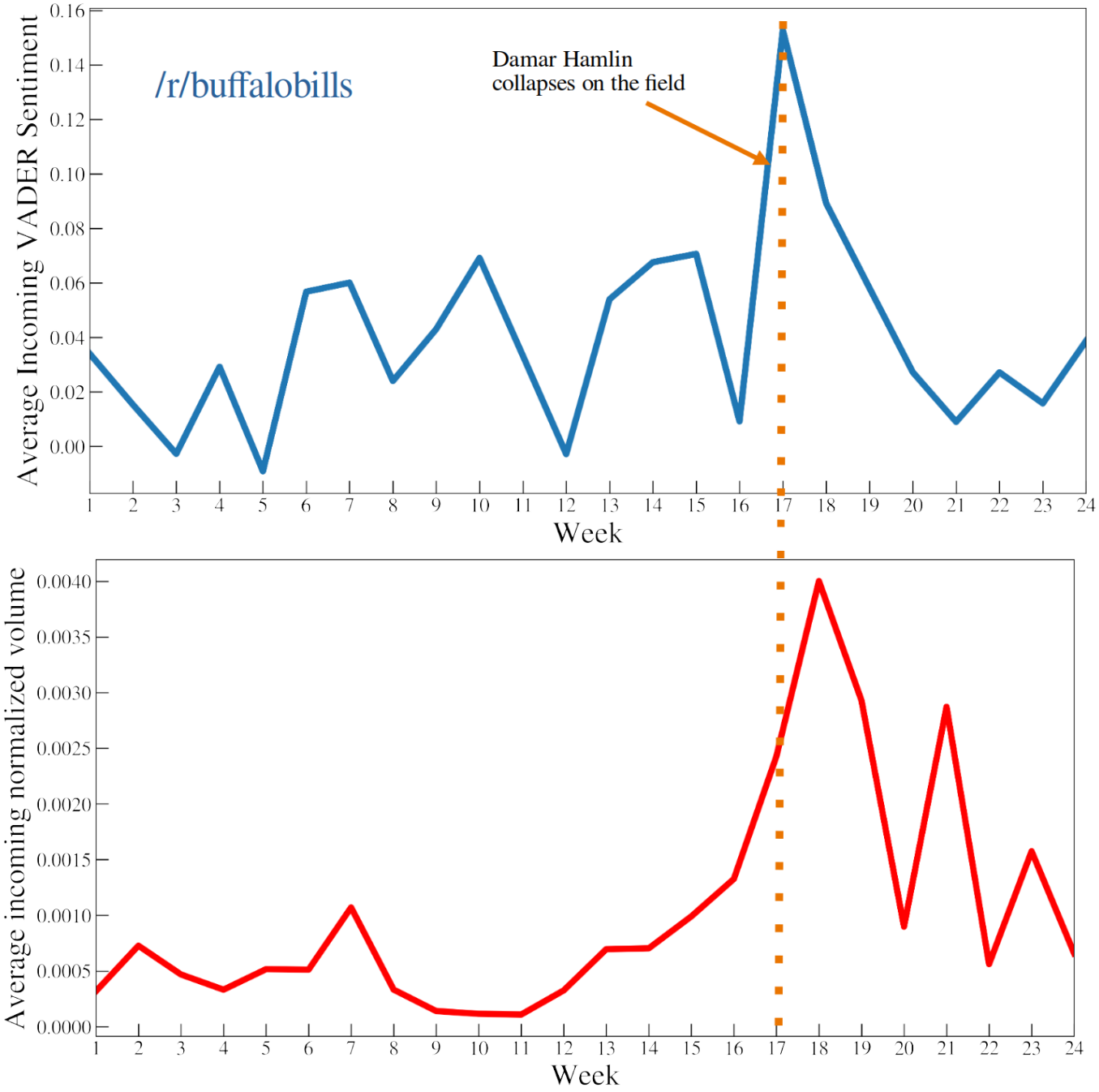

Figure 5. We plot the average weekly incoming sentiment, and average weekly incoming normalized volume in on /r/buffalobills in the top and bottom panels, respectively. The orange line marks the week in which Bills safety Damar Hamlin suffered a cardiac arrest on the field.

4.2. *Sentiment across the season*

Here we briefly consider two examples of sentiment as a time series. An NFL regular season consists of each team playing 17 games over 18 weeks. The playoffs culminating in the Super Bowl occur over the following 6 weeks. In the following, we bin comments by week across the 24 weeks that span the regular season and post-season combined. We note that in what follows, we cannot draw *causative* relationships between sentiment and events in the season. We do, however, point out some obvious correlations.

In the first case, we consider internal community sentiment in /r/eagles in light of the performance of the Philadelphia Eagles. The Eagles had one of the best seasons the franchise's history (Stolnis 2023) and com-

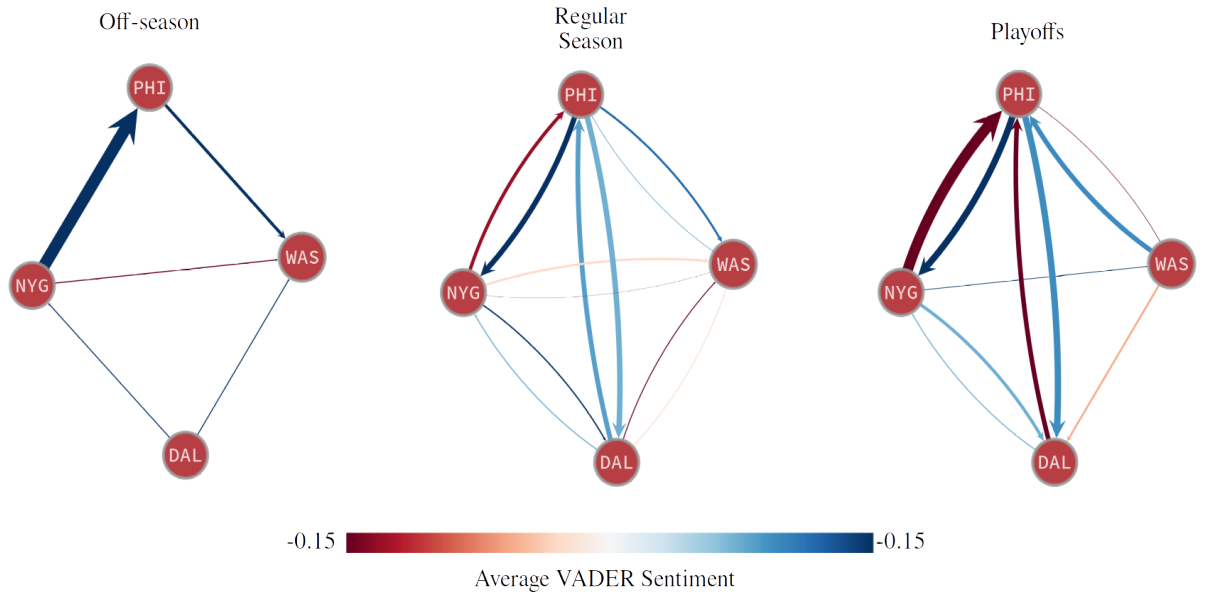

Figure 6. Directed graph of subreddits corresponding to NFC East teams across the off-season, regular season, and playoffs over 2022/2023. Edge thicknesses are weighted by the outgoing normalized volume and colored by the outgoing average sentiment. The Eagles (PHI), Giants (NYG), and Cowboys (DAL) made the playoffs. The Commanders (WAS) did not.

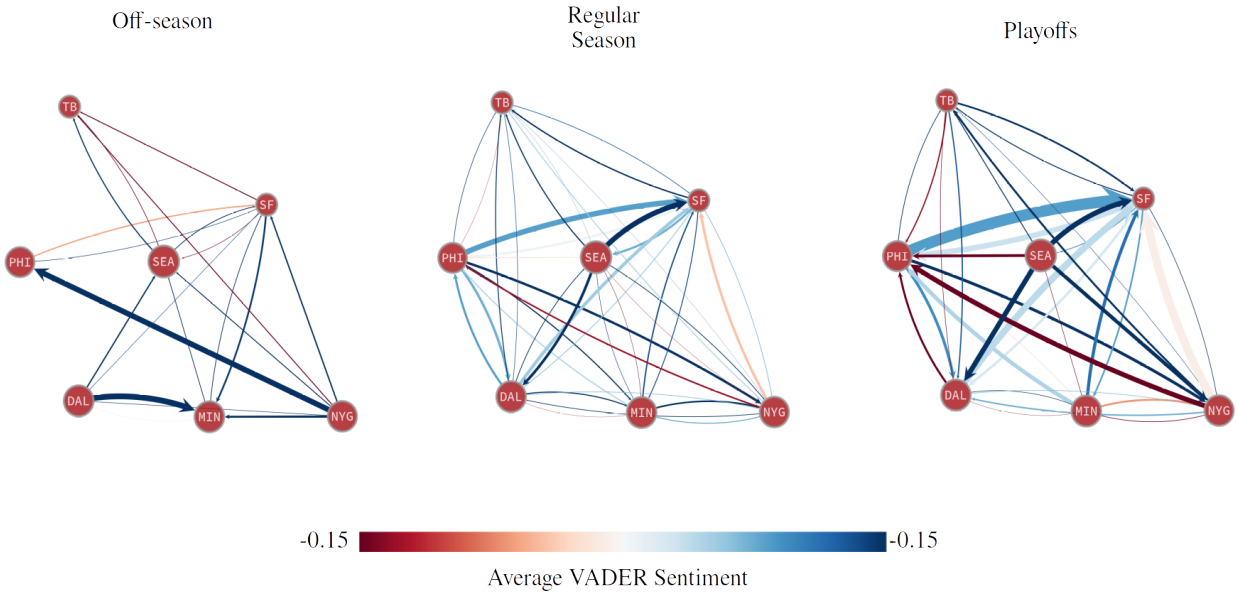

Figure 7. Directed graph of subreddits corresponding to NFC teams that made the playoffs across the off-season, regular season, and playoffs over 2022/2023. Edge thicknesses are weighted by the outgoing normalized volume and colored by the outgoing average sentiment.

ments made in /r/eagles by community members scored a positive sentiment on average each week with two exceptions, which can be seen in Figure 4. In weeks 10 and 16, average internal sentiment plummeted below 0, before recovering for a few weeks in between. Both of these weeks coincide with their first two losses, and the only divisional losses of the season. The NFL is organized into 8 divisions of 4 teams. Teams play their divisional rivals twice a season and those games competitively significant because only one team per division is guaranteed a playoff spot. The Eagles' third and final loss came after clinching a playoff spot.

In the second, and more somber case, we consider the volume and sentiment of members from other team subreddits commenting in /r/buffalobills. In Figure 5, we plot the incoming average sentiment and the incoming normalized volume in the top and bottom panels, respectively. In week 17, the average normalized volume nearly tripled, and the average incoming sentiment more than doubled the average to date. Members of other team subreddits were posting in larger volume and with more positive sentiment than they had the rest of the season. That same week, Bills safety Damar Hamlin suffered a cardiac arrest on the field in a prime time Monday Night Football game against the rival Bengals (Fairburn 2023). CPR was performed on the field, and players, coaches, and fans were visibly distraught. The decision was made to suspend the game due to a medical emergency for the first time in NFL history – including that time Chuck Hughes died on the field (Hille 2021) – and the following week saw an outpouring of support from fans and players across the league (Hernandez 2023; Olson 2023), including from fans of the opposing team. That same week, the volume of posts from /r/bengals members on the /r/buffalobills subreddit increased by 500%. We note that Damar Hamlin survived the incident (Daniel 2023).

4.3. *Visualizing community behavior*

Here, we provide an example of visualizing community behavior and evolution through the year as directed, weighted graphs. In Figures 6 and 7, we graph the behavior of users in subreddits for teams in the NFC East, and the subset of NFC teams that made the playoffs, across the 2022 off-season, 2022/2023 regular season, and 2022/2023 playoffs, as defined above. We fix a node for each subreddit in our set, and weight the edge between subreddit A and subreddit B by $\langle v_A \rangle^B$, scaling the thickness accordingly. We color the edge by the average outgoing sentiment $\langle s_A \rangle^B$, and plot the graph through the year. What appears is bears out the findings in Section 4.1. As we move from the off-season to the regular season to the postseason, incoming normalized volume increases, and sentiment intensifies amongst teams – from the regular season to the postseason, in subreddits corresponding to teams that made the postseason, the standard deviation of incoming sentiment increases by 45%. While not plotted here, this was repeated for the league as a whole across the entire year. Ranking edges by average sentiment, we note that of the 5 most negative edges, the Washington Commanders were on the receiving end of 3 of them. While not causative, we note that over the course of the year, calls for the owner of the Commanders, Dan Snyder, to sell the team over his blatant and shameless crimes have intensified (Rosman 2022).

5. CONCLUSIONS

Analyzing a corpus of 1.15 million comments posted NFL team subreddits across the 2022 and 2023, we track the volumetric behavior of NFL team community members both inside and outside of their communities as well as the sentiment of their written activity.

In our analysis, we:

1. Find that on most NFL team subreddits, non-community-members comment on a given subreddit with higher average sentiment than members of that subreddit

2. Identify subreddits whose members engage with other teams' subreddits more than external users engage with them. We find that Falcons fans do a lot of talking, and Colts fans keep their mouth shut, relatively speaking.

3. /r/miamidolphins members write with more positive sentiment on other teams' subreddits than they do their own, and members of other teams' subreddits write more positively on /r/miamidolphins than members of that subreddit. Cheer up, dolphins fans.

4. Find that team performance appears to correlate with the engagement of non-community-members with associated subreddits

5. Comment sentiment appears to correlate with team performance and major incidents in the league

6. Engagement concentrates around the subreddits of playoff teams during the playoffs, and sentiment intensifies.

7. Nobody likes the Washington Commanders.

Subreddit A	$\langle v_A \rangle^B$	$\langle v^A \rangle_B$	s_A^A	$\langle s_A \rangle^B$	$\langle s^A \rangle_B$
49ers	0.0011	0.0017	0.0884	0.0945	0.0687
azcardinals	0.0004	0.0004	0.0514	0.0829	0.0594
bengals	0.0016	0.0024	0.0802	0.0636	0.0391
browns	0.0007	0.0004	0.0684	0.0187	0.0360
buccaneers	0.0006	0.0005	0.0606	0.0365	0.1215
buffalobills	0.0014	0.0026	0.0802	0.0744	0.1244
chargers	0.0010	0.0007	0.0610	0.0626	0.0553
chibears	0.0008	0.0004	0.0778	0.0751	0.0825
colts	0.0004	0.0013	0.0668	0.1139	0.0797
commanders	0.0008	0.0003	0.0690	0.0417	0.0062
cowboys	0.0009	0.0007	0.0658	0.0309	0.0735
denverbroncos	0.0006	0.0011	0.0608	0.0598	0.0566
detroitlions	0.0012	0.0019	0.0907	0.1093	0.1212
eagles	0.0012	0.0007	0.0569	0.0721	0.0438
falcons	0.0016	0.0003	0.0970	0.0912	0.0461
greenbaypackers	0.0006	0.0005	0.0738	0.1391	0.0803
jaguars	0.0007	0.0025	0.0959	0.0723	0.1452
kansascitychiefs	0.0009	0.0025	0.0850	0.0843	0.1188
losangelesrams	0.0019	0.0004	0.0831	0.0190	0.1467
miamidolphins	0.0009	0.0010	0.0589	0.1470	0.1160
minnesotavikings	0.0006	0.0008	0.0913	0.0555	0.0652
nygiants	0.0012	0.0004	0.0733	0.0669	0.0885
nyjets	0.0004	0.0010	0.0530	0.0180	0.0853
panthers	0.0010	0.0005	0.0803	0.0981	0.1255
patriots	0.0011	0.0003	0.0690	0.0903	0.0113
raiders	0.0004	0.0006	0.0742	0.0637	0.0918
ravens	0.0009	0.0011	0.0713	0.1046	0.0946
saints	0.0014	0.0003	0.0583	0.0554	0.0156
seahawks	0.0017	0.0005	0.0891	0.1508	0.0378
steelers	0.0006	0.0007	0.0800	0.1574	0.1261
tennesseetitans	0.0003	0.0007	0.0731	0.0449	0.0675
texans	0.0006	0.0005	0.0662	0.1390	0.1035

Table 2. For a given subreddit A, we list the average of the normalized outgoing volume $\langle v_A \rangle^B$ over all other team subreddits B, the normalized incoming volume $\langle v^A \rangle_B$over all other team subreddits B, the average sentiment of comments made on subreddit A by members of that community s_A^A, the average outgoing sentiment from members of subreddit A to all other team subreddits B $\langle s_A \rangle^B$, and the average incoming sentiment of comments on subreddit A from members of all other subreddits B $\langle s^A \rangle_B$

Software: `VADER` (Hutto & Gilbert 2014), `graph-tools` ("Peixoto ????), `NumPy` (van der Walt et al. 2011), `SciPy` (Virtanen et al. 2020), `matplotlib` (Hunter 2007), `pandas` (Wes McKinney 2010)

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