RESEARCH ARTICLE

Social Media Sentiment Analysis for Solar Eclipse with Text Mining

Metin Madenciliği ile Güneş Tutulmasına Yönelik Duygu Durumu Analizi

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ABSTRACT

This study investigated public sentiment and emotional reactions to the Partial Solar Eclipse that occurred on October 25, 2022, by analyzing Twitter data. By leveraging text mining techniques and sentiment analysis, the research aims to understand individuals' diverse emotions and perspectives in response to this natural event. Tweets related to the solar eclipse were collected, preprocessed, and analyzed using different sentiment analysis libraries, including NRC and Bing, to identify positive and negative emotions associated with the event. Results revealed that 75% of the analyzed tweets were positive, indicating that most users had a favorable view of the solar eclipse, associating it with new beginnings and change. In contrast, fewer individuals expressed negative emotions, linking the event to potential harm or divine punishment. The study demonstrates the value of sentiment analysis in understanding public sentiment and emotional reactions to natural events, providing insights into societal perceptions and attitudes toward these occurrences.

Keywords: Text mining, sentiment analysis, social media analysis, partial solar eclipse, natural events

ÖZ

Bu çalışma, Twitter verilerini analiz ederek, 25 Ekim 2022'de meydana gelen Kısmi Güneş Tutulması'na karşı halkın duyarlılığını ve duygusal tepkilerini araştırıyor. Araştırma, metin madenciliği tekniklerinden ve duygu analizinden yararlanarak, bireylerin bu doğal olaya tepki olarak farklı duygularını ve bakış açılarını anlamayı amaçlıyor. Güneş tutulmasıyla ilgili tweetler toplandı, ön işleme tabi tutuldu ve olayla ilgili olumlu ve olumsuz duyguları belirlemek için NRC ve Bing dahil olmak üzere farklı duyarlılık analizi kitaplıkları kullanılarak analiz edildi. Sonuçlar, analiz edilen tweet'lerin %75'inin olumlu olduğunu ortaya çıkardı; bu, çoğu kullanıcının güneş tutulması hakkında olumlu bir görüşe sahip olduğunu ve onu yeni başlangıçlar ve değişimle ilişkilendirdiğini gösteriyor. Buna karşılık, daha az kişi, olayı potansiyel zarar veya ilahi ceza ile ilişkilendiren olumsuz duygular ifade etti. Çalışma, halkın duyarlılığını ve doğal olaylara karşı duygusal tepkilerini anlamada duygu analizinin değerini gösteriyor, toplumsal algılara ve bu olaylara yönelik tutumlara ilişkin içgörüler sağlıyor.

Anahtar Kelimeler: Metin madenciliği, duygu analizi, sosyal medya analizi, parçalı güneş tutulması, doğa olayları

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1. INTRODUCTION

The rapid growth of social media platforms has transformed how people communicate and share their thoughts and emotions about various events and experiences. Natural phenomena, such as solar eclipses, often evoke a wide range of emotions and reactions from the public, making social media an invaluable data source for understanding societal perceptions and attitudes toward these events. By analyzing social media content, researchers can gain insights into how individuals interpret and respond to such occurrences, shedding light on the collective sentiment and emotions surrounding these events.

A solar eclipse is a celestial event that occurs with the linear alignment of the Sun, Moon, and Earth. Heavenly bodies are either lined up in a straight or somewhat straight line. A solar eclipse occurs when the Moon falls between the Sun and the Earth, casting a shadow on the Earth and, in some areas, wholly or partially blocking the Sun's light. The Moon does not move in orbit in the same plane as the Sun and Earth. When they line up, the eclipse season occurs twice a year (Nasa, 2022).

The first solar eclipse of the 21st century was the Total Solar eclipse on June 21, 2001. A solar eclipse occurs when the Moon passes between the Earth and the Sun, thus completely or partially obscuring the view of the Sun for a viewer on Earth. During a total eclipse, the moon completely covers the sun. The next Total Solar Eclipse will occur on April 8, 2024. In an annular eclipse, the Moon cannot completely cover the Sun and leaves a visible edge. The next Annular Solar Eclipse will be on October 14, 2023. In a partial eclipse, the Moon partially covers the Sun as it passes in front of it. Because the Earth's surface is curved, sometimes an eclipse can alternate between circular and total as the Moon's shadow moves over Earth. This is called a hybrid solar eclipse (Nasa Types, 2022).

In the 21st century, there will be 224 solar eclipses, including 77 partial, 73 annular, 68 total, and seven total and annular solar eclipses. There will be a maximum of four eclipses per year in the 21st century. These dates are 2011, 2029, 2047, 2065, 2076, and 2094 (Nasa, 2022).

Two solar eclipses took place in 2022. The first was the Partial Solar Eclipse on April 30, 2022; the other was on October 25, 2022. It could be seen in most of Europe, North Africa, the Middle East, and Western Asia. It started at 11:58:21, according to Istanbul time, and ended at 16:02:11. The time of the total eclipse was stated as 14:00:16 (TimeandDate, 2022). The Moon covers about 82% of the Sun. The dates of the seven total eclipses that will take place in the upcoming period are shown in Figure 1.
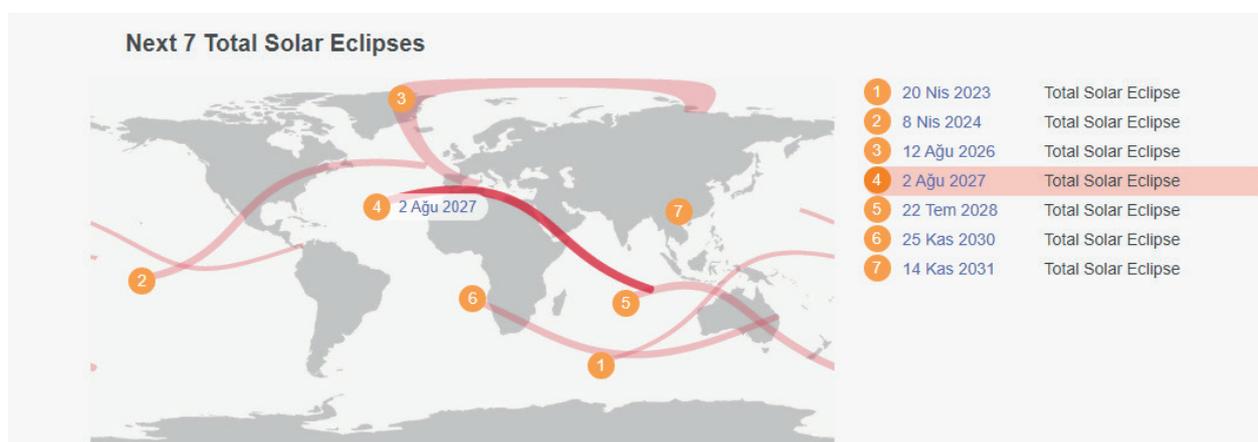

Figure 1. Date of Total Solar Eclipse

Many people believe that celestial conditions play a decisive role in life events. Scientifically, the effect of the Lunar Eclipse and Solar Eclipse on natural events is an undeniable issue (Javid, Tavaziani, & Shayanfar, 2022). Solar eclipses can affect living things on Earth. The first form of physical effect, the darkening that occurs during the transit of the Moon between the Sun and the Earth that prevents the sun's rays from contacting the Earth. The presence of light has a strong influence on animal behavior and hormones (Murdin, 2001). Studies in humans have shown that prolactin levels rise immediately after a solar eclipse (Boral, 1981). Prolactin is a hormone that regulates metabolism, the immune system, and the development of

the pancreas. Another physical effect is that during the Solar Eclipse, the Moon and Sun feel the combined force of both simultaneously as the gravity aligns. This unusual gravitational force's precise hormonal and behavioral effects are unknown (Norris, 2017).

The change in physical force that occurs on Earth during a solar eclipse is a shift in the electromagnetic field in the Earth's ionosphere. This electromagnetic field is caused by the electrical tension between the earth's surface's negative charge and the atmosphere's positive electric charge surrounding the world. Previous experiments show a high electrical voltage in our atmosphere during an eclipse. The shadow of the eclipse can cause changes in the ionosphere that are significant enough to affect radio wave propagation and possibly human physiology (Wang et al., 2022; Barad, Sripathi and England, 2022; Das, Barman, Pal, & Haldar, 2022; Chernogor, Garmash, Guo, Luo, Rozumenko, & Zheng, 2020).

Eclipses also have an essential astrological meaning. Eclipses in astrology represent periods of significant change and transformation. The solar eclipse opens the door to new beginnings and change, while the lunar eclipse releases energies that help us somehow complete a journey or change course. However, these changes only happen in stages. Transformation may begin in an eclipse, but the work continues if eclipses occur in the same set of signs (Winstersteen, 2022).

Solar eclipses have fascinated humanity for centuries, often evoking a wide range of emotions and reactions, from awe and wonder to fear and superstition (Espenak & Anderson, 2008). As extraordinary natural events, solar eclipses have been linked to various myths, legends, and religious beliefs throughout history, shaping how societies perceive and interpret these occurrences (Krupp, 1997). In contemporary times, solar eclipses continue to attract public interest and elicit diverse emotional responses, making them a relevant subject for sentiment analysis research.

Eclipses often come to the fore with dramatic effect in ancient cultures that have used mythology to explain celestial events. According to Swamy (2020), the Hindu culture in India prohibits food consumption during the eclipse. They believe that food spoils during this time, and if you are accidentally cut during an eclipse, the bleeding will not stop for a long time, which can leave a permanent scar on a person for the rest of their life. They keep pregnant women confined because they think this situation will affect the newborn child. In the United States, it is believed that an eclipse is a warning sign of the expected apocalypse. Hausa people in northern Nigeria noted that when there is a solar eclipse, it is usually not good. They gather in groups and wander the streets to pray for God's intervention (Izzuddin, Imroni, Imron, & Mahsun, 2022). Cofield (2017) The Toba people of South America believed that the red sky during an eclipse was the result of an attack by the spirits of the dead. Throughout history, people have approached such extraordinary natural phenomena similarly.

The advent of social media platforms, such as Twitter, has revolutionized how people share their thoughts, feelings, and experiences related to various events, including natural phenomena like solar eclipses (Java et al., 2007). The vast amount of user-generated content available on social media provides researchers with an invaluable data source for understanding public sentiment and emotions toward these events (Pak & Paroubek, 2010). Sentiment analysis, also known as opinion mining, is a subfield of natural language processing that involves extracting, classifying, and analyzing personal information from text (Liu, 2012). By applying sentiment analysis techniques to social media data, researchers gain insights into individuals' diverse emotions and perspectives in response to natural events such as solar eclipses.

In the age of information technology, social media platforms such as Twitter, Facebook, WhatsApp, and Instagram have become vital tools for communication during natural disasters and significant events. Their ability to facilitate real-time information dissemination has been pivotal in crisis response and management. Studies utilized these platforms to examine societal responses and attitudes toward various events in recent years. Only one study included the social effects associated with a solar eclipse. The survey by Goldy et al. analyzed 2,891,611 tweets concerning the Total Solar Eclipse in 2017. They found that the eclipse aroused awe among people on the road to wholeness. Individuals ultimately increased their tendencies toward humility, collective focus, commitment, and pro-sociality, enabling them to form collaborative social groups (Goldy, Jones, Piff, 2022).

A powerful research tool, Twitter data, has been used to assess the social impact of collective events on different issues. For example, Dore et al. identified temporal and spatial patterns in using emotional and cognitive words in tweets about the "Sandy Hook Elementary School" attack (Doré et al., 2015).

In the Garcia and Rimé studies, the first large-scale test of this theory was conducted by analyzing the digital traces of 62,114 Twitter users after the Paris terror attacks in November 2015. It supported the conclusion that collective feelings are associated with higher solidarity and elicit a community's social resilience after a disaster (Garcia & Rimé, 2019).

Similarly, another study constructed a natural disaster dataset of approximately 50,000 Twitter users' data about various natural disasters in the United States. Instead of merely examining positive or negative attitudes, it focused on extracting public attitudes and analyzing basic needs during disaster response, such as food, shelter, transportation, and medical supplies (Meng & Dong, 2020).

The case of the Kerala floods provides a compelling example of how sentiment analysis can offer actionable insights for governments and organizations. By analyzing trending keywords and sentiments during the floods, the study demonstrated how social media data could be used to understand public discussion trends, identify gaps in scheme implementation, and facilitate effective collaboration with influential Twitter users to disseminate crucial information (Mendon, Dutta, Behl, Lessmann, 2021).

In their study, Jones and Silver investigated the psychological responses to the 2018 false ballistic missile warning in Hawaii using Twitter data. The study analyzed 1.2 million tweets and 14,830 users. It showed that false alarms about dangerous threats raised anxiety and can persist in many people even after the danger disappeared (Jones & Silver, 2020).

The motivation and purpose of this study is to analyze people's emotions and perspectives on the "Partial Solar Eclipse" event through their social media interactions. After natural events and disasters, people often share their feelings and thoughts on social media platforms using text, videos, or pictures. By applying emotion analysis methods to these interactions, researchers gain insights into people's viewpoints on such events and begin to understand their societal impact. The study's primary goal was to investigate how people express their emotions regarding the solar eclipse in the context of supernatural events and determine the sentiment analysis of these expressions. The researchers focused on a partial solar eclipse to examine people's positive and negative emotions based on their recent experiences with the event.

2. Method

Using the "*pandas*" and "*snscrape*" libraries in Python programming, the researchers collected 19,285 tweets containing the phrase "*solar eclipse*", which were posted on Twitter between October 23-28, 2022. They analyzed the emotional content of these tweets using three different libraries:

NRC (National Research Council Canada) Emotion Lexicon: The lexicon contains English words and their associations with eight emotions and two sentiments. It associates words with eight basic emotions (anger, fear, anticipation, trust, surprise, sadness, joy, and disgust), and two sentiments (negative and positive) and contains 13,875 words. The words with no associated sentiment are not listed in the lexicon (Mohammad & Turney, 2013).

Bing Lexicon: This lexicon contains a list of English positive and negative opinion words or sentiment words containing 6,786 words. This lexicon determines whether a text expresses a positive or negative sentiment. Each word is assigned a polarity, which can be positive or negative, but not both (Liu & Hu, 2004).

AFINN Lexicon: This lexicon lists pre-computed sentiment scores for 2,477 English words. The words are rated with an integer between -5 (negative) and +5 (positive), signifying the sentiment value of the word. The higher the score, the more positive the sentiment of the word. Similarly, the lower the score, the more negative the sentiment (Nielsen, 2011).

The researchers also considered user-specific factors, such as the number of followers and friends, to determine whether a Twitter account was real or fake.

Since the analysis relied on word-based dictionaries (NRC, AFINN, and Bing) that contain only English words, it was necessary to preprocess the tweets to ensure accurate analysis. The preprocessing steps included:

• Converting tweets to lowercase: This standardizes the text for a more straightforward analysis.

- Removing retweets: This prevents duplication of content in the analysis.

- Eliminating punctuation marks: This includes periods, exclamation points, and commas.

- Removing non-essential content: URL links, mentions of other users (using '@'), extra spaces, symbols, and numbers.

- Excluding common but meaningless words: Words like "The," "an," "I," "am," and "you" were removed, as they do not carry any emotional information.

After preprocessing the tweets consisting of 494,503 words, sentiment analysis was performed on the remaining 262,732 words. These preprocessing steps helped clean up and standardize tweets, making them suitable for sentiment analysis using the NRC, AFINN, and Bing dictionaries.

Sentiment analysis with NRC, Bing, and AFINN dictionaries begins by tokenizing the text into individual words. For NRC, words are matched to emotions and sentiments within the lexicon, with the text's overall sentiment or emotion determined by a cumulative count. Bing Liu's lexicon categorizes words as positive or negative, with the text sentiment discerned by the majority sentiment or the difference between positive and negative word counts. The AFINN lexicon assigns a numeric score to each word, with the total sentiment of the text computed by adding up these scores. R software packages such as "*tidytext*", "*tm*", "*tidyverse*", "*stringr*", "*syuzhet*", "*dplyr*", "*wordcloud*" and "*ggplot2*" were used for data analysis and visualization.

3. FINDINGS

This section analyzed the tweets posted to the "*Particle Solar Eclipse*" event dated October 25, 2022, containing the word "solar eclipse" on Twitter between October 23, 2022, and October 28, 2022. The study analyzed tweets in English using NRC, Bing, and Afinn libraries. Data such as the number of followers and friends of the users were analyzed, and it was determined whether the user account was real or fake.
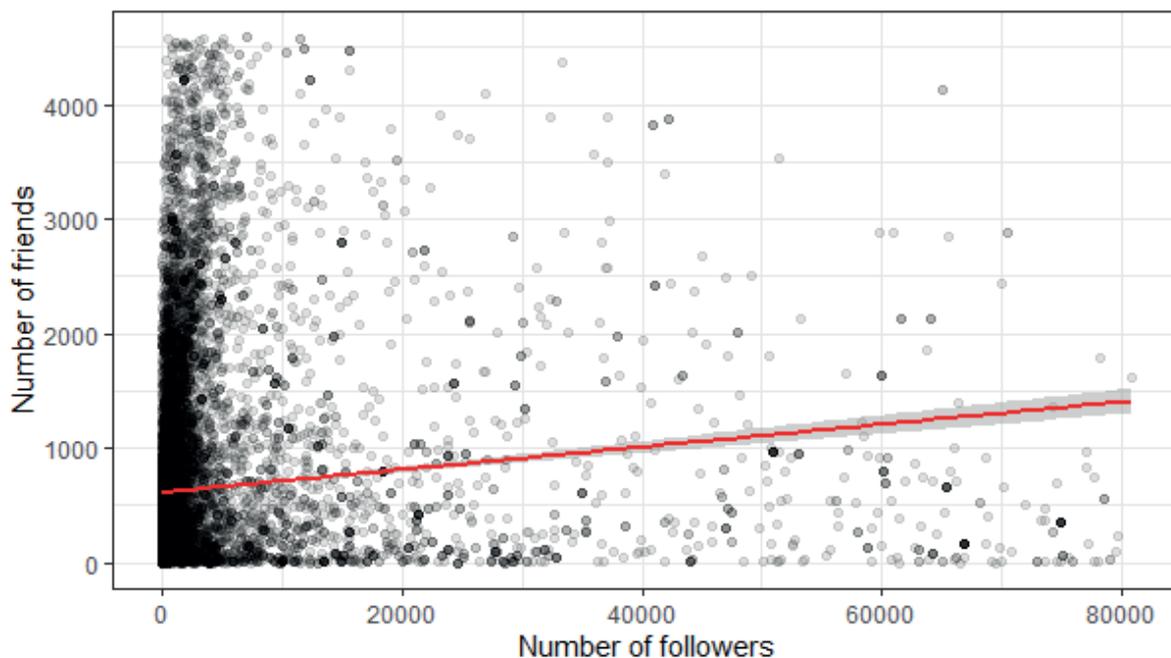

Figure 2. Followers and following numbers of users

User account information is provided in Figure 2 to determine whether Twitter data comes from real users or bots or whether tweets are generally sent from high-follower accounts. It shows that the number of people followed by the users tweeting in the context of the words "*solar eclipse*" is more than the number of followers. This indicates that users are not phenomena; they are regular users.
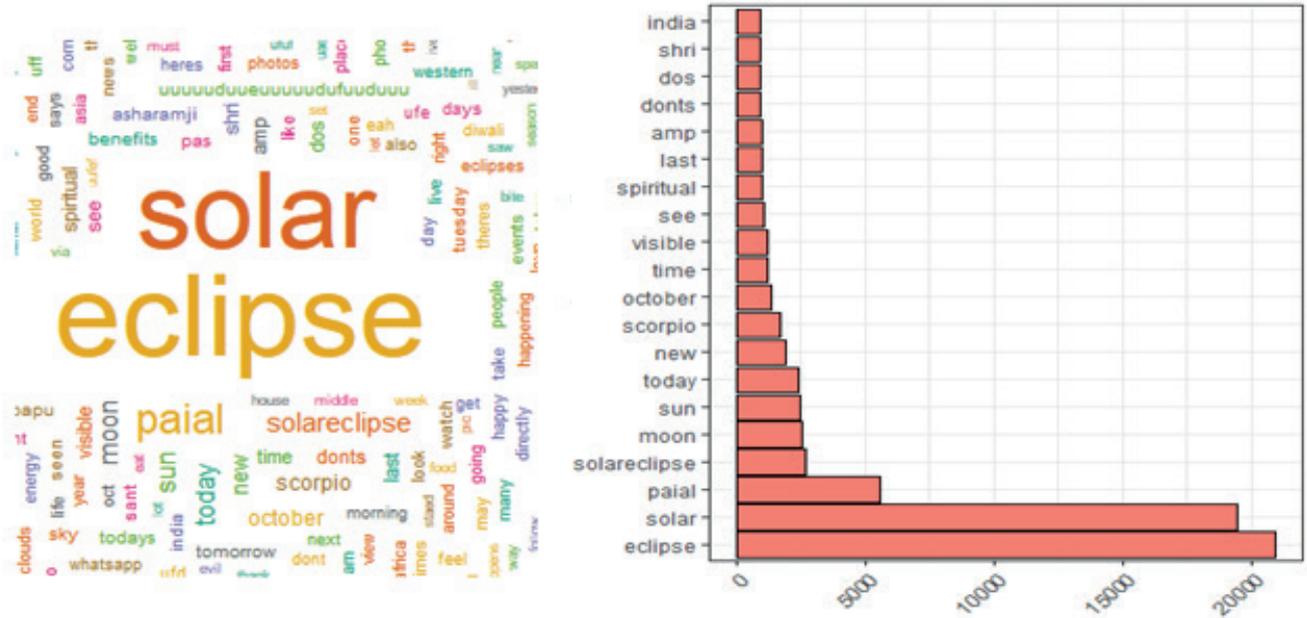
Figure 3. The most used word cloud and 20 words in tweets

When the words used in the tweets in Figure 3 and their intensities are examined, it shows that terms such as "*paial*," "*moon,*" and "*sun*" related to solar eclipse are used extensively. This indicates that the content of the tweets about the "*solar eclipse*" is directly proportional to the keywords.
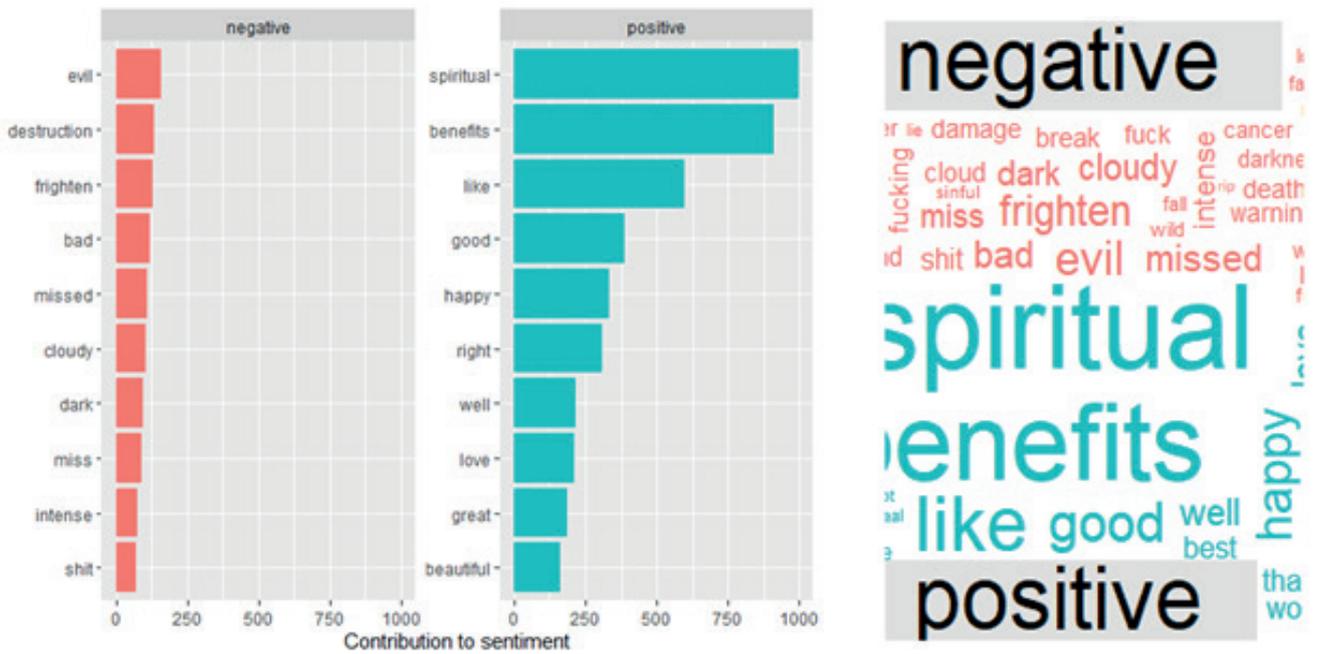
Figure 4. Top 10 words and clouds in negative/positive emotions

Analysis results for the "Partial Solar Eclipse" event using the Bing library are given in Figure 4. Positive emotions were associated with words like "*spiritual*," "*benefit*," "*like*," "*good*," *and* "*happy*." Using "*spiritual*" and "*benefit*" implies that some people saw the solar eclipse as a meaningful, potentially uplifting experience or connected it to rituals and positive beliefs about natural events. This suggests that the solar eclipse provided inspiration, fascination, or personal enrichment for these individuals. On the other hand, negative emotions were linked to words such as "*evil*," "*destruction*," "*frighten*,"

"*bad*," and "*missed*." The presence of "*evil*" and "*destruction*" indicates that some people viewed the solar eclipse as a negative or even threatening event, perhaps due to cultural or religious beliefs that associate extraordinary natural phenomena with divine wrath or punishment. The word "*frighten*" reflects the fear or anxiety some individuals might have experienced about the event, while "*missed*" could refer to feelings of regret for not being able to witness the eclipse. Some individuals found it a positive, inspiring occurrence, while others perceived it as an ominous or harmful event. This highlights the complex and varied ways people react to and interpret natural phenomena like solar eclipses.
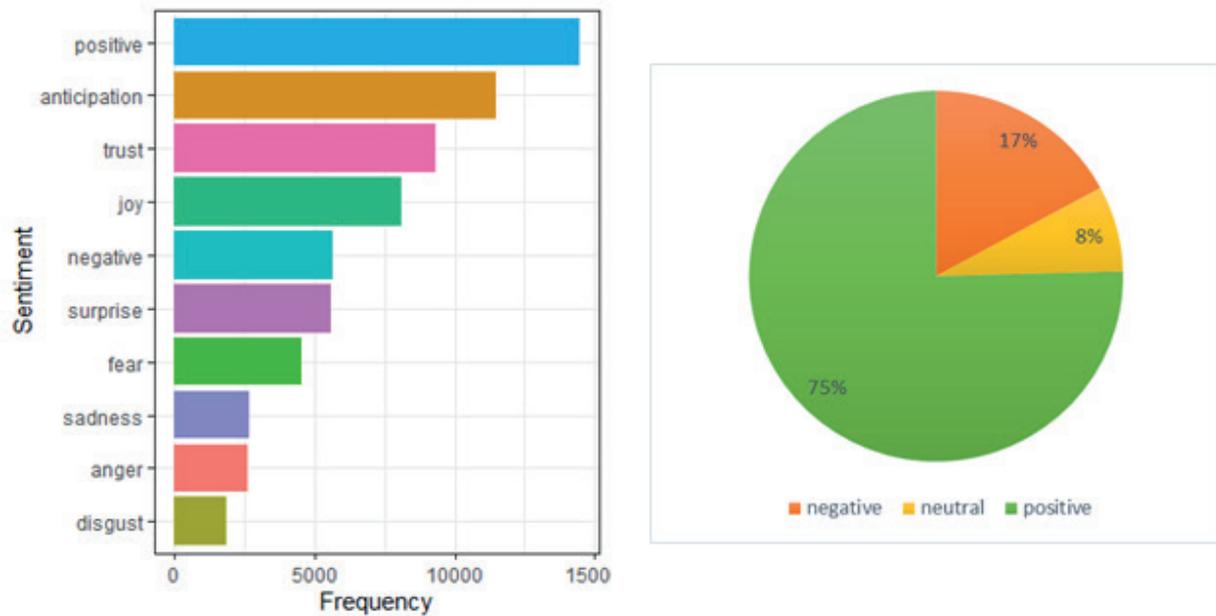
Figure 5. Emotion ratios of words and tweets

For the overall sentiment of the tweets, the words in each tweet were given a score of +1 for each positive emotion (positive, joy, anticipation, confidence, and surprise) and -1 for each negative word, using the NRC dictionary. If the sum of the scores for each tweet was greater than 0, it was marked as positive, equal to 0, neutral, and less than 0, as unfavorable. As a result of the analysis in Figure 6, the emotional state of the users' tweets was determined as 75% positive, 17% negative, and 8% neutral.
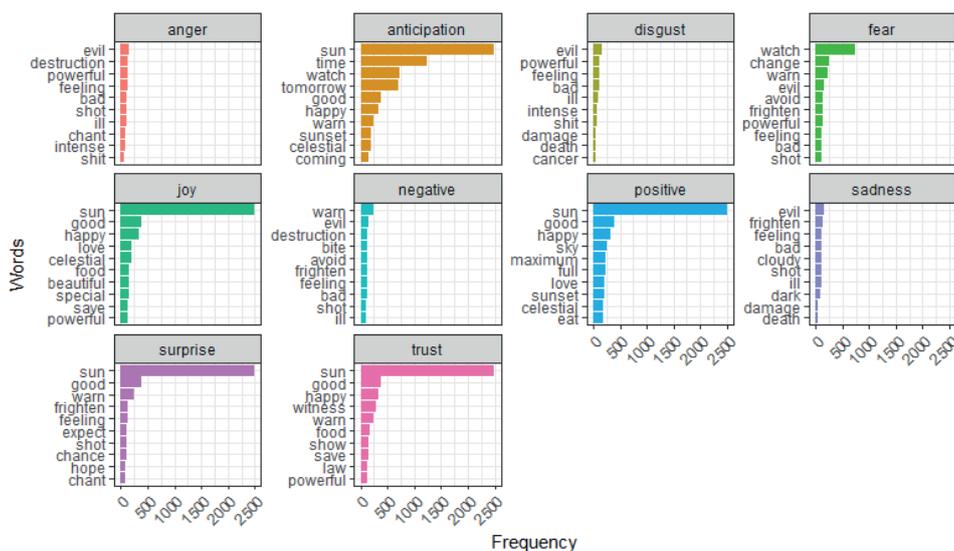

Figure 6. The number of uses of the ten most used words for each Emotion

In Figure 6, a word sentiment analysis of tweets with the keyword *'solar eclipse'* was performed using the NRC dictionary. For positive emotions, the words "*sun*," "*time*," "*good*," and "*happy*" appeared frequently. These words suggest that the positive emotions expressed in the tweets were related to the solar eclipse event itself ("*sun*" and "*time*"), as well as the enjoyable or exciting aspects of the experience ("*good*" and "*happy*"). The tweets with positive emotions were mainly associated with joy, surprise, trust, and anticipation, indicating that people found the solar eclipse fascinating, awe-inspiring, and something to look forward to. On the other hand, the most common words in tweets with negative emotions were "*evil*," "*destruction*," "*change*," and "*warning.*" These words imply that some people associated the solar eclipse with negative or ominous connotations. For instance, "*evil*" and "*destruction*" suggests fear or anxiety around the event, while "*change*" might reflect uncertainty or unease about the effects of the eclipse. The word "warning" could indicate that some users perceived the solar eclipse as a sign of impending danger or trouble.
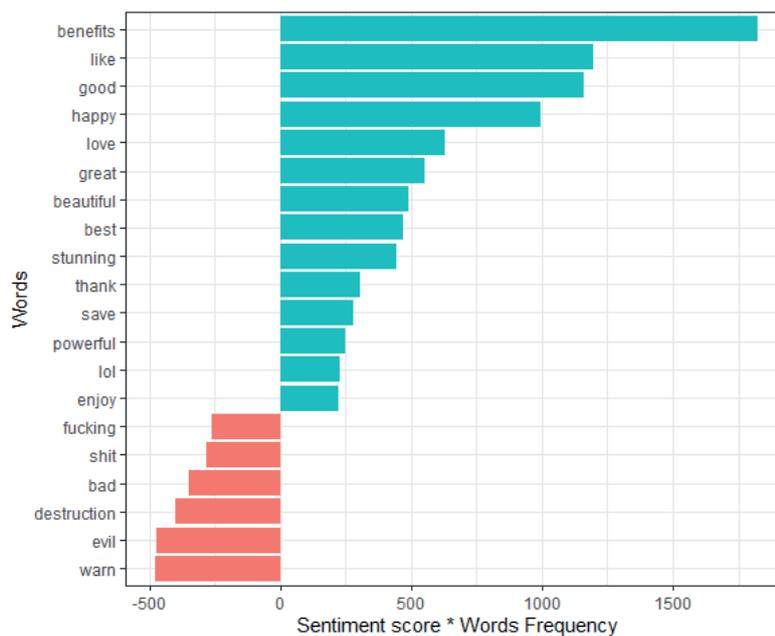

Figure 7. Positive and negative emotion usage scores of the most used words

In Figure 7, the Afinn library was used for the usage rates of the words used in tweets with positive and negative emotions. For tweets with positive emotions, the most frequently used words were "benefit," "like," "good," "happy," and "love." These words indicate that people enjoyed the event and had positive feelings about it, as they associated the eclipse with happiness, appreciation, and even affection. In contrast, the most used words in tweets with negative emotions were "warn," "evil," "destruction," "bad," and "shit." These words suggest that some people had negative perceptions of the solar eclipse, associating it with potential harm, malevolent forces, or unpleasant experiences.

4. DISCUSSION AND CONCLUSION

In this study, which was conducted to examine the effects of the Partial Solar Eclipse, which took place on October 25, 2022, on people, it showed that 75% of the tweets sent were positive. It turned out that the users who posted these tweets were average, not phenomena. As a result of the analysis, tweets of Twitter users participating in the research consisted of positive words such as "*spiritual, benefit, like, good* and *happy*" about the solar eclipse. This supports the idea in Astrology that a Solar Eclipse opens a portal to new beginnings and change. So, people support possible change by creating good thoughts and feelings in this way.

The absence of negative words in the first 20 most used words is directly proportional to the fact that the positive emotion category contains approximately two times more content than the negative emotion category. This shows that the concept of solar eclipse creates a positive impression on users tweeting in English.

When the words were evaluated on a dictionary basis, it was determined that "*evil*, *destruction*, *frighten*, *bad,* and *missed*" came first among the most negative words according to the positive and negative emotion categories in the context of the Bing library. Using the words "*benefit*" and "*spiritual*" about positive words could be considered rituals that people perform during natural events and positive expectations. On the other hand, the words "*evil*" and "*destruction*" can be explained as people's view of extraordinary natural events as divine disasters and punishment. This situation determined that the most used words for positive emotion in the NRC dictionary were *benefits*, *like*, *good*, *happy,* and *love*. The most commonly used words for negative emotion were *warn, evil, destroy, bad*, and *shit*. Similar emotional states emerged even when the data were analyzed with different dictionaries.

The findings of this study resonate with emerging research suggesting social media platforms like Twitter can be used as practical tools to capture public sentiment during significant natural events (Java et al., 2007; Pak & Paroubek, 2010). The discovered preponderance of positive sentiment (75%) corroborates Goldy et al.'s (2022) research that events like the Total Solar Eclipse in 2017 often catalyzed collective awe, humility, and pro-social behavior, leading to collaborative social groups. The frequent use of positive words such as "spiritual," "benefit," "like," "good," and "happy" in tweets corresponds with the astrological belief that a solar eclipse symbolizes new beginnings and change, implying that people may express positive sentiments to embrace this potential transformation (Goldy et al., 2022). The scarcity of negative terms among the top 20 most used words suggests a generally positive impression of the partial solar eclipse among Twitter users, aligning with Meng & Dong's (2020) observations on societal responses to significant events. The analysis of word usage based on Bing library and NRC dictionary unveiled that terms like "benefit" and "spiritual" could mirror rituals or positive expectations associated with natural events, while words such as "evil" and "destruction" might signify how some individuals perceive extraordinary natural events as divine punishments or disasters, similar to the psychological reactions observed in the 2018 false ballistic missile warning in Hawaii (Jones & Silver, 2020). By employing text mining and sentiment analysis methodologies, this research enriches the sentiment analysis and public sentiment research field, providing a robust foundation for future studies by offering insights into societal perceptions and attitudes towards natural events like the 2022 Partial Solar Eclipse (Liu, 2012). As for future research and study limitations, the proposal to diversify data sources beyond Twitter and to consider other eclipse events for a more thorough sentiment analysis is well-aligned with trends in social science research. Expanding the scope of data sources and focusing on longitudinal analysis could foster more profound insights into public sentiment and responses to natural events in future research (Mendon, Dutta, Behl, Lessmann, 2021).

This study contributes to sentiment analysis and public sentiment research by analyzing the public's emotional responses to the Partial Solar Eclipse of 2022 using Twitter data. Its contributions include demonstrating the effectiveness of text mining and sentiment analysis methods, providing a basis for future research on different types of natural events, enabling cross-cultural comparisons, and encouraging longitudinal analysis of public sentiment over time. This study offers valuable insights and a foundation for future research on societal perceptions and attitudes toward natural events.

In the context of the study's limitations for future research, more diversity and data sources can be obtained from different social media tools since it is only done on Twitter data. More comprehensive sentiment analysis can be done by considering the other partial eclipse event in the same year. Since the closest Total Solar Eclipse will take place on April 20, 2023, it will be possible to see whether there is a difference in people's perspectives on Total and Partial Solar Eclipse with the tweets to be sent in this date range. People's view of the situation can be analyzed by comparing it to the closest lunar eclipse.

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