

# Public emotion responses during COVID-19 in China on social media: An observational study

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## Abstract

COVID-19 (Corona Virus Disease 2019) has attacked many countries around world and caused profound impacts on public life. The outbreak of pandemic and other relevant factors are considered to cause emotion responses of residents. And the emotion responses of individuals are crucial for the execution of the prevention and control measures. By analyzing the linguistic features of posts on social media, this study aims to explore the change of public emotion responses during COVID-19 in China. We sampled 22,423 Weibo users and collected their Weibo posts by provincial area each day from January 1st, 2020 to April 18th, 2020. Next, we extracted linguistic features from posts according to the emotion-related dictionary. Based on important news and information released by the national and international organizations of public health, we divided the period from January 1st, 2020 to April 18th, 2020 into four stages (the initial period, the outbreak period, the stable period, and the prevention and control period). Then we gathered linguistic features by stage. After that, ANOVA was performed to examine the differences among these four stages. The results showed that the frequencies of 11 word categories showed significant differences among four stages, including fear, disappointment, guilt, missing, anger, panic, blessing, faith, love, praise, and surprise. The uses of several negative emotion words, such as fear, disappointment, guilt, and anger, increased saliently in the outbreak period compared with the initial period. Besides, panic words decreased significantly in the prevention and control period compared with the outbreak period. However, missing words were used more in the prevention and control period than other three periods. Moreover, people expressed more faith words and less love words in the outbreak period than the initial periods. Besides, people used more blessing words in the outbreak period compared with the stable period and prevention and control period. And praise words were used more in the outbreak period and the stable period compared with the initial period. The frequency of surprise words was significantly low only in the initial period. This study contributed to the understanding of public emotion responses during COVID-19, and had implications for the evidence-based execution of prevention and control measures.

## KEYWORDS

Corona Virus Disease, emotion changes, emotion dictionary, emotion expression, emotion responses, emotion word, negative emotion, public emotion, social media, Weibo data

## 1 | INTRODUCTION

The COVID-19 (Corona Virus Disease 2019) pandemic has affected many countries, such as China, Italy, and American, and is considered as a global health emergency. It has enormous influences on individuals' physical health, as well as mental health (Holmes et al., 2020). China has been hit hard by the coronavirus outbreak and has taken rapid actions to fight against this epidemic. After taking plenty of measures, such as city lockdown, mass gathering ban, school lockdown, to control this disease, COVID-19 has been under the control and many provinces have been classified as low-risk areas. Although people around the world have made great efforts to fight this epidemic, there are still second outbreaks in many countries and regions (Smith, 2020). Therefore, we cannot ignore the epidemic crisis even though the risk is low in mainland China (CDC, 2020) and should contribute to the execution of preventive measures.

The outbreak of epidemic could influence people's emotion, which may affect the implementation of epidemic prevention measures. For instance, the disease related emotion changes, such as fear and anger can be observed during the outbreak of Ebola (Shultz et al., 2016). Researchers hold the view that emotional influences (such as worry and fear) often lead to behavioral responses that depart from the best course of action (Loewenstein, Weber, Hsee, & Welch, 2001). During the outbreaks of SARS in 2003 and Ebola in 2014, fear and fear-related behaviors are implicated in impeding the infection control and even amplifying social problems (Person, Sy, Holton, Govert, & Liang, 2004; Shultz et al., 2016). Similarly, the affective response people have toward the COVID-19 might influence how people treat this disease and the affected patients. And even, although people know that we should work together to prevent the spread of this disease, the emotional influences might cause some improper behaviors contrary to our aim. Moreover, emotions are of vital importance for the formation of social solidarities and collective identities (Pantti, 2010). Such social solidarities and collective identities can unite people together to fight against coronavirus, which might be observed in the expression of emotions to some extent. Thus, by exploring emotion responses during COVID-19, we can provide a new perspective of how people react to this epidemic. It is crucial to understand public emotion responses and take proper steps to cope with them for the execution of measures on epidemic containment.

Existing research mainly concentrated on the emotion responses in the short term. Zhao and colleagues investigated the impact of the Wuhan lockdown at the first stage of the COVID-19 outbreak, and covered two weeks before and after the lockdown (Zhao et al., 2020). Besides, Li's survey lasted only 8 days in the early February (Li, Yang, et al., 2020). Zhao and Xu (2020) conducted their survey from December 31, 2019 to February 20, 2020, which was relatively long, but mainly focused on the outbreak period and could not reveal the individuals' responses when COVID-19 slowed down. In order to figure out the focus of prevention work in different stages of the epidemic, we should investigate people's emotional changes in the long term.

In recent years, a number of studies start to count the number of emotion words from online social network posts to examine how people feel about different events (Coviello et al., 2014; Jones, Wojcik, Sweeting, & Silver, 2016). For instance, Hou, Du, Jiang, Zhou, and Lin (2020) accessed public emotion responses on social media in the early stage of COVID-19 by the calculation of word frequency. Considering the long time span in this study, we need to take repeated measures of emotion for hundreds of times. Thus, we use the word counting method. Compared with the questionnaire approach, this method can avoid the recall bias and the learning effect. Weibo is the leading social media platform in China, and it achieves 222 million daily active users by the end of 2019. Thus, we use Weibo as the main social media platform to collect users' posts. As these posts are published on willingness of users and under the noninvasive circumstance, they are of high ecological validity.

In this study, we aim to explore public emotion responses in the context of COVID-19 through extracting psycholinguistic features of Weibo posts based on emotion-related dictionary.

## 2 | METHOD

This study aimed to explore public emotion responses during COVID-19. The Weibo data sample of this study was from our Weibo data pool, which was established by our laboratory and contained over 1.1 million active Weibo users (Li, Wang, et al., 2020). Our study was approved by the Ethical Committee and the ethic code was H15009.

As this study was conducted in the context of COVID-19 happened in China, we collected Weibo users from our Weibo data pool. We selected users who located at China (including 34 provincial areas) according to the geo-location in user profile. Finally, we collected 22,423 users and fetched their posts published from January 1st to April 18th. In order to ensure there were sufficient posts to analyze each day, we gathered users' posts by provincial area each day from January 1st to April 18th, that is, for a certain day, we got 34 postcollections.

In order to extract emotion-related features of posts, we used emotion dictionary named emotion word ontology toward Chinese of Dalian University of Technology to match with Weibo posts in this study (Xu, Lin, Pan, Ren, & Chen, 2008). This dictionary divided emotion words into 7 main categories and 21 sub-categories, which was based on the impactful emotional classification theory proposed by Ekman that emotions could be divided into 6 main categories, including enjoyment, anger, sadness, fear, disgust, and surprise (Ekman, 1993; Xu et al., 2008). Xu and colleagues established this dictionary by classifying emotional category manually and acquiring emotional intensity automatically. Many studies used this dictionary to explore the use of Chinese emotion words. Please refer to Appendix for more details about this emotion dictionary.

Then, we employed the TextMind system to extract linguistic features. TextMind system was developed by computational cyber psychology laboratory, Institute of Psychology, Chinese Academy of Sciences (Gao et al., 2013). By inputting a post collection into this

system, it would segment these Weibo posts into words, match these words with emotion dictionary, and finally calculate and output word frequency of each emotional category, that is, the ratio of words belonging to a certain category to total words. Hence, for every province and every day during period from January 1st to April 18th, we got word frequency result of each emotional category. Our sample data covered 34 provinces and 109 days, and thus contained 3,706 pieces of data for each word category.

According to the development of the pandemic and official communications related to the epidemic prevention and control, we found three key time points during COVID-19 and divided the period from January 1st to April 18th into four stages. The first key time point was January 20th, 2020. On January 20, the fact that the virus could spread from person to person was confirmed, which was a turn for disease control and prevention (Yang, 2020). February 24th, 2020 was the second key time point. On that day, the World Health Organization said that China passed the peak of the outbreak and kept declining steadily (Lovelace Jr, 2020). The third key time point was March 23rd, 2020. On March 23rd, the leading group of China's COVID-19 epidemic response stated that the domestic transmission of epidemic was basically blocked and we should focus on both the prevention of imported cases and the resurgence of domestic cases (Huaxia, 2020a). Therefore, we got four stages during the period from January 1st to April 18th. The initial period was from January 1st to January 19th. Besides, we considered the period from January 20th to February 23rd as the outbreak period. And the period from February 24th to March 22nd was regarded as the stable period. Moreover, the period from March 23rd to April 18th was the prevention and control period. After finishing the division of stage, we labeled every piece of data with its corresponding stage name according to its date.

Considering our sample data was much more than 30 and contained 4 levels, we conducted ANOVA (analysis of variance) to compare the differences of the psycholinguistic features in these four periods. For the word categories which met the homogeneity of variance, we conducted one-way ANOVA. Other word categories were analyzed by using Welch ANOVA. During the data analysis, we used SPSS 26.0, which was published by IBM (International Business Machines Corporation, Armonk, NY).

### 3 | RESULT

We collected 22,423 participants from our Weibo data pool. Of these, 16,422 participants were female users, and the remaining 6,001 participants were males. Besides, we found 21.54% of participants filled their age information in user profile. Among them, the median age was 29. The demographic attributes are summarized in Table 1.

According to the ANOVA results, 11 word categories showed significant differences in the use of emotion words among four stages, including fear ( $F_{(3,1880.026)} = 8.895$ ,  $p < .001$ ), disappointment ( $F_{(3,3702)} = 7.072$ ,  $p < .001$ ), guilt ( $F_{(3,2003.910)} = 9.697$ ,  $p < .001$ ),

**TABLE 1** Demographic attributes and corresponding categories

Attribute	Demographic variables range	Sample size
Gender	Female	16,422 (73.24%)
	Male	6,001 (26.76%)
Age	≤9	190 (0.85%)
	10–19	41 (0.18%)
	20–29	2,392 (10.67%)
	30–39	1770 (7.89%)
	≥40	437 (1.95%)
	Missing	17,593 (78.46%)

missing ( $F_{(3,1744.152)} = 5.656$ ,  $p = .001$ ), anger ( $F_{(3,1941.622)} = 5.458$ ,  $p = .001$ ), panic ( $F_{(3,1863.986)} = 3.147$ ,  $p = .024$ ) blessing ( $F_{(3,1778.267)} = 7.148$ ,  $p < .001$ ), faith ( $F_{(3,3702)} = 2.731$ ,  $p = .042$ ), love ( $F_{(3,1884.727)} = 9.194$ ,  $p < .001$ ), praise ( $F_{(3,1874.353)} = 4.811$ ,  $p = .002$ ), and surprise ( $F_{(3,2036.608)} = 36.153$ ,  $p < .001$ ). These 11 word categories are displayed in Table 2. However, we did not find any differences in the use of other word categories in the four periods of COVID-19.

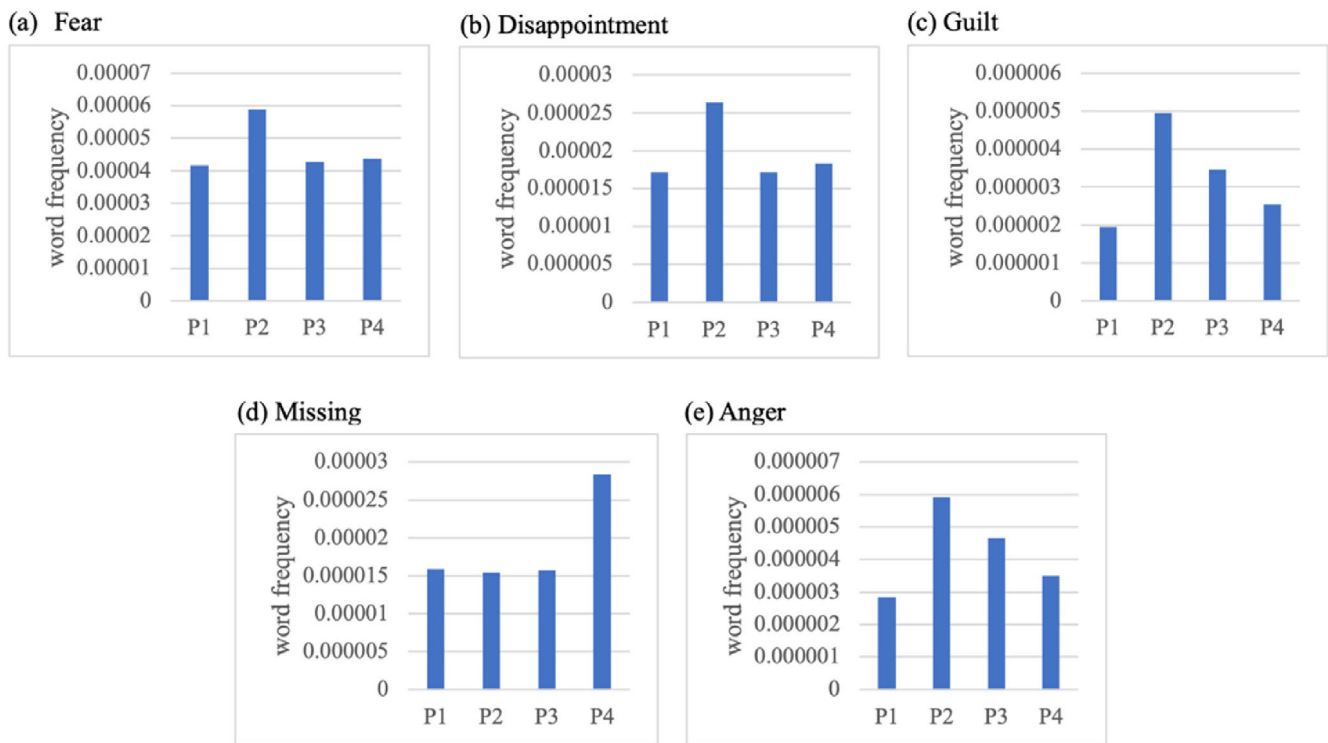
For the 11 word categories listed in Table 2, we used post hoc test to examine more detailed differences among four periods. And we divided these 11 word categories into two classes, that is, negative emotion word and non-negative emotion word, to display the detailed result. The histogram of the use of negative emotion words during COVID-19 was shown in Figure 1. And Figure 2 displayed the line graph of the use of negative emotion words, which could provide a better perspective of changing tendency among these word categories.

The use of fear words significantly increased in the outbreak period compared with the initial period ( $M_D = -1.7347E-005$ ,  $p = .001$ ), and significantly decreased in the stable period compared with the outbreak period ( $M_D = 1.6133E-005$ ,  $p < .001$ ). Besides, there was a salient decrease in the use of fear words in the prevention and control period compared with the outbreak period ( $M_D = 1.5264E-005$ ,  $p < .001$ ). However, there was no significant difference in the stable period and the prevention and control period ( $M_D = -8.6893E-007$ ,  $p = .996$ ). The frequency changes of disappointment words were identical with fear words. The significant differences were observed between the initial period and the outbreak period ( $M_D = -9.0908E-006$ ,  $p = .001$ ), between the outbreak period and the stable period ( $M_D = 9.10145E-006$ ,  $p < .001$ ), and between the outbreak period and the prevention and control period ( $M_D = 7.9784E-006$ ,  $p = .001$ ).

Compared with the initial period, the use of guilt words increased saliently in the outbreak period ( $M_D = -3.0075E-006$ ,  $p < .001$ ). Moreover, there were significant decreases in the use of guilt words in the prevention and control period compared with the outbreak period ( $M_D = 2.4021E-006$ ,  $p < .001$ ). However, we did not observe significant differences between the outbreak period and the stable period ( $M_D = 1.4987E-006$ ,  $p = .221$ ), and between the stable period and the prevention and control period ( $M_D = 9.0344E-007$ ,  $p = .546$ ). The changes of the use of anger words during COVID-19 were identical

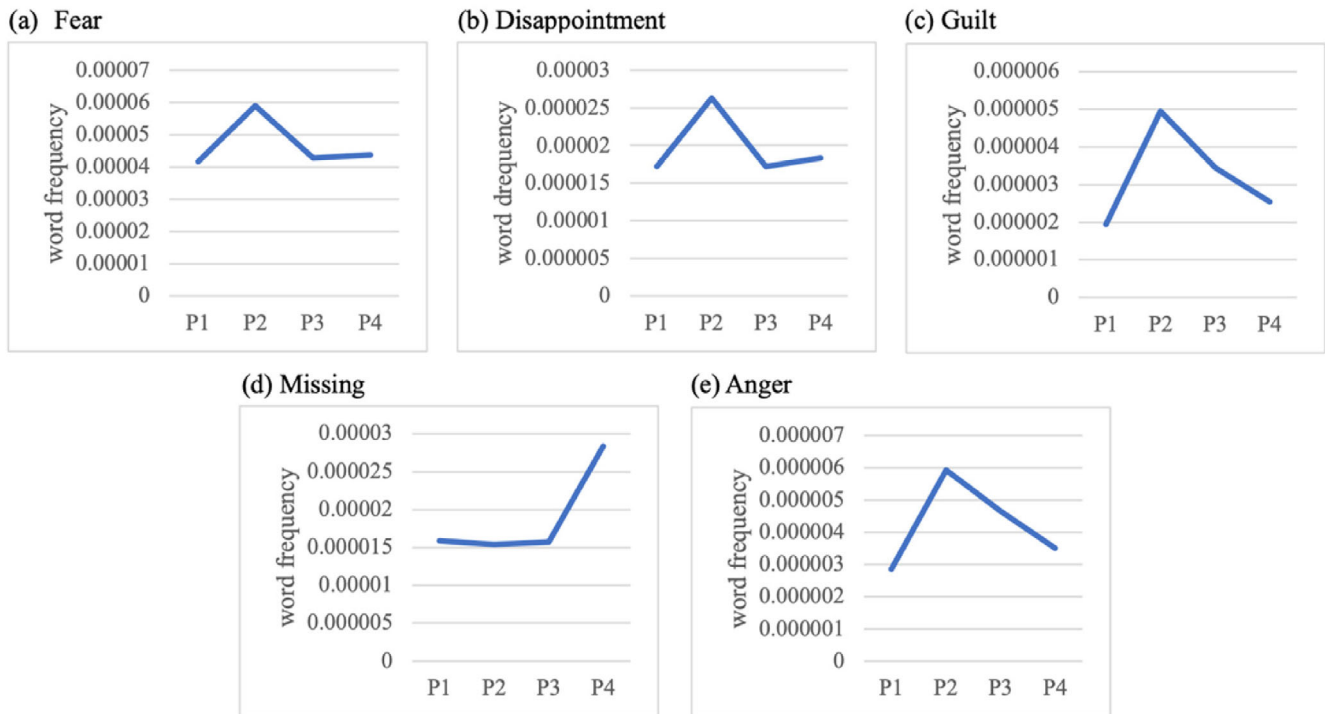
**TABLE 2** The word categories whose frequencies significantly changed among four stages

Main category	Word category	M ± SD (*E-05)				F
		The initial period	The outbreak period	The stable period	The prevention and control period	
Negative emotion	fear	4.16 ± 9.41	5.90 ± 9.03	4.29 ± 8.24	4.37 ± 8.24	8.895***
	disappointment	1.72 ± 8.09	2.63 ± 4.78	1.72 ± 4.90	1.83 ± 4.11	7.072***
	guilt	0.19 ± 0.78	0.50 ± 1.68	0.35 ± 1.88	2.55 ± 9.12	9.697***
	missing	1.59 ± 4.71	1.54 ± 3.14	1.57 ± 3.18	2.84 ± 9.23	5.656**
	anger	0.29 ± 1.34	0.59 ± 2.15	0.47 ± 2.51	3.50 ± 1.22	5.458**
	panic	0.96 ± 3.44	1.24 ± 3.90	1.13 ± 3.70	0.86 ± 2.25	3.147**
Non-negative emotion	blessing	4.05 ± 20.45	5.02 ± 11.20	3.45 ± 7.85	3.29 ± 6.42	7.148***
	faith	1.48 ± 2.34	1.94 ± 3.00	1.66 ± 3.45	1.71 ± 4.49	2.731**
	love	15.65 ± 13.86	12.58 ± 13.59	13.53 ± 13.97	15.11 ± 15.69	9.194***
	surprise	3.87 ± 4.17	6.63 ± 16.37	6.10 ± 5.76	6.06 ± 8.06	36.153***
	praise	10.59 ± 11.43	12.58 ± 12.95	12.40 ± 15.83	13.79 ± 43.10	4.811**

\*\* $p < .05$ .\*\*\* $p < .001$ .**FIGURE 1** The histogram of the use of negative emotion words during COVID-19

with guilt words. The use of anger words increased significantly in the outbreak period compared with the initial period ( $M_D = -3.0748E-006$ ,  $p = .001$ ), and decreased saliently in the prevention and control period compared with the outbreak period ( $M_D = 2.4293E-006$ ,  $p = .005$ ). But there were no significant differences between the outbreak period and the stable period ( $M_D = 1.2646E-006$ ,  $p = .605$ ), and between the stable period and the prevention and control period ( $M_D = 1.1648E-007$ ,  $p = .574$ ).

We found that Weibo users used more missing words in the prevention and control period compared with the initial period ( $M_D = -1.2489E-005$ ,  $p = .003$ ), the outbreak period ( $M_D = -1.2970E-005$ ,  $p < .001$ ), and the stable period ( $M_D = -1.2657E-005$ ,  $p = .001$ ). However, there were no significant differences in the use of missing words between the initial period and the outbreak period ( $M_D = 4.8037E-007$ ,  $p = .996$ ), and between the outbreak period and the stable period ( $M_D = -3.1249E-007$ ,  $p = .996$ ). Besides, panic



**FIGURE 2** The line graph of the use of negative emotion words during COVID-19

words decreased significantly in the prevention and control period compared with the outbreak period ( $M_D = 3.8220E-006$ ,  $p = .025$ ). Nevertheless, there were no significant differences between the initial period and the outbreak period ( $M_D = -2.7708E-006$ ,  $p = .396$ ), between the outbreak period and the stable period ( $M_D = 1.0863E-006$ ,  $p = .912$ ), and between the stable period and the prevention and control period ( $M_D = 2.7357E-006$ ,  $p = .212$ ).

The histogram of the use of non-negative emotion words during COVID-19 was shown in Figure 3. And Figure 4 displayed the line graph of the use of non-negative emotion words, which could help us better understand the changing tendency among these word categories.

There were significant decreases in the use of blessing words in the stable period ( $M_D = 1.5693E-005$ ,  $p = .001$ ) and the prevention and control period ( $M_D = 1.7307E-005$ ,  $p < .001$ ) compared with the outbreak period, while there was no salient difference between the initial period and the outbreak period ( $M_D = -9.6614E-006$ ,  $p = .681$ ), and between the stable period and the prevention and control period ( $M_D = 1.6144E-006$ ,  $p = .962$ ). As for the use of faith words, we found a significant increase in the outbreak period compared with the initial period ( $M_D = -4.5891E-006$ ,  $p = .007$ ).

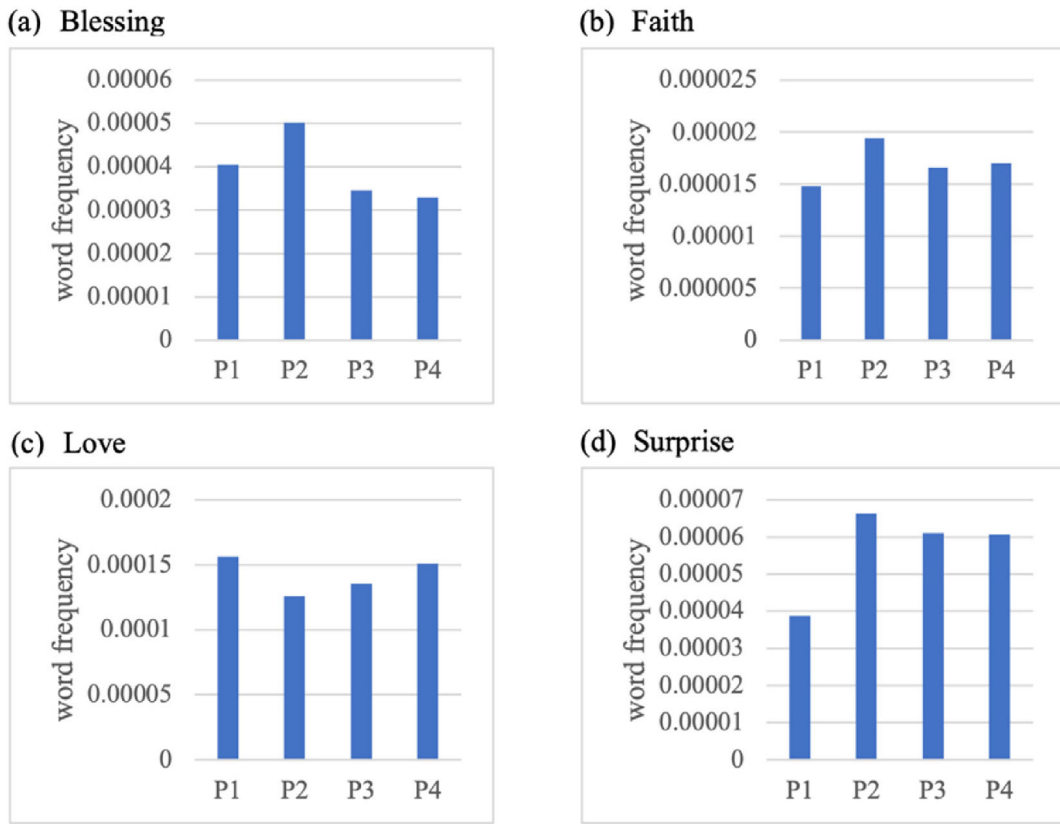
Compared with the initial period, the use of love words decreased saliently in the outbreak period ( $M_D = 3.0679E-005$ ,  $p < .001$ ) and the stable period ( $M_D = 2.1150E-005$ ,  $p = .015$ ). Besides, there was a significant increase in the prevention and control period compared with the outbreak period ( $M_D = -2.5282E-005$ ,  $p = .001$ ). However, there were no significant differences between the outbreak period and the stable period ( $M_D = -9.5287E-006$ ,  $p = .386$ ), and between the stable

period and the prevention and control period ( $M_D = -1.5754E-005$ ,  $p = .101$ ).

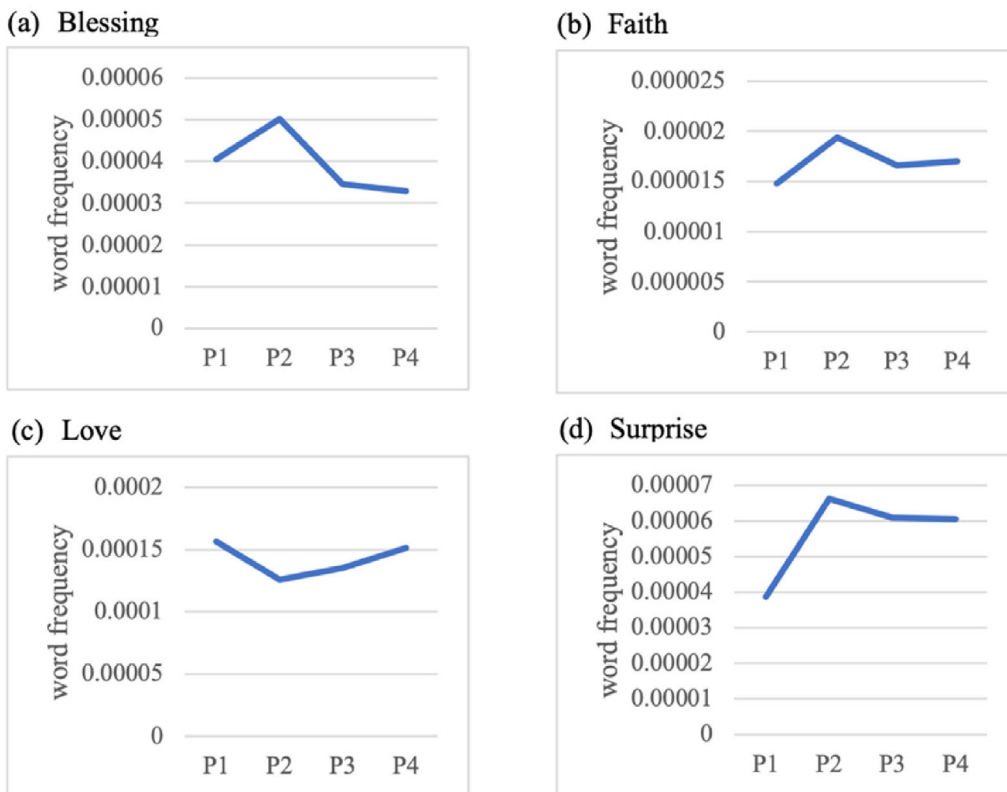
Moreover, we found that compared with the initial period, the use of surprise words saliently increased in the outbreak period ( $M_D = -2.7616E-005$ ,  $p < .001$ ), the stable period ( $M_D = -2.2338E-005$ ,  $p < .001$ ) and the prevention and control period ( $M_D = -2.1918E-005$ ,  $p < .001$ ). But no significant differences were observed in the outbreak period compared with the stable period ( $M_D = 5.2776E-006$ ,  $p = .729$ ), and in the stable period compared with the prevention and control period ( $M_D = 4.2065E-007$ ,  $p = .999$ ). The change of praise words was similar but not identical to surprise words. The use of praise words significantly increased in the outbreak period ( $M_D = -1.9923E-005$ ,  $p = .004$ ) and the stable period ( $M_D = -1.8129E-005$ ,  $p = .040$ ) compared with the initial period. However, there were no salient difference in between the outbreak period and the stable period ( $M_D = 1.7931E-006$ ,  $p = .992$ ), and between the stable period and the prevention and control period ( $M_D = -1.3920E-005$ ,  $p = .794$ ).

## 4 | DISCUSSION

This study examined the differences of the psycholinguistic features that people expressed in Weibo posts among four stages under the context of COVID-19. And we found significant differences in the use of 11 word categories, including fear, disappointment, guilt, missing, anger, panic, blessing, faith, love, praise, and surprise.



**FIGURE 3** The histogram of the use of non-negative emotion words during COVID-19



**FIGURE 4** The line graph of the use of non-negative emotion words during COVID-19



The uses of several negative emotion words, including fear, disappointment, guilt, and anger, increased significantly in the outbreak period compared with the initial period. Such changes of emotion expression on social media was consistent with psychological responses during pandemic. Chew, Wei, Vasoo, Chua, and Sim (2020) found several common psychological responses during the outbreaks of pandemic, including fears, depression, anger, and guilt. Moreover, Mamun's study also suggested that social distancing, isolation, and quarantine, as well as the social and economic fallout related to the pandemic can trigger psychological responses, including sadness, fear, anger, guilt, and helplessness (Mamun & Griffiths, 2020). We considered such psychological responses might be expressed when people used social media, which may lead to the increased use of relevant negative emotion words.

Among the negative emotion words, we found that Weibo users used more fear words in the outbreak period while less in the stable period. Moreover, the change in the use of disappointment words was similar to the fear words. Researchers believed that the perceived risk of pandemic made people lose the sense of control of their living circumstances, which may cause fear emotion (Zhao et al., 2020). Besides, the emotion of disappointment was considered to be in relation with the loss of hope or reward and the loss of usual habits, which was identified in the outbreak of SARS and COVID-19 (Liang, 2003; Serafini et al., 2020). We suspected that such feeling of loss during COVID-19 might be conveyed by Weibo posts.

Our results suggested that although the uses of negative emotion words such as fear, guilt, anger, and disappointment increased in the outbreak period, they decreased over time. Moreover, Qian et al. (2003) found that residents in Beijing experienced similar changes of fear in the outbreak of SARS, that is, people had strong feelings of fear at first, and then the level of fear declined. In addition, Chew, Wei, and Vasoo (2020) also identified the same tendency of emotional responses toward infectious disease. Besides, panic words were also observed to decrease significantly in the prevention and control period compared with the outbreak period. Medford, Saleh, Sumarsono, Perl, and Lehmann (2020) found that the expression of anger on Tweets was accompanied with several common topics, including government reactions, isolation, and quarantine, and lack of supplies and information, while the expression of fears was associated with topics including fear of infection, death, inability to travel, and the concerns of effect on the economy and politics. Moreover, researchers indicated that panic during COVID-19 may be caused by the infectivity of this pandemic and inaccurate information (Qiu et al., 2020; Samuel, Ali, Rahman, Esawi, & Samuel, 2020). Altogether, these negative emotions seemed to be closely related to the development of pandemic, government reactions, and accurate information about COVID-19. As the disease was under control, people might express these negative emotions less accordingly.

Missing words presented different change compared with other negative emotion words. People used more missing words in the prevention and control period than other three periods. The expression

of missing may be attributed to the Qingming Festival. On April 4, 2020, that is, China's Qingming Festival, a national mourning was held for the coronavirus martyrs and victims according to the State Council (That's, 2020). Many people mourned the coronavirus martyrs and victims online, and shared feelings by using the topic "National Mourning" on Sina Weibo, which attracted over 2 billion reads by Saturday afternoon (Huaxia, 2020b). Such online mourning in the prevention and control period increased the use of missing words to a great extent.

Our results also showed that the use of positive emotion words, including faith, blessing, praise, and love, changed significantly in the development of pandemic. People expressed more praise words in the outbreak period and the stable period compared with the initial period. According to the report published by National Health Commission of the People's Republic of China, over 42,000 medical workers from 344 medical assistance teams came to aid Hubei from 25th January to 1st March (Yao & Xu, 2020). Many people praised and admired their contributions in fighting the pandemic on social media. For example, they were hailed as heroes in harm's way (Aurora Vision, 2020). We suspected the increase of praise words in the outbreak period and the stable period may be related to the expressions of praise for these contributors when fighting COVID-19.

Besides, the use of faith words increased in the outbreak period compared with the initial period. Moreover, the frequency of love words was lower in the outbreak period compared with the initial period and the prevention and control period. And the use of blessing words increased in the outbreak period compared with the stable period and the prevention and control period. However, there was no significant difference in the use of blessing words between the initial period and the outbreak period. We considered that people might express blessings and wishes on social media in the initial period because it was near to the Spring Festival, the biggest and most important festival in China all year round. Researchers considered that the uses of positive emotion words such as faith and blessing indicated the attention of group cohesiveness instead of personal emotions (Li, Wang, et al., 2020). However, considering words in the love word category such as "first love," "wife," "kiss," and "rose," we thought that the love words might have a closer relation with the personal emotions. Researchers suggested that epidemic diseases made people concentrate more on the social solidarity, which may result in higher level of group cohesiveness (Tziner, 1982). With the focus on group, people might express more faith and blessing words and less love words in the outbreak period, which was the most serious and urgent period during COVID-19.

The frequency of surprise words was significantly high since the outbreak period compared with the initial period. The emotion of surprise was common in the expression of social media during pandemic. Recent study conducted on Twitter suggested that surprise was the second most common emotion when analyzing pandemic-related Tweets (Medford et al., 2020). We suspected that the expression of

surprise might be related to the development of pandemic and the discussions of social events on Weibo.

Our study explored the emotion responses during COVID-19 by examining the psycholinguistic features of Weibo posts, which could provide detailed evidence for prevention and control measures in future epidemics. For instance, the expression of fear was observed to increase significantly only in the outbreak period. Thus, we should focus on the expression and spread of fear on social media once the epidemic was introduced to the public. And in the outbreak period, our prevention and control focus should be to publish and disseminate the detailed information about the epidemic and the corresponding prevention measures to alleviate the feeling of fear and panic in public.

There are still some limitations in our study. First, large part of Weibo users are young adults. According to the Sina microblog user development report, the age of Weibo users mainly concentrates on 18–41 years (Sina Microblog Data Center, 2018). Thus, our result cannot reveal emotion responses of children and the aged to a great extent. Moreover, our study only focuses on one social media platform. Other social media platforms, such as Wechat, Douyin, and Douban, also attract vast amounts of users. Considering the difference of user groups between different platforms, there is inevitable bias of our sample. Besides, although our study divided the period of COVID-19 spreading in China by the disease transmission of official communication, researchers could consider new standard of division, such as the number of confirmed cases. Future work could try this new standard of division to explore emotion responses during COVID-19.

## 5 | CONCLUSION

This research examined the differences of psycholinguistic features of Weibo posts among four periods under the context of COVID-19. Results showed that the uses of 11 word categories significantly changed among four periods. These word categories included fear, disappointment, guilt, missing, anger, panic, blessing, faith, love, praise, and surprise. Especially, people expressed more fear, disappointment, guilt, anger, praise, and faith words, and less love words in the outbreak period compared with the initial period. Besides, people used more missing words in the prevention and control period compared with other three periods. Compared with the initial period, the use of surprise words was significantly higher in other three periods. This result suggested that emotion people expressed in the outbreak period tended to be the most complicated. Besides, we observed positive emotions during COVID-19, which suggested the attention of group cohesiveness to some extent. With the focus on group and society, people were more likely to learn and perform epidemic prevention measures, which would contribute to carry out epidemic prevention and control work led by government. This study furthered our understanding of public emotion responses during COVID-19, and provide evidence for the execution of prevention and control measures in future outbreaks.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

Research data are not shared.

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## REFERENCES

- Aurora Vision. (2020). *Different opinions about the pictures of heroes in harm's way*. Retrieved from <http://n.eastday.com/pnews/1582505114017643>.
- CDC (Chinese Center for Disease Control and Prevention). (2020). *2020 national day and mid-autumn festival holiday health care highlights for travel*. Retrieved from [http://www.chinacdc.cn/yw\\_9324/202009/t20200922\\_220883.html](http://www.chinacdc.cn/yw_9324/202009/t20200922_220883.html).
- Chew, Q. H., Wei, K. C., Vasoo, S., Chua, H. C., & Sim, K. (2020). Narrative synthesis of psychological and coping responses towards emerging infectious disease outbreaks in the general population: practical considerations for the COVID-19 pandemic. *Singapore Medical Journal*, *61*(7), 350–356.
- Coviello, L., Sohn, Y., Kramer, A. D., Marlow, C., Franceschetti, M., Christakis, N. A., & Fowler, J. H. (2014). Detecting emotional contagion in massive social networks. *PLoS One*, *9*(3), e90315. <https://doi.org/10.1371/journal.pone.0090315>
- Ekman, P. (1993). Facial expression and emotion. *American Psychologist*, *48*(4), 384–392.
- Gao, R., Hao, B., Bai, S., Li, L., Li, A., & Zhu, T. (2013). *Improving user profile with personality traits predicted from social media content*. In Proceedings of the 7th ACM Conference on Recommender Systems, Hong Kong, China. pp. 355–358.
- Holmes, E. A., O'Connor, R. C., Perry, V. H., Tracey, I., Wessely, S., Arseneault, L., ... Ford, T. (2020). Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science. *The Lancet Psychiatry*, *7*, 547–560.
- Hou, Z., Du, F., Jiang, H., Zhou, X., & Lin, L. (2020). *Assessment of public attention, risk perception, emotional and behavioural responses to the COVID-19 outbreak: Social media surveillance in China* <https://doi.org/10.2139/ssrn.3551338>
- Huaxia. (2020a). *China deploys measures to curb imported COVID-19 cases, rebound in indigenous cases*. Retrieved from [http://www.xinhuanet.com/english/2020-03/23/c\\_138908683.htm](http://www.xinhuanet.com/english/2020-03/23/c_138908683.htm)
- Huaxia. (2020b). *Xinhua headlines: China pauses in silence to mourn lives lost to coronavirus*. Retrieved from [http://www.xinhuanet.com/english/2020-04/04/c\\_138947695.htm](http://www.xinhuanet.com/english/2020-04/04/c_138947695.htm)
- Jones, N. M., Wojcik, S. P., Sweeting, J., & Silver, R. C. (2016). Tweeting negative emotion: An investigation of Twitter data in the aftermath of violence on college campuses. *Psychological Methods*, *21*, 526–541. <https://doi.org/10.1037/met0000099>
- Li, J. B., Yang, A., Dou, K., Wang, L. X., Zhang, M. C., & Lin, X. Q. (2020). Chinese public's knowledge, perceived severity, and perceived controllability of the COVID-19 and their associations with emotional and behavioural reactions, social participation, and precautionary behaviour: A national survey.
- Li, S., Wang, Y., Xue, J., Zhao, N., & Zhu, T. (2020). The impact of COVID-19 epidemic declaration on psychological consequences: A study on active Weibo users. *International Journal of Environmental Research and Public Health*, *17*(6), 2032.
- Liang, B. (2003). Common psychological stress responses and psychological interventions during the SARS epidemic in China. *Studies of Psychology and Behavior*, *1*(3), 223–230.



- Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin*, 127(2), 267–286.
- Berkeley Lovelace Jr (2020). *WHO says coronavirus outbreak in China has peaked, new cases in Iran and Italy are 'deeply concerning'*. Retrieved from <https://www.cnbc.com/2020/02/24/who-says-coronavirus-outbreak-in-china-has-peaked-new-cases-in-iran-and-italy-are-deeply-concerning.html>
- Mamun, M. A., & Griffiths, M. D. (2020). First COVID-19 suicide case in Bangladesh due to fear of COVID-19 and xenophobia: Possible suicide prevention strategies. *Asian Journal of Psychiatry*, 51, 102073.
- Medford, R. J., Saleh, S. N., Sumarsono, A., Perl, T. M., & Lehmann, C. U. (2020). An "Infodemic": Leveraging high-volume Twitter data to understand public sentiment for the COVID-19 outbreak. *medRxiv*
- Pantti, M. (2010). The value of emotion: An examination of television journalists' notions on emotionality. *European Journal of Communication*, 25(2), 168–181.
- Person, B., Sy, F., Holton, K., Govert, B., & Liang, A. (2004). Fear and stigma: the epidemic within the SARS outbreak. *Emerging Infectious Diseases*, 10(2), 358–363.
- Qian, M., Ye, D., Dong, W., Huang, Z., Zhang, L., Liu, X., ... Nie, J. (2003). Behaviour, cognition and emotion of the public in Beijing towards SARS. *Chinese Mental Health Journal*, 17(8), 515–520.
- Qiu, J., Shen, B., Zhao, M., Wang, Z., Xie, B., & Xu, Y. (2020). A nationwide survey of psychological distress among Chinese people in the COVID-19 epidemic: implications and policy recommendations. *General Psychiatry*, 33(2), e100213.
- Samuel, J., Ali, G. G., Rahman, M., Esawi, E., & Samuel, Y. (2020). Covid-19 public sentiment insights and machine learning for tweets classification. *Information*, 11(6), 314.
- Serafini, G., Parmigiani, B., Amerio, A., Aguglia, A., Sher, L., & Amore, M. (2020). The psychological impact of COVID-19 on the mental health in the general population. *An International Journal of Medicine*, 113(8), 531–537.
- Shultz, J. M., Cooper, J. L., Baingana, F., Oquendo, M. A., Espinel, Z., Althouse, B. M., ... Mazurik, L. (2016). The role of fear-related behaviors in the 2013–2016 West Africa Ebola virus disease outbreak. *Current Psychiatry Reports*, 18(11), 104.
- Sina Microblog Data Center. (2018). *Sina microblog user development report [in Chinese]*. Retrieved from <https://data.weibo.com/report/reportDetail?id=433>.
- Smith, D. (2020). *What will end the COVID-19 pandemic? The situation now as the coronavirus rages on*. Retrieved from <https://www.cnet.com/how-to/what-will-end-the-covid-19-pandemic-the-situation-now-as-the-coronavirus-rages-on/>
- That's. (2020). *China to Mourn COVID-19 victims during Qingming festival*. Retrieved from <https://www.thatsmags.com/shanghai/post/30955/china-to-mourn-covid-19-victims-during-qingming-festival>
- Tziner, A. (1982). Group cohesiveness: A dynamic perspective. *Social Behavior and Personality: An International Journal*, 10(2), 205–211.
- Xu, L., Lin, H., Pan, Y., Ren, H., & Chen, J. (2008). Constructing the affective lexicon ontology. *Journal of the China society for scientific and technical information*, 27(2), 180–185.
- Yang, J. (2020). The government's cold treatment, the ambiguity of disease control, the competition of thesis, the person to person transmission of Zhong Nanshan. Retrieved from <http://www.wmtv.cn/article/202002/202002051546033437.html>
- Yao, C., & Xu, B. (2020). *Armed with white coat*. Beijing, China: National Health Commission of the People's Republic of China Retrieved from <http://www.nhc.gov.cn/wjw/mtbd/202003/e0d5f8a773b54fc39113988dbcb19136.shtml>
- Zhao, N., Wang, Y., Li, S., Liu, X., Wu, P., & Zhu, T. (2020). Psychological and behavioral impact of wuhan lockdown and suggestions. *Bulletin of the Chinese Academy of Sciences*, 35, 264–272.

Zhao, Y. & Xu, H. (2020). Chinese public attention to COVID-19 epidemic: Based on social media. *medRxiv*.

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## APPENDIX

Main category	Sub-category	Example
Enjoyment	Enjoyment	Pleasure(快乐), be smiling(笑咪咪), and excited(兴奋)
	Ease	Comfortable(自在), peaceful(恬静), and calm(镇静)
Likes	Respect	Look up to(敬仰), admire(钦佩), and martyr(烈士)
	Praise	Handsome(英俊), excellent(优秀), and decisive(果断)
	Faith	Support(支持), certainly believe(笃信), and truth(真理)
	Love	Have a preference for(偏爱), treasure(珍宝), and love at first sight(一见钟情)
	Blessing	Wish(祝福), ambition(抱负), and success immediately upon arrival(马到成功)
Anger	Anger	Annoyed(恼火), get out(滚出去), and popular anger(民愤)
Sadness	Sadness	Pity(怜悯), sigh(叹气), and lonely(孤独)
	Disappointment	Desperate(绝望), low self-esteem(自卑), and depressed(沮丧)
	Guilt	Sorry(对不起), apologize(赔罪), and blame myself(自责)
	Missing	Nostalgic(怀旧), look back(回首), and unrequited love(单相思)
Fear	Panic	Stammer(结巴), in a hurry(匆忙), and run away(逃奔)
	Fear	Flinch(畏缩), scary(吓人), fatal(致命)
	Shame	Ablush(脸红), shy(害羞), and humiliating(丢人)
Disgust	Tedium	Impatient(不耐烦), bored(无聊), and annoying(恼人)
	Abomination	Traitor(叛徒), abhor(憎恶), and black heart(黑心肠)
	Reproach	Indecent(不雅), prejudice(偏见), and petty(小心眼)
	Jealousy	Envious(嫉妒), rival in love(情敌), and envy(妒忌)
	Doubt	Suspect(怀疑), query(质疑), and question mark(问号)
Surprise	Surprise	Amazing(惊人), curious(好奇), and suspense(悬念)

Note: “missing” means “If you miss someone who is no longer with you or who has died, you feel sad and wish that they were still with you” or “If you miss something, you feel sad because you no longer have it or are no longer doing or experiencing” (referred to Collins Gem English Learner’s Dictionary).