Mitchell Ewald
Computational Social Science

Do Exogenous Shocks Make Social Media More Negative?:
Analyzing the Effect of the 2023 Hamas Attack in Israel on Internet Sentiment Via Time-Series Modeling

Introduction

It is no secret that the internet has become steadily more ingrained in society over the past few decades. Each new development in digital communication allows people more methods of interacting with others to exchange information and find new connections and communities.

In fact, people now devote a significant portion of their lives to digital social media, an area of the internet that exemplifies this new era of communication. Therefore, it is valuable to study the social internet ecosystem as it plays an increasingly standard part of everyday life for societies. Many studies have linked internet phenomena to real world consequences. However, it is rare for research to study the physical world's impact on the internet, which may in turn feed back into individuals' everyday lives and societal sentiments. In fact, governments worldwide widely accept this new reality and commonly implement information campaigns to influence online social spaces domestically and abroad (Jensen & Ramjee 2023). Studies to quantify and observe sentiment over time in these spaces are therefore valuable. The present study aims to analyze the concept of how sudden, real-world events – defined here as *exogenous shocks* – impact the social internet ecosystem. The study achieves these means via a time-series analysis surrounding an exogenous shock's social media impact. Specifically, I examine how the October 7th, 2023 terrorist attack in Israel affects the average daily sentiments of two differently-focused Reddit communities: r/PoliticalDiscussion and r/CasualConversation.

Literature Review

Social science researchers have studied how exogenous shocks impact societal outcomes in a myriad of ways. One classic example is how exogenous stressors such as a terrorist attack, earthquake, or political revolution in a region can affect maternal stress and therefore child birth weight (Camacho 2008, Hawash 2019, Torche 2011). Torche finds that in a Chilean region affected by a sudden earthquake pregnant women gave birth to children of lower birth weight than the average. Findings are robust to whether the women's residences were in the affected

earthquake area or just outside the impacted area. Such a finding suggests that merely the psychological stress of an exogenous shock rather than the direct physical impact from the shock can still produce unexpected societal outcomes.

The field of economics has also shown exogenous shocks to change societal outcomes. For example, research shows that a parent's sudden change in employment status tends to increase time spent with their children and have some positive short-term effects on child development via the increased parental time investment (Basu 2020). At the organizational level, Schuenemann, et al. observe how the US and European stock markets exhibited different change patterns in intraindustrial market connections over the course of COVID-19 waves (2023). The latter study provides empirical evidence that different groups can react differently to the same exogenous shock. Li, et al. expound on this finding, showing how the different dimensions of an exogenous shock affect companies differently (2017). Their results uncover that a shock's higher geographic proximity to a company and a shock's higher relevance to a company's goals are both more likely to impact a company's performance – whether producing better or worse outcomes.

Finally, the field of computational social science (CSS) has already produced several studies analyzing the impact of exogenous shocks on an internet sentiment time-series. For example, Gunaratna, et al. find that after an unexpected score in a high-stakes international soccer match the advantaged team's Twitter fanbase showed higher emotional resilience throughout the game (2020). They also found that the disadvantaged team's Twitter fanbase had the opposite reaction. This study exemplifies how "user engagement and emotional resilience of an online population holding highly polarized stances can be manipulated through an exogenous event of high importance." Another study measures New Zealand's Gross National Happiness Index (GNH)[1] in the early stages of the COVID-19 pandemic via Twitter sentiment analysis (Morrison, et al. 2022). The researchers find significant, temporary GNH drops right before cases began in the country, suggesting that anticipation itself of the pandemic had a larger impact on internet sentiment than the spike in COVID cases. However, these two studies and the broader field of exogenous shock analysis leave plenty of space for CSS research to explore how a shock impacts digital population sentiment over time.

[1]: While GNH is a broader social science term, the usage here refers to a specific CSS tool named GNH which was developed to track real time, in-depth aggregate Twitter post sentiment scores by country (gnh.today).

Theoretical Framework

First, I select my parameters and a shock according to the parameters. For this study, I choose to examine a recent shock with a clear start date in order to ascertain the shock's impact itself, rather than analyze a population's anticipatory effects. I define a *shock* here as a low probability, high-impact, and surprising event to which individuals and/or organizations feel compelled to respond (Ferretti, et al. 2013). I select the Oct.7th, 2023 Hamas-led terrorist attack in Israel to this end. On Oct.7th, Hamas[2] killed approximately 1,100 people in a surprise terrorist attack in Israel, including at least 700 Israeli civilians and 70 foreigners (France 24 2023). The attack took Israeli intelligence, international intelligence, and world governments completely off-guard (Hardy 2023). Therefore, it also shocked average citizens around the world – especially with the Israel-Palestine land dispute being one of the most well-known and fiercely debated topics in Western society.

I also consider the Israeli government's swift countermeasures to the Oct.7th attack in my analysis. Israel's responses in the weeks after Hamas's attack included preventing water, electricity, and food from entering Gaza and destroying enough buildings to displace 1.4 million Palestinians (Britannica 2024). These actions instigated a humanitarian crisis in the Gaza region, and many countries and individuals condemned the Israeli countermeasures for excessive civilian consequences. Any of this study's measured sentiment changes during this period thus stem from both the initial Oct.7th attack and the Israeli government's drastic countermeasures.

For alternative recent shocks to test, one could feasibly argue for the 2020 COVID pandemic surge or the 2022 Russian invasion of Ukraine. I choose the Oct.7th attack instead as it has a clear shock date without prior buildup. For example, the WHO in March 2020 characterized the COVID-19 outbreak as a pandemic. The vast majority of countries internationally then went into lockdown. However, international news had been reporting on COVID for months beforehand as a public health concern, so this event had obvious prior anticipation (WHO 2024). The Russia/Ukraine conflict also did not start as suddenly as the Israel/Hamas conflict. International news reported for months before the invasion that Russia had been assembling troops at the Ukrainian border (USNews 2024). Governments and media

[2]: Hamas is a militant Islamist group which has ruled since 2007 over the Gaza Strip – one of two Palestinian territories (AP News 2023). Both territories lie in modern-day Israel.

already considered this measure an unprecedented increase in regional tensions. Therefore, the Oct.7th attack represents a more defined shock event than the alternatives, which each have months of events leading to their respective inflection points.

For the next step, I select the online communities to analyze. I choose the two Reddit communities r/PoliticalDiscussion and r/CasualConversation for their number of subscribers and their respective purposes. Each subreddit has approximately two-million subscribers each as of July 2024, which allows this study to control for subreddit size. In addition, these two subreddits are forums dedicated to dialogue amidst their subscribers. However, r/PoliticalDiscussion's mission statement on their homepage is that it is "a subreddit for substantive and civil discussion on political topics." r/CasualConversation in contrast considers its discussions "a place to escape from more serious issues" and forbids explicit political commentary. In fact, this subreddit only allows conversations about serious issues if the conversations remain casual. Therefore, each subreddit may shift in sentiment differently in response to the Oct.7th terrorist attacks in line with each community's respective goals.

Finally, I define the nature of the chosen shock relative to these online communities in order to make educated hypotheses. Note that a shock may not necessarily lead to negative outcomes for those reacting to the shock, but each group may view the shock as a "turning point that may lead to better or worse outcomes" (Li, et al. 2017). Therefore, each subreddit in the study is not limited to a strictly negative outcome – in this case, a more negative daily sentiment. In addition, a shock can be defined relative to a population in three dimensions: event strength, event space, and event timing (Morgeson, et al. 2015). *Event strength* considers the event's novelty, criticality, and disruption to a group. *Event space* is how proximate it is to the target group. Then, *event time* is the event's duration and timing. For these three dimensions, I view Oct.7th and the Israeli government's countermeasures with the following relationships to the two measured subreddits:

- *event strength*: a strong exogenous shock given its Western cultural tie-ins detailed above
- *event space*: far geospatial distance from the lives of Reddit users, who are predominantly North American, European, and Australian (Statista 2024).
- *event duration*: the initial few weeks of events are the actual "shock" period, as opposed to entire Israel-Hamas war thereafter (which has lasted 10+ months at the point of this study)

Taking the above literature review and theoretical framework into account, I hypothesize the following:

> **Hypothesis 1**: r/PoliticalDiscussion's daily sentiment shifts negatively in response to the shock of Oct.7th and the drastic countermeasures thereafter.

I propose this hypothesis under an assumption that the community would condemn the violence and have intracommunity arguments about the controversial events.

> **Hypothesis 2**: r/CasualConversation's daily sentiment shifts positively in response to the shock.

I propose this hypothesis since the community advertises itself as a "place to escape from serious issues". I therefore assume they would lean further into lighthearted discussions as a counterweight to stressful news cycles and other subreddits become more negative.

> **Hypothesis 3**: The shock's effect on each subreddit's sentiment levels is temporary. Each subreddit returns to their original pre-shock trends after an elapsed time post-shock.

Data

Reddit is a quintessential staple of modern social media. This website serves as a massive social forum site which specializes in social news aggregation, discussion boards, and web content rating. On a smaller scale, each *subreddit* on Reddit is a forum specialized around a specific topic. Subreddits can focus on a wide range of topics such as science, hobbies, entertainment, news, or fun personal anecdotes. Users (referred to as redditors) post text, image, link, or video content. Then, other redditors can "upvote" or "downvote" a post based on their assessment of the post's quality, which influences the post's visibility within the subreddit. Redditors choose which subreddits to subscribe to so their Reddit homepage upon login will provide a customized timely insight into a personalized slate of the redditor's chosen subreddits.

For this study, I extract data on all comments posted in the subreddits r/PoliticalDiscussion and r/CasualConversation via a public database. This database gives general access to text data on all Reddit submissions and comments since 2010 for the top 40,000 subreddits by size (Watchful1 2024). The database's owner compiles and merges

subreddit data from two sources. One source contains submission and comment data prior to April 2023, gathered before Reddit's highly public shift in API policy (shiruken 2023). The database owner's second source is data obtained post-API shift via a redditor's extensive data collection efforts, which seek to "[make] Reddit data accessible to researchers, moderators[3] and everyone else" (Heitmann 2024).

After extracting the data by subreddit, I employ the database owner's Python script to pre-filter the zipped data down to the desired date range[4] of when redditors posted their comments. The data requires pre-filtering since the original unzipped files contain 7+ GB of data per file. This file size requires significant computational power beyond the capacities of the R software and personal laptop used to conduct this project. After the pre-filtration process, the data are finally ready for statistical processing. I can provide all related files discussed in this section by request.

Next, I take several steps to clean the pre-analysis comment data when I load it into R. First, many comments have been removed by the original commenters or the subreddit's moderators. All these comments are visible online and in the data scrape as "[removed]" or "[deleted]". I clean out these comments from the dataset since they contribute nothing to the analysis and there are no tools to detail their original text.

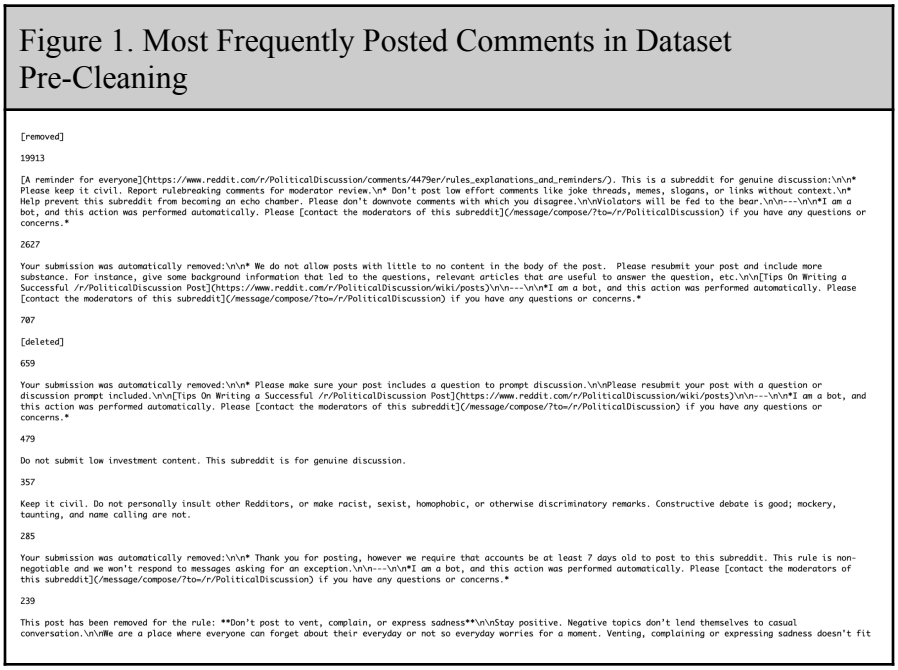
In addition, I choose to remove moderator bot comments to keep this analysis focused on human conversations. These bots are automated text-posting accounts which assist moderators in enforcing and explaining subreddit rules. Data processing software has difficulty identifying bot comments accurately. However, these bot comments often include the helpful phrase "I am a bot" and/or include reminders of subreddit rules such as "Do not submit low investment content" or "Do not personally insult other Redditors." Repeated frequency analyses of comment texts help me to identify and remove such moderator bot comments.

This data-cleaning step does not remove all moderator bot comments from the dataset, as these bots do not always follow easy-to-identify linguistic patterns. However, this step filters out the most frequently recurring moderator bot comments. By the end of the process, all the most frequently posted comments appear to be posted by human commenters instead of bots. Figures 1 and 2 on the next page display the pre- and post-data cleaning comment frequency tables.

[3]: Subreddit moderators are a subreddit's select small team of volunteers given status within a forum and mechanisms to enforce subreddit rules (Reddit 2023).

[4]: The chosen date range is 2023/08/07 to 2023/12/06, sixty days before and after Oct.7th.

Figure 1. Most Frequently Posted Comments in Dataset Pre-Cleaning



[removed]

19913

[A reminder for everyone](https://www.reddit.com/r/PoliticalDiscussion/comments/4479er/rules_explanations_and_reminders/). This is a subreddit for genuine discussion:\n\n* Please keep it civil. Report rulebreaking comments for moderator review.\n* Don't post low effort comments like joke threads, memes, slogans, or links without context.\n* Help prevent this subreddit from becoming an echo chamber. Please don't downvote comments with which you disagree.\n\nViolators will be fed to the bear.\n\n---\n\n*I am a bot, and this action was performed automatically. Please [contact the moderators of this subreddit](/message/compose/?to=/r/PoliticalDiscussion) if you have any questions or concerns.*

2627

Your submission was automatically removed:\n\n* We do not allow posts with little to no content in the body of the post. Please resubmit your post and include more substance. For instance, give some background information that led to the questions, relevant articles that are useful to answer the question, etc.\n\n[Tips On Writing a Successful /r/PoliticalDiscussion Post](https://www.reddit.com/r/PoliticalDiscussion/wiki/posts)\n\n---\n\n*I am a bot, and this action was performed automatically. Please [contact the moderators of this subreddit](/message/compose/?to=/r/PoliticalDiscussion) if you have any questions or concerns.*

707

[deleted]

659

Your submission was automatically removed:\n\n* Please make sure your post includes a question to prompt discussion.\n\nPlease resubmit your post with a question or discussion prompt included.\n\n[Tips On Writing a Successful /r/PoliticalDiscussion Post](https://www.reddit.com/r/PoliticalDiscussion/wiki/posts)\n\n---\n\n*I am a bot, and this action was performed automatically. Please [contact the moderators of this subreddit](/message/compose/?to=/r/PoliticalDiscussion) if you have any questions or concerns.*

479

Do not submit low investment content. This subreddit is for genuine discussion.

357

Keep it civil. Do not personally insult other Redditors, or make racist, sexist, homophobic, or otherwise discriminatory remarks. Constructive debate is good; mockery, taunting, and name calling are not.

285

Your submission was automatically removed:\n\n* Thank you for posting, however we require that accounts be at least 7 days old to post to this subreddit. This rule is non-negotiable and we won't respond to messages asking for an exception.\n\n---\n\n*I am a bot, and this action was performed automatically. Please [contact the moderators of this subreddit](/message/compose/?to=/r/PoliticalDiscussion) if you have any questions or concerns.*

239

This post has been removed for the rule: **Don't post to vent, complain, or express sadness**\n\nStay positive. Negative topics don't lend themselves to casual conversation.\n\nWe are a place where everyone can forget about their everyday or not so everyday worries for a moment. Venting, complaining or expressing sadness doesn't fit

Figure 2. Most Frequently Posted Comments in Dataset Post-Cleaning

Thank you!	Yes	No	Thanks!	Thank you
167	135	118	93	80
Yes.	😂	Same	Lol	No.
62	57	57	50	50
Thanks	Thank you.	🤣	Congratulations!	😂😂😂
40	33	32	30	29
❤	no	Thank you so much!	Same!	Me too
28	28	27	26	25

This dataset's final purity test is identifying and eliminating bad-actor bots. These bots have become more prominent on social media in recent years. However, Reddit's bad-actor bots can have a unique behavior. In fact, entire data science articles have attempted to develop methodologies to identify them (Skowronski 2019; Skowronski 2019). In Reddit threads discussing the topic, no redditors offer an identifiable linguistic pattern in bad-actor bot activity. They instead point mostly toward inhumanly frequent comment posts from a single account or controversial comments posted by new accounts (r/RedditforBusiness 2023; quinn_thomas 2023;

Xova_YT 2023). Bots also appear to have more presence in certain subreddits, as indicated by one thread's user who mentioned that some subreddits "haven't been hit by a bot wave so far."

Altogether, we cannot dismiss the possible influence of bad-actor bot activity in r/CasualConversation and r/PoliticalDiscussion. In my own anecdotal observations, bad-actor bots appear to thrive in massive subreddits or media-posting subreddits (ex. image or video sharing) as opposed to the mid-sized, discussion subreddits that are the target of this study. This dataset itself even appears to have low bad-actor bot activity – either because the moderators removed most repeat-posting bot activity or because the bots do not repeatedly post the same comments. I account for both these components in the comment frequency analyses. However, as discussed in this section, bad-actor bot activity can be notoriously difficult to identify by easily identifiable linguistic structures alone. Therefore, I leave any results open to an interpretation in which bad-actor bots impact the findings. My approach still analyzes whether daily average sentiment in these subreddits change post-shock. Although, it is understandable if one partially attributes any findings to bad-actor bot activity.

Methodology

To analyze the core research question, this study exploits two major tools: VADER sentiment analysis and interrupted time-series regression.

I use the VADER (Valence Aware Dictionary for sEntiment Reasoning) sentiment analysis model after data cleaning to score each comment on the tool's scale of continuous numbers [-1, 1]. The scale considers texts scored in the range [-1, -0.05) as negative sentiment, texts scored in the range [-0.05, 0.05] as neutral sentiment, and texts scored in the range (0.05, 1] as positive sentiment.

The VADER tool is a rules- and lexicon-based model which is trained to work with internet text, vernacular, and language structures (Hutto and Gilbert 2014). In fact, in the cited literature, VADER outperforms human hand-scored sentiment coding in large-scale accuracy trials. Even in modern studies, this model impressively outperforms all other rules-based sentiment models and even some more complex sentiment machine-learning (ML) algorithms – with VADER performing at 72-87% accuracy on sentiment scores (Lazrig & Humpherys 2022). This study employs VADER for its strong accuracy and for the sake of research time constraints. However, researchers should take advantage of the cited high-performing ML tools in future

time-series sentiment analysis studies. I provide a cursory explanation of VADER coding methodology from its core documentation in Figure 2 below.

Figure 2. Explanation of VADER Methodology (Hutto 2014)

```
if __name__ == '__main__':
    # --- examples -------
    sentences = ["VADER is smart, handsome, and funny.",  # positive sentence example
                 "VADER is smart, handsome, and funny!",
                 # punctuation emphasis handled correctly (sentiment intensity adjusted)
                 "VADER is very smart, handsome, and funny.",
                 # booster words handled correctly (sentiment intensity adjusted)
                 "VADER is VERY SMART, handsome, and FUNNY.",  # emphasis for ALLCAPS handled
                 "VADER is VERY SMART, handsome, and FUNNY!!!",
                 # combination of signals - VADER appropriately adjusts intensity
                 "VADER is VERY SMART, uber handsome, and FRIGGIN FUNNY!!!",
                 # booster words & punctuation make this close to ceiling for score
                 "VADER is not smart, handsome, nor funny.",  # negation sentence example
                 "The book was good.",  # positive sentence
                 "At least it isn't a horrible book.",  # negated negative sentence with contraction
                 "The book was only kind of good.",
                 # qualified positive sentence is handled correctly (intensity adjusted)
                 "The plot was good, but the characters are uncompelling and the dialog is not great.",
                 # mixed negation sentence
                 "Today SUX!",  # negative slang with capitalization emphasis
                 "Today only kinda sux! But I'll get by, lol",
                 # mixed sentiment example with slang and constrastive conjunction "but"
                 "Make sure you :) or :D today!",  # emoticons handled
                 "Catch utf-8 emoji such as 🇺🇸 and 💋 and 🇺🇸",  # emojis handled
                 "Not bad at all"  # Capitalized negation
                 ]
```

To assess the validity of the tool's scores on this study's dataset, I extract a small sample (n = 150) of comments from the dataset. From here, I hand-score the comments according to the tool's scale without having observed the VADER scores nor the comments' subreddit of origin. I then analyzed the differences between my personal scores and the VADER model scores, which is a common and advisable accuracy check in textual analysis (Grimmer and Stewart 2013).

This methodology provides an additional check to VADER's scores as Reddit comments may require their own contextual understanding. For example, Twitter allows an individual to merely comment on another's post; but Reddit allows redditors to comment on another redditor's post, comment on another comment on a post, and so forth. While my scores cannot represent the layperson's perception of a comment's sentiment nor stand in for the average redditor's perception, I have participated on the site's forums for 10+ years. I can therefore understand online cultural norms by which these communities abide, as Reddit has its own sets of informal cultural norms colloquially dubbed Reddiquette (Reddit 2023). Figures 3 and 4 below compare the sample's human-coded scores to the VADER-coded scores.

Figure 3.
Comparing Human vs. VADER Sentiment Scores in Sample

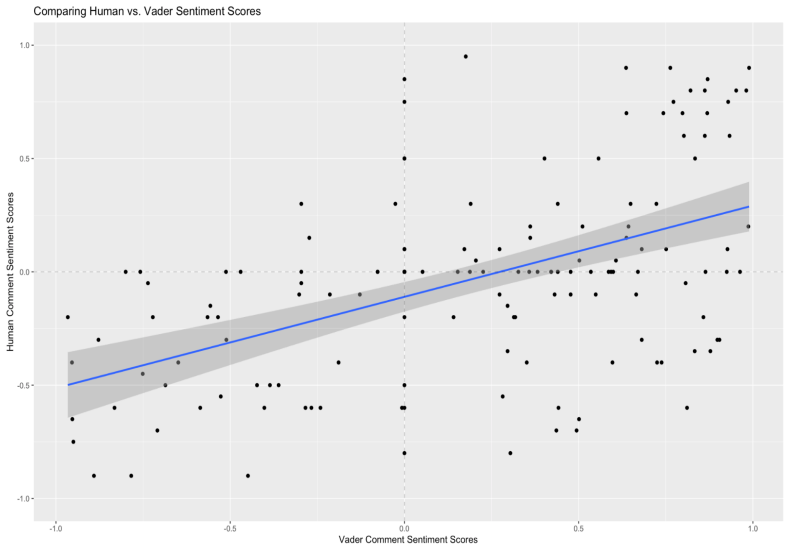
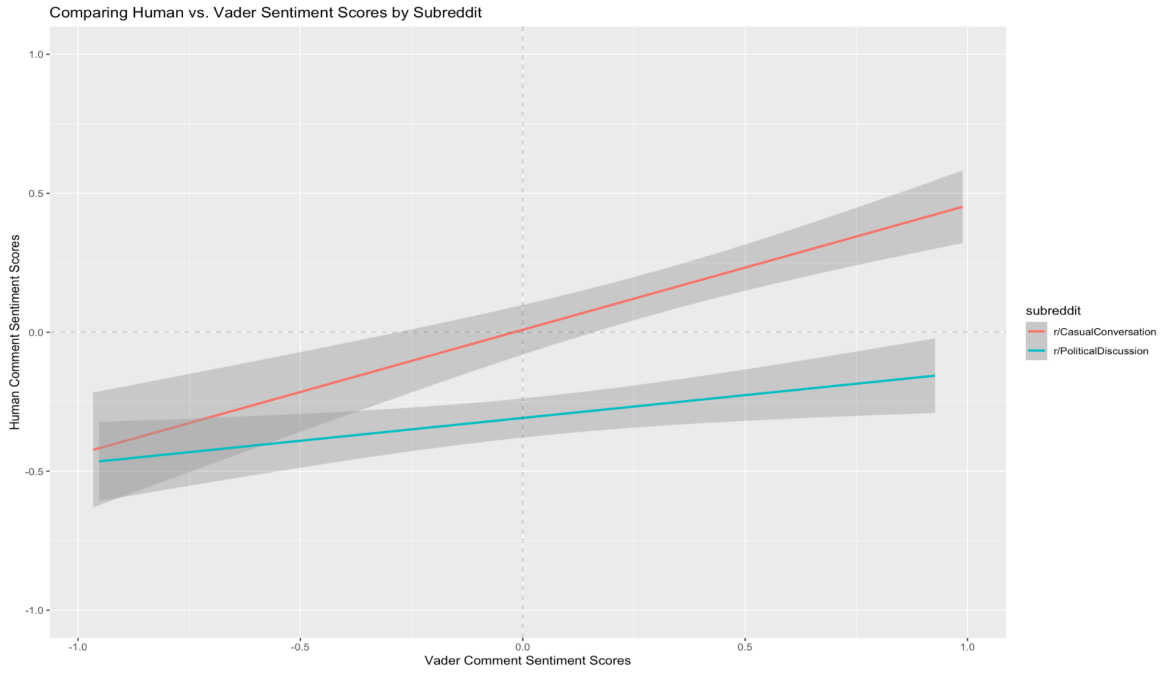


Figure 4. Comparing Human vs. VADER Sentiment Scores by Subreddit in Sample



Each figure helps us compare how a human coder (in this case, myself) and the VADER model perceive Reddit comment sentiment. Figure 2 shows us that I code comments on average more negatively and moderately than VADER. However, there is an obvious positive correlation between our comment scores. It is fantastic that VADER and I typically agree on when comments are more positive relative to others since this study seeks to measure *relative* average daily comment scores. Therefore, this result validates VADER's utility to the core study.

Figure 3 breaks down Figure 2's results by target subreddit. We can see that I score comments on average more moderately than VADER regardless of the target subreddit. We can also observe that I typically agree with VADER's r/CasualConversation comment sentiment assessment (i.e. whether a comment is positive, neutral, or negative). However, I broadly score r/PoliticalDiscussion comments as negative regardless of VADER's score. These results do not significantly impact the statistical analyses later in this study, thankfully. This is due to the fact that there is still an obvious positive correlation between my scores and VADER's scores. So, the model and I generally agree on when comments are more positive than others, regardless of subreddit. Figure 3's most important takeaway is that I (and possibly other redditors/laypersons) would on average perceive r/PoliticalDiscussion's sentiments as more negative than VADER does.

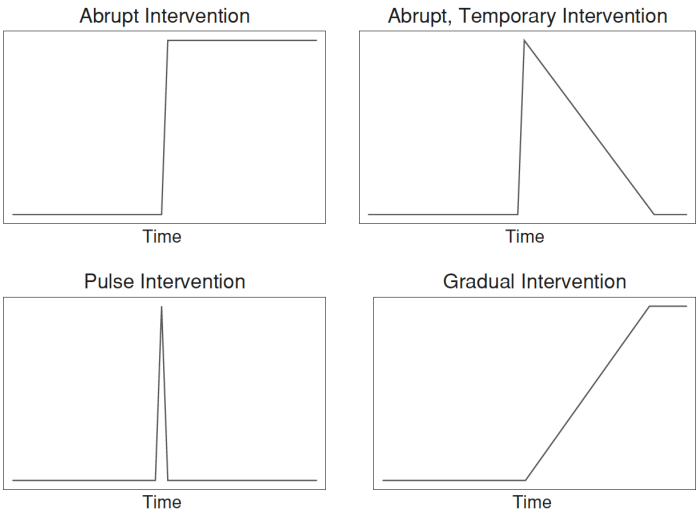
After comparing the scores, I convert the VADER comment sentiment scores into a time-series. I achieve this by calculating the mean of the VADER scores by comment post date and by subreddit. I refer to this time-series data moving forward as the DASS (Daily Average Sentiment Score).

This study also takes advantage of the interrupted time-series regression (ITS), which is an intuitive, quasi-experimental method to evaluate a potential causal relationship in a time-series. Simply stated, this method statistically compares the outcome variable before and after a key event's point in the time-series and evaluates for a change between the two periods' mean functions or trends. Quantitative methodologists laud ITS as one of the best quasi-experimental designs since it controls for "secular trends in a time series of outcome measures", can comfortably analyze population rates, works well with analyzing unintended effects of significant events, and produces easily interpretable visual results (Penfold and Zhang 2013). This study's access to comment data with precise time measurements but without

traditional experimental parameters (i.e. the ability to randomize treatment) lends the analysis particularly well to ITS.

ITS also allows this study to measure different types of shock impacts on the DASS outcome variable. Figure 5 below displays each of these impact types.

Figure 5. Types of Interventions in ITS Analysis (Righetti 2022)

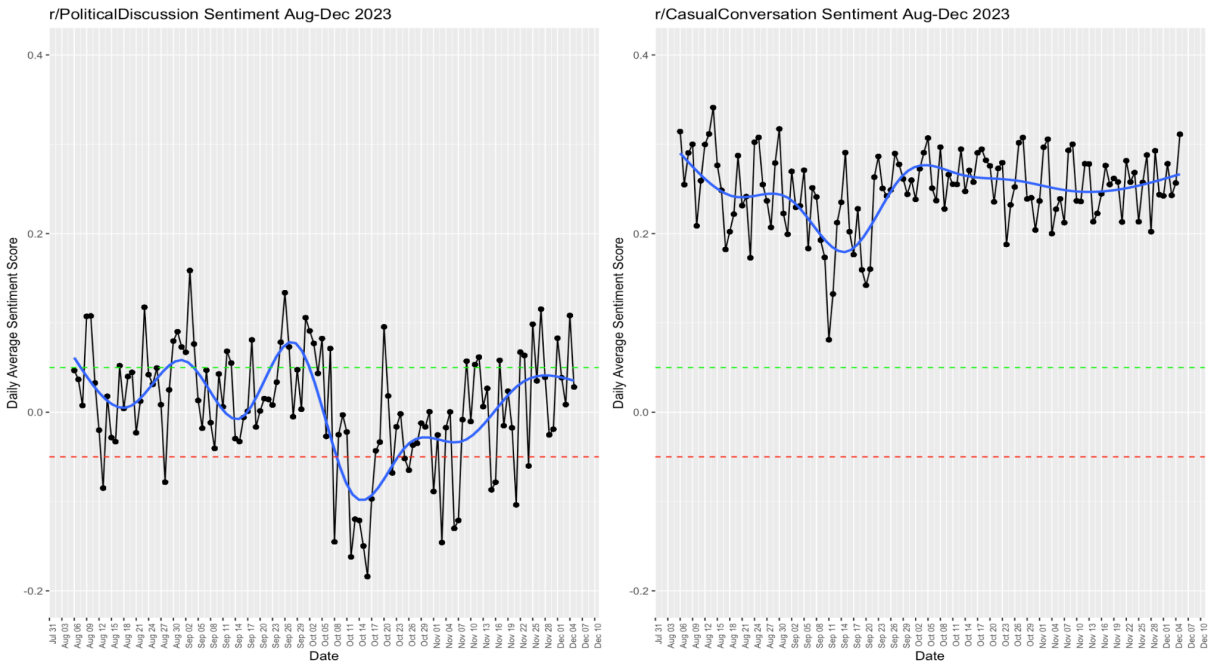


In line with Hypothesis 3, this study assumes that the shock's DASS impact takes the form of the *abrupt, temporary intervention*. I do not expect DASS to shift permanently (i.e. abrupt or gradual intervention) nor for DASS to shift for only a day or two (pulse intervention).

Results

Figure 6 below shows r/PoliticalDiscussion and r/CasualConversation DASS over the measured date range. We can clearly see that VADER scores r/PoliticalDiscussion comments as neutral on average with DASS centering around 0.0. In contrast, VADER scores r/CasualConversation comments more positively with DASS centering around +0.25. Each subreddit time-series also follows their own fluctuation patterns, which is noteworthy in the next steps.

Figure 6. Daily Average Sentiment Score (DASS) Time-Series by Subreddit, 2023/8/7 - 2023/12/6



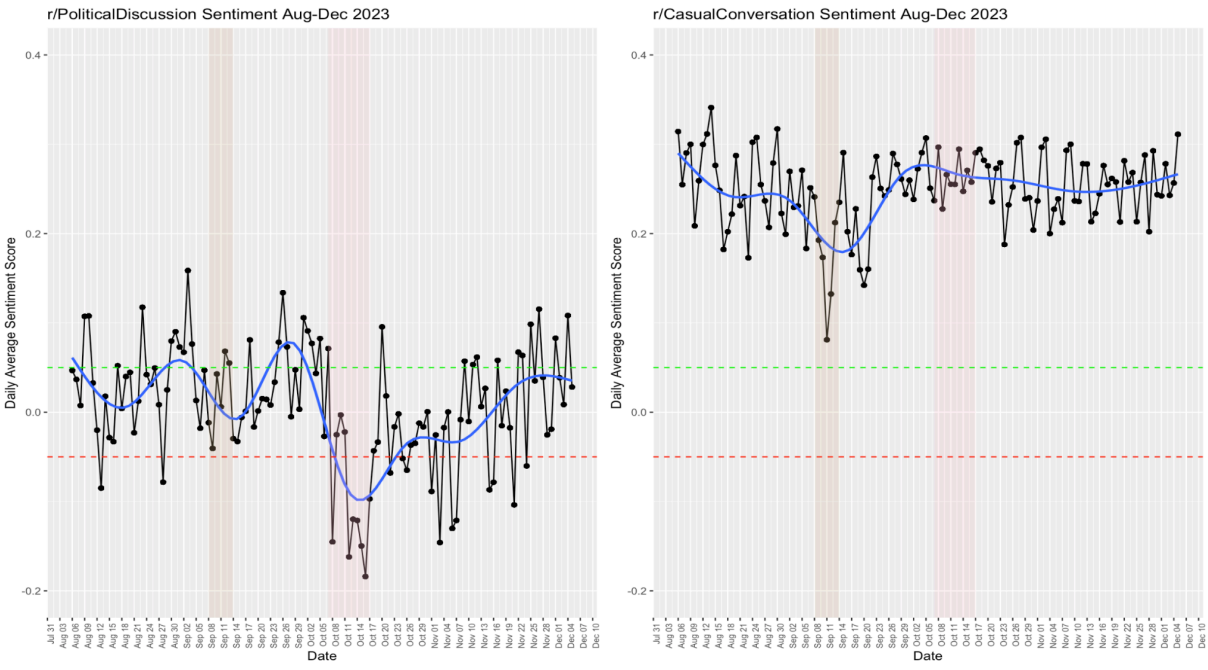
We can see a clear negative trend in r/PoliticalDiscussion DASS around the target dates, which are Oct.7th and the weeks thereafter. In fact, visually, the chart appears to provide evidence toward Hypothesis 1 *and* Hypothesis 3. The shock appears to affect DASS negatively via an abrupt, temporary intervention. Then, the DASS eventually stabilizes toward pre-shock norms near the end of the study timeframe.

In comparison, r/CasualConversation has more positive DASS around the target dates relative to its pre-shock trends. However, its chart provides less visual evidence toward the subreddit's respective hypotheses. In fact, the subreddit has a downward DASS trend in the months preceding Oct.7th. This trend even has an example of a negative DASS pulse intervention around Sep.11th (the anniversary of the 2001 terrorist attack which successfully collapsed the US World Trade Center). Then, the subreddit DASS begins rising before Oct.7th instead of during the attack period. Since r/CasualConversation could not have anticipated this terrorist attack, there is low visual evidence for Hypothesis 2.

Interestingly, the two subreddits do not share overlap in DASS trends. r/PoliticalDiscussion does not share r/CasualConversation's early-study downward trend nor the negative pulse impact around Sep.11th. r/CasualConversation similarly does not share r/PoliticalDiscussion's abrupt, temporary, negative impact around Oct.7th. The two communities therefore appear to react to different incidents from each other.

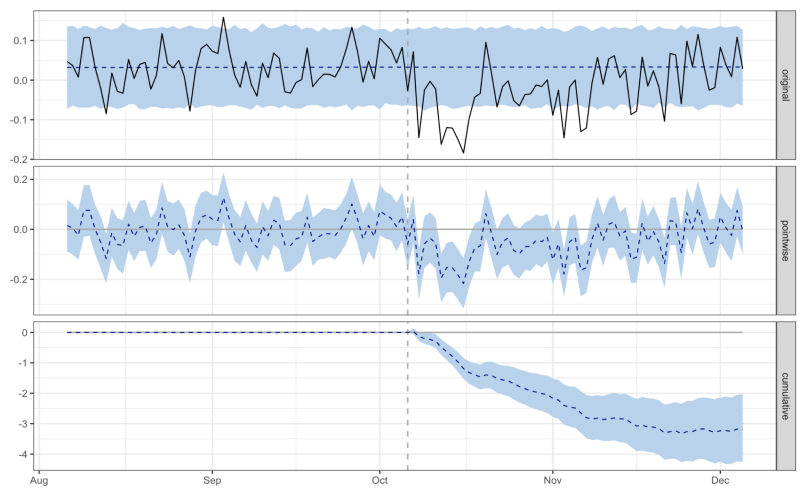
Figure 7 below demonstrates this contrast between the two online communities. It highlights the Oct.7th period in pink and highlights the Sep.11th period in brown.

Figure 7. DASS Time-Series by Subreddit w/ Highlighted Periods of Focus, 2023/8/7 - 2023/12/6



ITS analyses corroborate these results, as shown in Figures 8 and 9 below.

Figure 8. Interrupted Time-Series (ITS) Regression, r/PoliticalDiscussion DASS

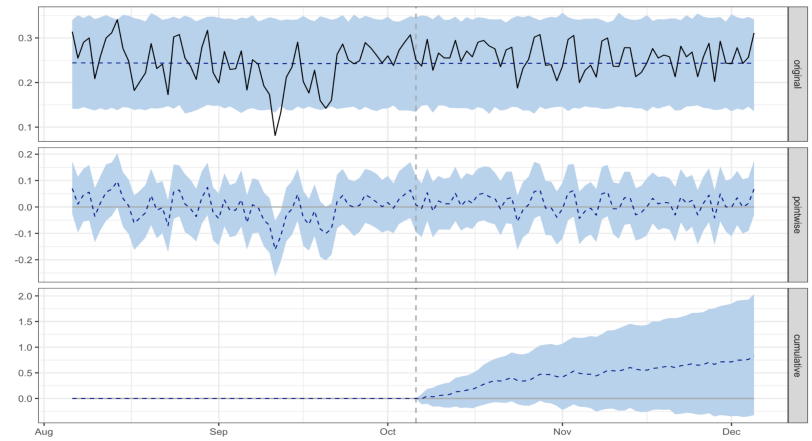


Posterior inference {CausalImpact}

	Average	Cumulative
Actual	-0.02	-1.21
Prediction (s.d.)	0.033 (0.0097)	1.976 (0.5791)
95% CI	[0.014, 0.051]	[0.829, 3.052]
Absolute effect (s.d.)	-0.053 (0.0097)	-3.181 (0.5791)
95% CI	[-0.071, -0.034]	[-4.258, -2.035]
Relative effect (s.d.)	-109% (2178%)	-109% (2178%)
95% CI	[-241%, -139%]	[-241%, -139%]

Posterior tail-area probability p: 0.00101
Posterior prob. of a causal effect: 99.8995%

Figure 9. ITS Regression, r/CasualConversation DASS



Posterior inference {CausalImpact}

	Average	Cumulative
Actual	0.26	15.42
Prediction (s.d.)	0.24 (0.0099)	14.59 (0.5915)
95% CI	[0.22, 0.26]	[13.39, 15.74]
Absolute effect (s.d.)	0.014 (0.0099)	0.828 (0.5915)
95% CI	[-0.0054, 0.034]	[-0.3227, 2.034]
Relative effect (s.d.)	5.9% (4.3%)	5.9% (4.3%)
95% CI	[-2%, 15%]	[-2%, 15%]

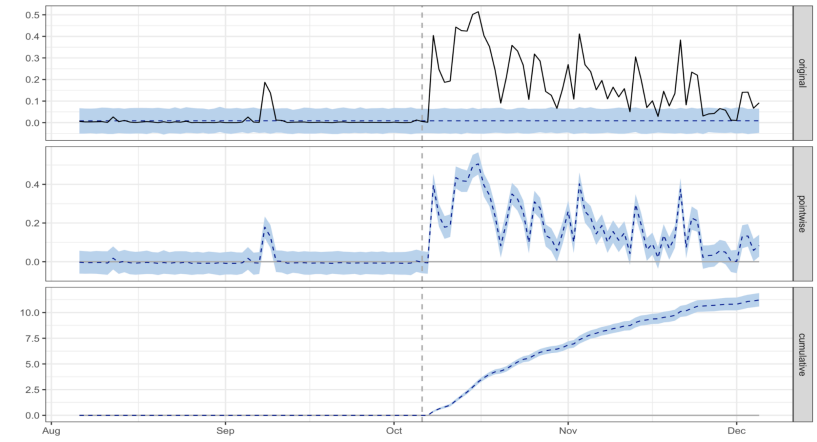
Posterior tail-area probability p: 0.07035
Posterior prob. of a causal effect: 93%

Figure 8 shows a probability $p < 0.001$ of obtaining r/PoliticalDiscussion's drop in DASS around the shock period by chance. Therefore, the Oct.7th shock's negative DASS impact is statistically significant in this community. In addition, the shock's cumulative effect approaches its limit around late November, indicating the shock's impact as only temporary.

Figure 9 gives a probability $p < 0.1$ of obtaining r/CasualConversation's DASS increase around the shock period by chance. This is admittedly a fairly strong probability that points in favor of Hypothesis 2. I must note, however, the corresponding time-series's aforementioned shortcomings. I therefore cast doubt on these near-significant results without more pre-shock DASS in r/CasualConversation to analyze, which would give us further insights into what r/CasualConversation's typical DASS trends look like.

In addition, I provide a follow-up ITS analysis on r/PoliticalDiscussion data as a robustness check. This check allows us to provide evidence that the significant results stem from the Oct.7th attack and not another event which occurs around the same period. In this analysis, I measure the percentage of daily comments referring to one of five keywords related to the attack: "Israel", "Palestine", "Gaza", "Hamas", and "Netanyahu[4]". Results are given in Figure 10 below.

Figure 10.
ITS Regression, r/PoliticalDiscussion % of Daily Comments Mentioning Any Keywords



Posterior inference {CausalImpact}

	Average	Cumulative
Actual	0.2	11.7
Prediction (s.d.)	0.0085 (0.0056)	0.5099 (0.3362)
95% CI	[-0.0027, 0.019]	[-0.1594, 1.134]
Absolute effect (s.d.)	0.19 (0.0056)	11.22 (0.3362)
95% CI	[0.18, 0.2]	[10.60, 11.9]
Relative effect (s.d.)	1280% (29654%)	1280% (29654%)
95% CI	[-14832%, 17138%]	[-14832%, 17138%]

Posterior tail-area probability p: 0.00101
Posterior prob. of a causal effect: 99.8995%

For more details, type: summary(impact, "report")

Figure 10's robustness check provides further evidence toward Hypotheses 1 and 3. Clearly, there is a large increase in comments discussing any of the five keywords. The pre-shock daily keyword-presence average is 0.3%, whereas the post-shock daily average is 19.5%. The results, similar to Figure 8, start to flatten toward the end of the measurement period.

[4]: The term "Netanyahu" refers to Benjamin Netanyahu, Israel's prime minister at the time of the Oct.7th, 2023 attacks.

Shortcomings

There are a variety of limits to this study. For example, we must rely on the integrity of the source data, which is the result of several passionate internet hobbyists. If any of the hobbyists had undisclosed limitations in their data preparation, it would affect this study's data reliability. As of writing this study, I am not aware of any such limitations with the data.

Additionally, the data could have significant enough bot activity so as to interfere with the results. I take precautions over the course of this study to limit repeat comments, which comprise a significant amount of bot comments. However, more sophisticated or unique bots could feasibly bypass these measures undetected. I do not believe the analyzed online communities have enough bot activity to impact the results, but we cannot rule this interpretation out altogether.

The study also could have included more days of comment data pre- and post-shock so as to provide additional DASS context for both subreddits. We see this issue prominently in the r/CasualConversation time-series. This time-series appears to already undergo a temporary, downward trend in the beginning of its measured timeframe, which makes comparing pre- and post-shock trends difficult. Similarly, the r/PoliticalDiscussion time-series can benefit from an extended timeframe to further contextualize its significant results. In an ideal research environment, the study would simply expand the data time-frame. However, in the interest of the limited time given for this study's execution, I settle for the current timeframe.

In regards to r/PoliticalDiscussion's significant results, I cannot rule out the possibility that a different event around Oct.7th could have influenced the observed DASS trend. I provide reasonable evidence in this paper, however, that indicates a causal relationship between the shock and the measured DASS drop.

Finally, VADER is not a perfect text sentiment-scoring tool. As demonstrated in the Methodology section, VADER comment scores and my comment scores occasionally disagree on whether comments were positive, neutral, or negative – especially regarding r/PoliticalDiscussion comments. However, there is an obvious positive correlation between the two scoring methods, regardless of subreddit. Since the study seeks to compare relative DASS, it is great that VADER and I tend to agree about relative comment sentiment scores.

Conclusion

In this study, I consider how the unexpected Oct.7th, 2023 terrorist attack in Israel impacts the average daily sentiments of two Reddit communities, r/PoliticalDiscussion and r/CasualConversation. The analysis examines how such an exogenous shock can impact the two communities in different capacities due to their different collective goals. Research has ventured little into understanding an exogenous shock's impact on an online community's sentiment, so this piece adds valuable knowledge to the exogenous shock and CSS literature.

The study's data show distinct differences in the two communities' sentiments via their average sentiment levels, the unsynchronized DASS trends, and what impacts their DASS. It therefore provides empirical evidence of heterogeneity in online community sentiment.

The analysis shows how a strong exogenous shock can create an abrupt, temporary impact in an online community, through which the shock reverberates for months – even if the shock is geospatially distant from the online community's physical locations. However, further exploration is required to see if a shock – often political or economic in nature – can impact spaces which forbid explicitly discussing such topics (ex. r/CasualConversation). Future research should also study whether exogenous shocks can impact DASS in partially political online spaces or even non-discussion-based spaces such as video, image, or humor-based discussion forums. It would also be fascinating to observe what other examples could impact online communities beyond the Oct.7th attacks, as I am positive there are more shocks to uncover with greater and/or more long-term impacts.

In the end, this DASS shock analysis methodology can prove greatly useful beyond academic research. The work can be used to assess sentiment trends in important groups, such as analyzing countries undergoing volatile social periods or studying underground movements which thrive on the internet. This piece merely investigates one corner of a much larger, increasingly important online social ecosystem to explore.

Disclaimer

I used ChatGPT to write code for VADER to score the 400,000+ comments used in this study in chunks, which sped up data processing. I also used the service on occasion to correct a line of code or to help form a sentence for this paper. I did not use ChatGPT nor any other generative AI in this study for purposes other than those listed here.

References

Basu, S. (2020). Essays on Behavioral Change Caused by Exogenous Shocks [Ph.D., Tulane University].

Camacho, A. (2008). Stress and Birth Weight: Evidence from Terrorist Attacks. American Economic Review, 98(2), 511–515.

Does Reddit have a problem with Bots? (2023, February 1). [Reddit Post]. R/RedditforBusiness. www.reddit.com/r/RedditforBusiness/comments/10r4xo2/does_reddit_have_a_problem_with_bots/

Ferretti, M., Profumo, G., & Tutore, I. (2015). Shock events and corporate announcements. Journal of Communication Management, 19(1), 81–101.

Grimmer, J., & Stewart, B. M. (2013). Text as Data: The Promise and Pitfalls of Automatic Content Analysis Methods for Political Texts. Political Analysis, 21(3), 267–297.

Gross National Happiness—Home. (n.d.). Retrieved July 23, 2024, from https://gnh.today/

Gunaratne, C., Ray, S. K., Alves, C. L., & Waldl, M. (2020). Exogenous Shocks Lead to Increased Responsiveness and Shifts in Sentimental Resilience in Online Discussions (arXiv:2004.04820). arXiv. http://arxiv.org/abs/2004.04820

Harding, E. (2023). How Could Israeli Intelligence Miss the Hamas Invasion Plans? https://www.csis.org/analysis/how-could-israeli-intelligence-miss-hamas-invasion-plans

Hawash, R. (2019). Prenatal Stress and Birth Weight: Evidence from the Egyptian Revolution. International Journal of Development and Conflict, 9(1), 19–42.

Heitmann, Arthur. (2024). ArthurHeitmann/arctic_shift [TypeScript]. https://github.com/ArthurHeitmann/arctic_shift (Original work published 2023)

Hutto, C., & Gilbert, E. (2014). VADER: A Parsimonious Rule-Based Model for Sentiment Analysis of Social Media Text. Proceedings of the International AAAI Conference on Web and Social Media, 8(1), 216–225.

Hutto, C. J. (2024). Cjhutto/vaderSentiment [Python]. https://github.com/cjhutto/vaderSentiment (Original work published 2014)

Infographic: How Popular Is Reddit Around the World? (2024, May 8). Statista Daily Data. https://www.statista.com/chart/26423/percentage-of-regular-reddit-users-by-country

Israel-Hamas War | Explanation, Summary, Casualties, & Map | Britannica. (2024, July 21). https://www.britannica.com/event/Israel-Hamas-War

Israel social security data reveals true picture of Oct 7 deaths. (2023, December 15). France 24.

Jensen, B., & Ramjee, D. (2023). Beyond Bullets and Bombs: The Rising Tide of Information War in International Affairs. https://www.csis.org/analysis/beyond-bullets-and-bombs-rising-tide-information-war-international-affairs

Lazrig, I., & Humpherys, S. L. (2022). Using Machine Learning Sentiment Analysis to Evaluate Learning Impact.

Li, J., Sun, W., Jiang, W., Yang, H., & Zhang, L. (2017). How the Nature of Exogenous Shocks and Crises Impact Company Performance?: The Effects of Industry Characteristics. International Journal of Risk and Contingency Management, 6(4), 40–55.

Moderation Bots & Tooling. (2023, June 15). Reddit Help. https://support.reddithelp.com/hc/en-us/articles/16471395473812-Moderation-Bots-Tooling

Morgeson, F. P., Mitchell, T. R., & Liu, D. (2015). Event System Theory: An Event-Oriented Approach to the Organizational Sciences. Academy of Management Review, 40(4), 515–537.

Morrison, P. S., Rossouw, S., & Greyling, T. (2022). The impact of exogenous shocks on national wellbeing. New Zealanders' reaction to COVID-19. Applied Research in Quality of Life, 17(3), 1787–1812.

Penfold, R. B., & Zhang, F. (2013). Use of Interrupted Time Series Analysis in Evaluating Health Care Quality Improvements. Academic Pediatrics, 13(6), S38–S44.

"PoliticalDiscussion" [r/PoliticalDiscussion] *Reddit*, n.d., www.reddit.com/r/PoliticalDiscussion/

quinn_thomas. (2023, June 8). What is going on with the sudden increase of bot accounts on Reddit? [Reddit Post]. R/OutOfTheLoop. www.reddit.com/r/OutOfTheLoop/comments/144hool/what_is_going_on_with_the_sudden_increase_of_bot/

Reddiquette. (2023, November 8). Reddit Help. https://support.reddithelp.com/hc/en-us/articles/205926439-Reddiquette

Righetti, N. (2022). Chapter 10 Intervention Analysis | Time Series Analysis With R. https://nicolarighetti.github.io/Time-Series-Analysis-With-R/intervention-analysis.html

Schuenemann, J.-H., Katenka, N., & Ribberink, N. (2023). US and European Stock Markets in Response to Exogenous Shocks: Cross-Regional Analysis of Dynamic Networks During the COVID-19 Pandemic. Global Business Review, 09721509231158867.

shiruken. (2023, May 1). Reddit Data API Update: Changes to Pushshift Access [Pushshift is in violation of the Reddit Data API terms and has been unresponsive despite multiple outreach attempts. Reddit is suspending Pushshift's access to the Data API starting today] [Reddit Post]. R/Pushshift. www.reddit.com/r/pushshift/comments/134uvzz/reddit_data_api_update_changes_to_pushshift/

Skowronski, J. (2019, July 30). Trolls and bots are disrupting social media—Here's how AI can stop them (Part 1). Medium.

Skowronski, J. (2019, July 30). Identifying trolls and bots on Reddit with machine learning (Part 2). Medium.

"The friendlier part of Reddit" [r/CasualConversation] *Reddit*, n.d., www.reddit.com/r/CasualConversation/

Torche, F. (2011). The Effect of Maternal Stress on Birth Outcomes: Exploiting a Natural Experiment. Demography, 48(4), 1473–1491.

Xova_YT. (2023, April 16). Why is there such a bot problem on Reddit right now? [Reddit Post]. R/NoStupidQuestions.

www.reddit.com/r/NoStupidQuestions/comments/12o7fr0/why_is_there_such_a_bot_problem_on_reddit_right/

Watchful1. (2024, February 7). Separate dump files for the top 40k subreddits, through the end of 2023 [Reddit Post]. R/Pushshift. www.reddit.com/r/pushshift/comments/1akrhg3/separate_dump_files_for_the_top_40k_subreddits/

What is Hamas? The group that rules the Gaza Strip has fought several rounds of war with Israel. (2023, October 9). AP News.

World Health Organization (WHO). 2024. Coronavirus disease (COVID-19) pandemic. https://www.who.int/europe/emergencies/situations/covid-19