Analysis of International Interests and Emotional Responses to the Coronavirus Pandemic

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Abstract

The outbreak of coronavirus disease 2019 (COVID-19) in December 2019 is still exerting a global impact in 2022, with various media outlets reporting related news items on a daily basis. We analyzed the interest in, and emotional reactions to, COVID-19 of people around the world, as expressed on Twitter. As a measure of interest, we examined replies to news tweets posted by four news outlets (Yahoo! News, The Wall Street Journal, The Guardian, and The Times of India), and classified the emotional content of each reply tweet using Plutchik's wheel of emotion. The analysis suggested that negative sentiment prevailed worldwide between January 2020 and May 2022; fear-related tweets were significantly more common from January to February 2020 than in the other months in all news reports. However, anticipation-related tweets were more common than those in all other emotion categories in October–November 2021 in Japan. We also analyzed the factors that contributed to the rise of a particular emotion by tracing the news to which tweets with the emotion replied. Our approach that used the news and reply tweets was useful in approximating the factors of the emotional reactions of people to COVID-19.

Keywords: Twitter, Sentiment Analysis, COVID-19

1   Introduction

The coronavirus disease 2019 (COVID-19) outbreak that began in December 2019 was a novel event with global consequences. Subsequently, variants including the Delta and Omicron strains were identified, and policies were implemented by governments to control the spread of COVID-19 including mask-wearing recommendations, lockdowns and vaccination programs. Many people learned about these developments by watching the news. For events of interest to the general population, the media may provide new reports whenever there are developments; various media outlets reported a range of COVID-19 related news on a daily basis. The total numbers of tweets in reply to COVID-19 related news posted on Twitter between January 1, 2020 (when COVID-19 emerged as a newsworthy topic worldwide) and May 31, 2022 by several news outlets (Yahoo! News, The Wall Street Journal, The Guardian, and The Times of India) are shown in Figure 1. In this figure, the tweets matching the query (corona (コロナ) OR covid) posted by each news outlets are counted by month. It can be seen that the number of COVID-19 related news items

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peaked between March and April 2020. Since that time, the news tweets have gradually declined, but even in May 2022, over 100 of news has been posted. From this, COVID-19 has been one of the most important news topics in the past 2 years for people around the world. When covid-19 was discovered, many people would have been concerned about it as an unknown virus, but the continued reporting of analysis and government countermeasure information on this virus would have helped people gain a better understanding and awareness. However, awareness of new problems related to the event or ongoing problems that persist may cause more interest, and some individuals may continue to feel anxious. We are interested in understanding how people's level of interest and emotional responses change over time in response to news reports related to the COVID-19, and the related factors. Research on this topic would help to investigate what triggers people's feelings of anxiety and security, and clarify the differences and common elements in the emotions expressed by people from around the world.

To investigate changes in people's interests and emotions in relation to COVID-19, we analyzed reply tweets to tweets posted by the news outlets shown in Figure 1. Reply tweets are the indicator of people's level of interest in the news dealing with specific events. Another advantage of using reply is that can collect tweets that mention or comment on news that are not matched by query-based searches. In our analysis of the emotional responses, we used binary classifiers trained on a labeled dataset based on Plutchik's wheel of emotions [1]. Plutchik distinguished eight primary emotions: joy, sadness, anticipation, surprise, anger, fear, disgust, and trust. By analyzing the emotional content of the reply tweets, the emotional responses of the general population could be tracked over the course of the COVID-19 pandemic. Furthermore, we traced the tweets back to the original news items when a particular emotion is aroused. We demonstrate that our approach using news items, their reply tweets, and emotional classification is useful in providing an overview of the factors that have changed people's emotions.

The rest of this paper is organized as follows: the second section reviews the relevant literature; the third section describes the approach used to collect reply tweets to COVID-19-related news tweeted by the various media outlets, the emotion classification system, and the text analysis approach; the fourth section discusses the results of the tweet analysis; and the last section summarizes the findings.
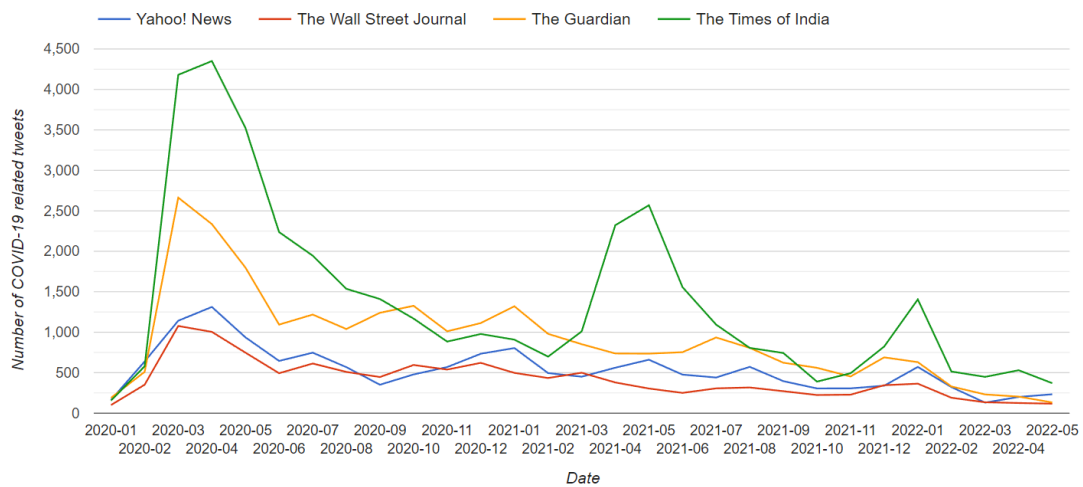

Figure 1: Numbers of coronavirus-related tweets by four major news outlets.

2 Related Work

Many studies have identified various topics emerging during the COVID-19 pandemic, and have analyzed people's feelings about these topics, and changes therein over time. In a Brazilian study, De and Figueiredo [2] applied sentiment analysis to news articles and tweets, to identify changes in sentiment over time to COVID-19-related topics. Ghasiya and Okamura [3] analyzed news articles on COVID-19 in four countries, while other studies used Top2Vec [4] and RoBERTa [5] to analyze differences in sentiment among countries. Other studies performing sentiment analysis focused on specific themes and topics emerging during the COVID-19 pandemic. Bhagat et al. [6] applied sentiment analysis to blog and newspaper articles using TextBlob [7], with the goal of understanding public opinion of online learning during the COVID-19 pandemic. Wang et al. [8] analyzed controversial topics related to mask-wearing and vaccination in the United States using latent Dirichlet allocation [9]. Specifically, they analyzed how interest in these topics changed over time using sentiment scores calculated by TextBlob, and identified factors associated with fluctuations in those scores. Hu et al. [10] analyzed how sentiments and opinions about vaccines evolved in the United States according to two critical events: clinical trials of the Moderna vaccine in March 1, 2020 and the administration of the first dose of a COVID-19 vaccine in February 28, 2021. Yousefinaghani et al. [11] used VADER [12] to classify tweets pertaining to the COVID-19 vaccine as negative or positive, in various countries including the United States, United Kingdom, and Canada, and extracted keywords for each class. They then defined "anti-vaccine," "hesitant," and "pro-vaccine" categories, and again identified keywords associated with each category. Finally, they analyzed the volume of tweets in each category by country. In the current study, we determined how people's interest in and feelings about COVID-19 around the world changed over time. We approximated this analysis by examining tweets in reply to news items.

3 Analysis Approach

3.1 Overview

We analyzed COVID-19-related tweets posted by major news outlets (Yahoo! News, The Wall Street Journal, The Guardian, and The Times of India), and tweets made in reply to those posts. We calculated the total and average number of reply tweets by month, and examined changes therein. Through this approach, we tracked public interest in COVID-19. We also classified the reply tweets on the basis of the eight emotions defined in Plutchik's wheel of emotion, and examined changes in their relative proportions. Through this analysis, we identified common and distinct factors associated with changes in the emotional responses of people worldwide to the COVID-19 pandemic. In addition, we traced the reply tweets back to the original news tweets to identify the events that evoked emotional responses. Section 3.2 describes the tweet collection process, and Section 3.3 describes the construction of the emotional classification model.

3.2 Collection of Tweet Data

Reply tweets to the news tweets described in Section 1 were collected. Specifically, the account name of the news outlet beginning with @ as a query was entered. Then, using tweet ID that shows the reply-to tweet included in each tweet, each reply tweet was linked to the corresponding news tweet. The Yahoo! News reply tweets were all in Japanese, while those for the other outlets were all in English. The data collection period was January 1, 2020 to May 31, 2022. Table 1

shows the total number of reply tweets for each news outlet.

3.3 Classification Model

We used machine learning to construct a binary tweet classification model. We describe the dataset and parameter settings used to construct the binary classifiers, as well as the classification performance for each emotion, below.

3.3.1 Dataset

For the classification of Japanese tweets, we used the Japanese emotion analysis dataset compiled by Kajiwara et al. [13]. This dataset contains 43,200 texts posted on social networking services labeled with Plutchik's eight emotions on four levels of emotional intensity (none, weak, medium, and strong). In addition, the labels included five types: one applied by the writer of the text, three applied by three readers of the text, and one by averaging the emotional intensities assigned by the three readers. We used 40,000 data for training, 1,200 data for validation, and 2,000 data for evaluation. Labels representing the average emotional intensity by the three readers were used, with weak, medium, and strong emotional intensity being positive, and none being negative.

For the classification of English tweets, we used the English emotion analysis dataset from the Emotion Classification (E-c) task, which is included in the dataset distributed in SemEval 2018 Task 1: Affect in Tweets [14]. This dataset contains 6,838, 886, and 3,259 data subsets for training, validation, and evaluation, respectively, and each text posted on a social networking service is labeled with 11 different emotions (Anger, Anticipation, Disgust, Fear, Joy, Love, Optimism, Pessimism, Sadness, Surprise, Trust). We used eight of the eleven emotions (Anger, Anticipation, Disgust, Fear, Joy, Sadness, Surprise, and Trust) to unify our classification with the emotion labels used in the dataset of Kajiwara et al.

3.3.2 Parameter Settings

As a classification model, we used BERT [15]. Parameters were set to 32 for batch size, 10 for epochs, 1e-6 for learning rate, and 128 for the number of tokens. Adam [16] was used for optimization. As a learning model for Japanese and English, we used "bert-based-japanese-whole-word-masking"[†] and "bert-base-uncased"[‡], respectively.

3.3.3 Classification Performance

Table 2 shows the classification performance for each emotion, separately for Japanese and English data. These classifiers were used to classify the reply tweets. Each tweet could be classified into multiple emotion categories because of the binary classification approach.

[†] https://huggingface.co/cl-tohoku/bert-base-japanese-whole-word-masking

[‡] https://huggingface.co/bert-base-uncased

Table 1: Total number of reply tweets for each news outlet

News Outlet	Account name	Total number of reply tweets
Yahoo! News	@YahooNewsTopics	898,222
The Wall Street Journal	@WSJ	181,911
The Guardian	@guardian	186,465
The Times of India	@timesofindia	105,223

Table 2: Classification performance for each emotional category

|	*Japanese*		*English*	
	Recall	*Precision*	*Recall*	*Precision*
Joy	0.693	0.784	0.767	0.765
Sadness	0.567	0.635	0.118	0.510
Anticipation	0.779	0.758	0.738	0.725
Surprise	0.421	0.621	0.732	0.722
Anger	0.063	0.500	0.861	0.835
Fear	0.333	0.619	0.545	0.646
Disgust	0.138	0.678	0.758	0.700
Trust	0.093	0.438	0.131	0.434

4 Results and Discussion
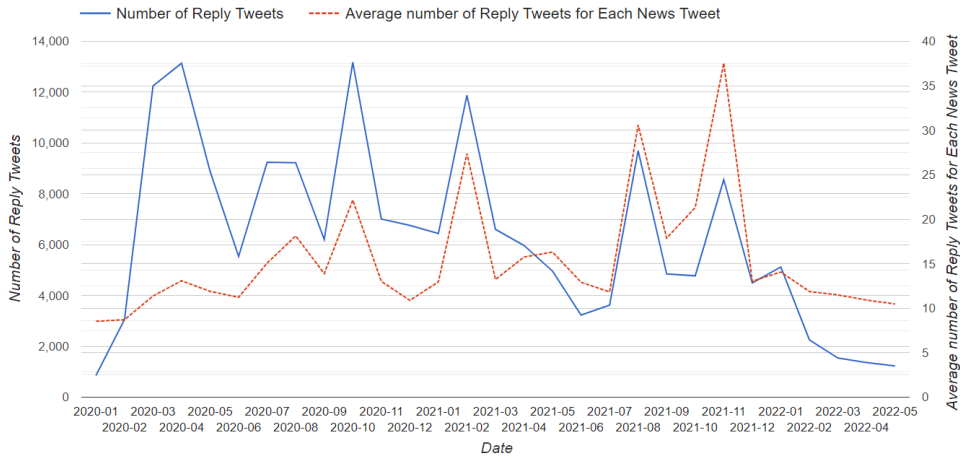
4.1 Distribution of Reply Tweets

Numbers of reply tweets to news tweets per month and monthly average number of reply tweets by news outlet are shown in Figure 2(a)–(d). In March and April 2020, the number of reply tweets by all outlets was considerably higher than the overall monthly average, after which there was a gradual decrease (in line with a decline in the number of news tweets). This may indicate that interest in covid-19 related topics may be narrowed down to a specific people. Interestingly, the peak for monthly average of the reply tweets was not seen in March or April 2020 for all news outlets; it occurred in April 2020 and August 2021 for Yahoo! News, November 2021 for The Wall Street Journal, April 2020 and May 2022 for The Guardian, and April and May 2021 for The Times of India. While COVID-19 was an unknown virus in early 2020, since 2021 awareness and understanding have increased, and countermeasures have been introduced in many countries. Overall, the results suggest that public interest in the pandemic changed between the early part of 2020 and the post-2021 period.

4.2 Classification Results and Discussion

Figures 3(a)–(d) show the monthly average ratio of emotional reply tweets for the four news outlets. As shown in Figure 3(a), gear and anticipation were commonly expressed in reply tweets to posts by Yahoo! News. Here, the precision exceeded 60% for both fear and anticipation, while the recall was 33.3% and 77.9%, respectively, as shown in Table 2. On the basis of these data, there may have been more fear tweets than suggested in Figure 3(a), particularly in response to posts by Yahoo! News. As shown in Figures 3(b)–(d), anger and disgust were commonly expressed in reply tweets to posts by The Wall Street Journal, The Guardian, and The Times of India. The proportion of joy reply tweets was higher for posts by The Times of India compared with those by the other media outlets. Here, comparing the performance of joy, anger, and disgust in Table 2, each showed the recall and precision of over 70%, suggesting that there is a certain degree of reliability in the transition of these three emotions in Figures 3 (b) to (d).
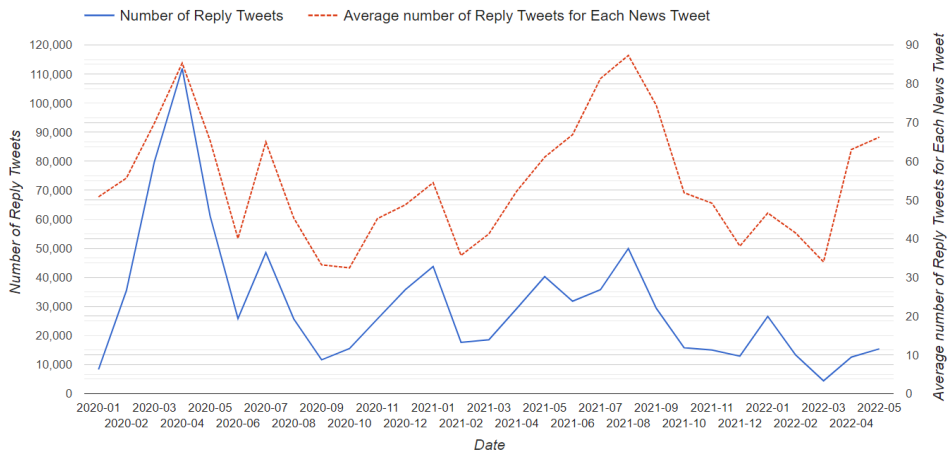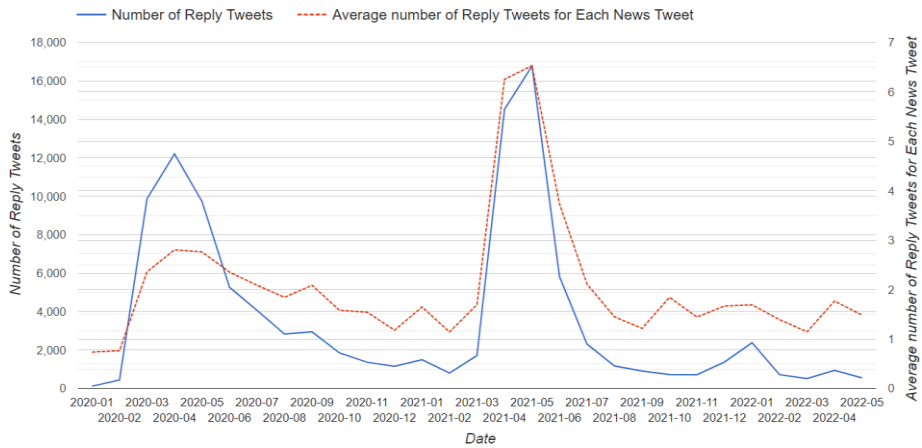
(a) Yahoo! News.

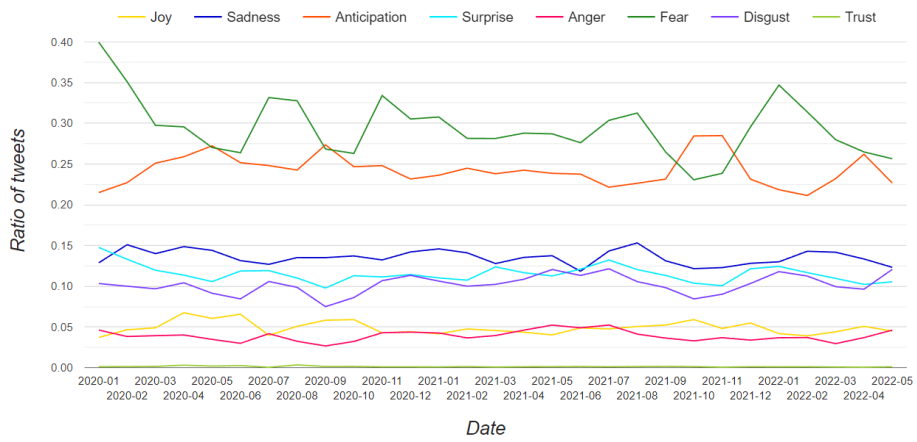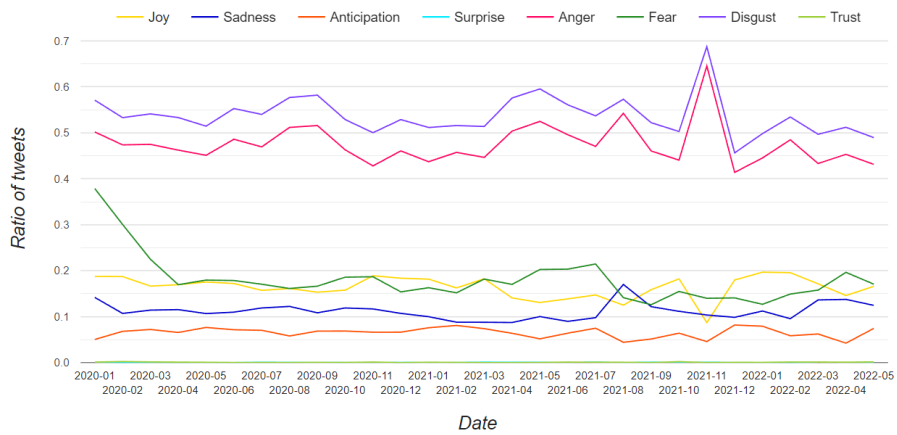(b) The Wall Street Journal.
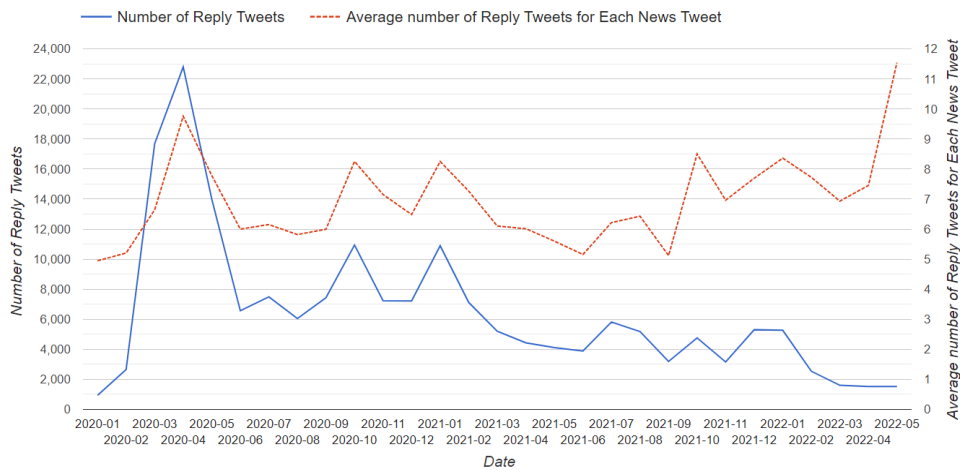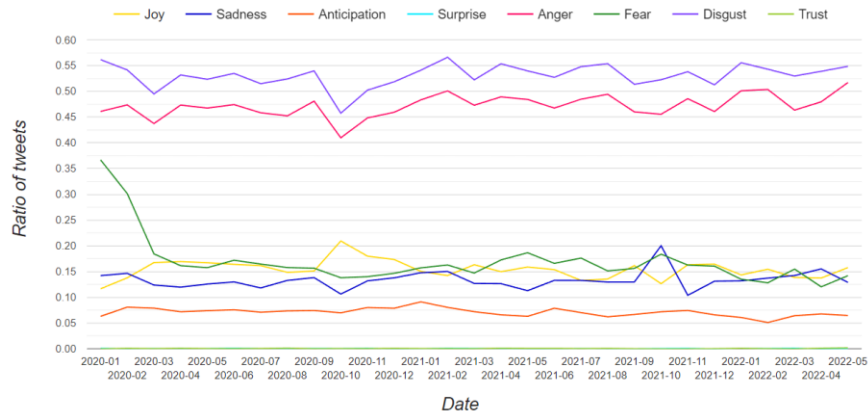

(c) The Guardian.

(d) The Times of India.

Figure 2: Numbers of reply tweets to news tweets per month and monthly average number of reply tweets by news outlet.
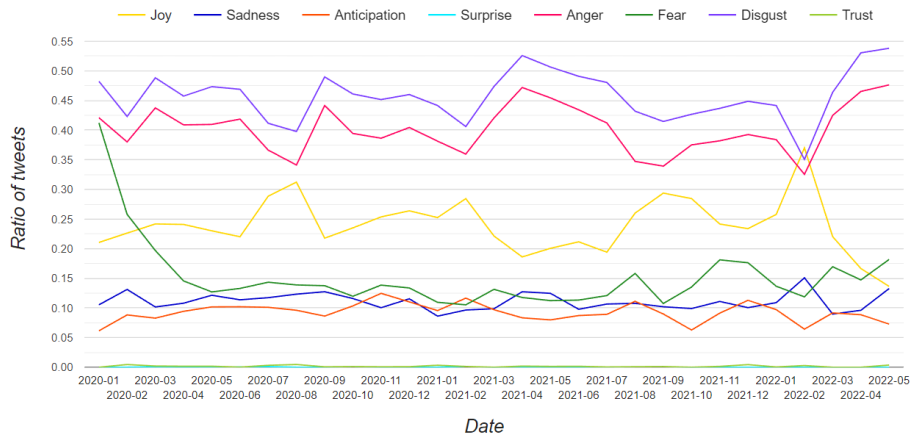

(a) Yahoo!News.

(b) The Wall Street Journal.

(c) The Guardian.

(d) The Times of India.

Figure 3: Relative proportions of reply tweets in the various emotional categories.

Interestingly, across all media, the proportion of fear tweets was significantly higher in January and February 2020 than in all other months. We investigated the associated events by examining the news tweets in those months. Table 3 shows the top news tweets with the highest number of fear reply tweets for each news outlet. From this table, it was common to see the emergence of news stories that were closely watching moves in China against COVID-19 or were concerned about the impact of COVID-19 on their own country. Also, the COVID-19 outbreak onboard the Diamond Prince cruise ship, which was covered by Yahoo! News and The Wall Street Journal, was of interest to many people, as it could shed light on how the novel virus affects in an enclosed environment. Of course, although they do not appear in Table 3, the Guardian and the Times of India have also published news on this topic. However, the number of replies in January and February 2020 is significantly lower than in the following months as shown in Figure 2, suggesting that some people who were interested in events before COVID-19 became a common topic around the world had a heightened sense of fear and concern about events related to COVID-19.

We here focus on the news that "toilet paper will be in short supply" appeared in news tweets in Yahoo! News. In Japan, a nationwide buying up of toilet paper and other paper products occurred from the end of February to April 2020, became a major social problem. The origin of this is believed to be a post on a social networking site that can be translated as follows: "Most toilet

paper is manufactured and exported in China, and will be in short supply due to COVID-19". There was a surge of posts claiming that this was a hoax; the news media then picked up the story and people became aware that the rumor was false. However, many people considered it possible that others would be fooled by the hoax and thus purchase more toilet paper, leading to a shortage; as a result, they themselves bought more of the product, leading to a genuine shortage. From this, such hoax-based anxiety and fear may have also led to fear in covid-19 pandemic in Japan.

Figure 3 shows that negative emotions as fear, anger, and disgust reply tweets were dominant in response to posts by all of the news outlets. However, tweets expressing anticipation, i.e., a positive emotion, were dominant over fear tweets in October and November 2011 as shown in Figure 3(a). Table 4 shows the five news tweets with the most anticipation reply tweets; news appeared regarding economic support from the government, including direct cash transfers to individuals and the Go To Travel campaign to support Japan's tourism sector. A news also appeared that dealt with a different topic than the above: "Japanese Society of Infectious Diseases is calling for active vaccination with the influenza vaccine". An examination of reply tweets to this news revealed that some users posted tweets about continuing to wear masks and gargle and wash their hands. These can be seen as positive statement that we will continue to use established practices and knowledge under the covid-19 pandemic against this news. On the other hand, sever-al tweets also found that said the news was announced by an organization making money from vaccines. Such opinions could be viewed as a (non-essential) anticipation of the push for vaccination with a cynical response to this news. Thus, our approach can be useful in capturing roughly the news that results from a particular emotional upsurge and people's reactions to it.

5   Conclusion

We analyzed tweets made in reply to news tweets posted by major news outlets pertaining to COVID-19 to investigate the changes in interest in, and emotional responses to, COVID-19 of people around the world were investigated. Our analysis results suggested that fear was commonly expressed in reply tweets to Yahoo! News posts, while anger and disgust were commonly expressed in replies to tweets by The Wall Street Journal, The Guardian, and The Times of India (from January 2020, when the pandemic began, to May 2022). In addition, the numbers of fear reply tweets were significantly higher in January and February 2020 than in all other months, for all news outlets, while Anticipation tweets were dominant in October and November 2021 in Japan. We also analyzed the factors that contributed to the rise of a particular emotion by tracing the news to which tweets with the emotion replied. Our approach was useful for tracking the emotional reactions of people over the course of the COVID-19 pandemic. In future, we will aim to devise additional emotional categories for tweets using analysis techniques such as cluster analysis.

Table 3: Example news tweets provoking fear reply tweets in the period January–February 2020

Account	Date	Number of Replies	News Tweet
Yahoo! News	2020/ 02/16	229	A male paramedic in his 30s from Yokohama Fire Department was infected with a new type of coronavirus, a Kanagawa Prefecture official said. The crew member was wearing a high-grade mask, goggles, and other personal protection equipment.
	2020/ 02/27	211	Phrases such as "toilet paper scarcity" have become prominent on social networking sites, but the notion that toilet paper is in short supply due to the novel coronavirus is incorrect. Only about 2.3% of Japan's toilet paper is imported from China.
	2020/ 02/21	199	Many Ministry of Health, Labour and Welfare of Japan (MHLW) employees working on the cruise ship where an outbreak of the novel coronavirus occurred have returned to work without being tested for the virus. The MHLW has decided not to allow these employees to undergo testing at this time.
	2020/ 02/19	197	With the spread of the novel coronavirus, Chinese social networking sites drew attention to marathons held over the weekend in various parts of Japan. On the basis of the experience of Wuhan, some people believe that Japan may encounter difficulties if this situation continues, or be worse off than Wuhan.
	2020/ 02/21	192	A person who recovered from infection with the novel coronavirus in China has been reinfected. The patient, who had been hospitalized in Sichuan Province with a novel coronavirus infection, was discharged from the hospital and, after 10 days of home isolation, was confirmed to have been reinfected.
The Wall Street Journal	2020/ 02/15	38	The State Department will evacuate US citizens and their families onboard the Diamond Princess cruise ship quarantined for coronavirus, a Centers for Disease Control and Prevention official has said.
	2020/ 01/31	32	Public ire over Hong Kong's relative inaction in response to the coronavirus outbreak has grown as neighboring Macau, another self-governed Chinese territory, stepped up preventive efforts.
	2020/ 02/07	31	A doctor in Wuhan reprimanded by the police for his early warnings about the dangers of the coronavirus has died, triggering an extraordinary outpouring of emotion in China. #WSJWhatsNo
	2020/ 02/20	22	A man and a woman, both in their 80s, onboard the Diamond Princess cruise ship have died.
	2020/ 02/07	21	Heard on the Street: What will happen to the Sino-American trade deal as the coronavirus outbreak spreads worldwide?
The Guardian	2020/ 02/02	59	Coronavirus: Hong Kong health workers to strike in China border row as deaths pass 300
	2020/ 01/31	22	Is the coronavirus panic turning the UK into a hostile environment for East Asians? #coronavirusuk
	2020/ 01/24	18	Coronavirus shakes citizens' faith in Chinese government.
	2020/ 01/24	16	Chinese state media downplays coronavirus as Xi strikes positive tone.
	2020/ 02/27	16	Tell us how coronavirus is affecting your day to day life.
The Times of India	2020/ 01/27	5	Air India Boeing 747 on standby to evacuate Indians from Wuhan amid coronavirus outbreak.
	2020/ 01/25	3	Coronavirus: Seven people who travelled to China under observation.
	2020/ 02/21	3	Iran confirms 13 more coronavirus cases, two deaths - Health ministry.
	2020/ 02/06	3	Economy affected with coronavirus, but govt giving medication for common cold: Manish Tewari.
	2020/ 02/01	3	#CoronavirusOutbreak: 324 Indians evacuated from China's Wuhan in special Air India plane.

Table 4: Example news tweets by Yahoo! News provoking anticipation reply tweets in the period October–November 2021

Date	Number of Replies	News Tweet
2021/ 11/04	684	The government and ruling party have decided to provide 100,000 yen in cash to children and young people (aged < 18 years) as a one-time support measure in response to the spread of the novel coronavirus. No income limit will be set. The plan will be included in a major economic stimulus package to be finalized by the government on March 19.
2020/ 10/11	436	Prime Minister Kishida stated on a TV Tokyo program (November 11) that he would like to implement economic measures in response to the novel coronavirus, and that he was "not opposed" to Komeito's proposal to provide a fixed amount of 100,000 yen to children (aged < 18 years), adding that he would discuss the details with the ruling party and decide on the specifics.
2021/ 10/04	388	Prime Minister Kishida was asked if he would provide cash transfers to individuals as a measure against the new coronavirus strain, and he stated that he would consider cash transfers for women, non-regular workers, and students on a case-by-case basis. He indicated that he would decide on the amount after consulting with the ruling party.
2021/ 10/07	185	The Japanese Society of Infectious Diseases is calling for active vaccination against influenza. Last season, the number of influenza cases plummeted as a result of countermeasures taken in the wake of the coronavirus pandemic. If restrictions on overseas travel are eased and the virus is brought into Japan, there is a risk of a pandemic this season.
2020/ 10/05	137	At a press conference held on May 5, the Minister of Land, Infrastructure, Transport, and Tourism, Tetsuo Saito, stated that he will consider the status of the novel coronavirus before resuming the Go To Travel tourism support project. He stated that the project is "essential for the recovery of tourist areas and local economies".

Acknowledgments

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