The Impact of Haze (PM2.5) on Emotions is Moderated by Regional Factors

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Abstract

This study investigates the role of regional factors in the influence of haze on emotions, based on social media big data. Employing a word frequency statistical method on Weibo data and controlling for the impact of Weibo hotspot events on emotions, this research conducts term frequency analysis and examines the moderating variable (region) using original Weibo content posted by users in Beijing (Chaoyang District) and Chengdu from 2015 to 2016. The introduction of the moderating variable (region) reveals a significant interaction effect between region and haze (PM2.5). Specifically, haze (PM2.5) demonstrates a positive correlation with negative emotions in the Beijing region, whereas it exhibits a negative correlation with negative emotions in the Chengdu region. These findings suggest that the effect of haze (PM2.5) on emotions varies by region, potentially attributable to differences in lifestyle and historical culture between the two cities.

Full Text

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Abstract

Based on social media big data, this study investigates the role of regional factors in the process through which haze influences emotion. Through word frequency analysis of Weibo data, we examined original posts by users from Beijing (Chaoyang District) and Chengdu between 2015 and 2016, after controlling for the impact of trending events. By introducing region as a moderating variable, we found a significant interaction between region and haze (PM2.5). In Beijing, haze (PM2.5) was positively correlated with negative emotion, whereas in Chengdu, haze (PM2.5) was negatively correlated with negative emotion. These findings demonstrate regional differences in how haze (PM2.5) affects emotion, which may be related to differences in lifestyle and historical culture between the two cities.

Keywords: haze (PM2.5); emotion; moderating variable; region
Classification Number: B849

Introduction

In recent years, haze has become one of the most concerning environmental issues in many Chinese cities, with increasingly frequent, persistent, and severe occurrences. Beyond its impacts on daily life, transportation, and physical health, the psychological effects of haze cannot be ignored. Emotion constitutes a fundamental aspect of human psychological activity and represents an important perspective for studying negative events. Under the influence of haze, people may experience fear, sadness, disgust, anxiety, and other negative emotions. A thorough investigation into how haze affects public emotion can help us understand its psychological impacts and provide an empirical basis for interventions and governance.

With the development of Web 2.0 technologies, Weibo has become an important channel for netizens to express personal opinions and vent emotions. The massive accumulation of information on this platform enables direct measurement of social sentiment. Scholars both domestically and internationally have utilized Weibo and Twitter to measure social emotion from multiple perspectives. Golder and Macy analyzed emotional information from massive Twitter content and discovered patterns of emotional variation across diurnal, weekly, and seasonal cycles. Asur et al. leveraged emotional information in Twitter content to predict movie box office performance. Wang Jingying and colleagues analyzed Sina Weibo to identify characteristics of emotional fluctuation rhythms. These studies demonstrate that large-scale text analysis based on microblogs can scientifically reflect public emotional fluctuations. Therefore, this study proposes using Weibo data to explore the association between haze and emotion, thereby providing a theoretical foundation for addressing emotional problems caused by haze.

Reviewing existing research on the relationship between haze and emotion, most scholars agree that haze induces less severe but frequent negative emotions. Cho

analyzed nearly 5,000 cases of depression-related emergency visits in Seoul from 2005 to 2009 and found a positive correlation between the number of depression-related emergencies and PM2.5 levels. Power et al. discovered through questionnaire surveys that increased anxiety levels were significantly correlated with PM2.5 exposure. Zhuo and Wu' s research found that haze-related emotions varied with air quality conditions; as air quality deteriorated, negative emotions toward haze increased, while sustained improvement in air quality elicited positive emotions such as joy, pleasure, and reassurance. However, other studies have shown that improved air quality does not necessarily bring positive emotional experiences, with respondents still reporting negative emotions. Some researchers analyzing self-reported responses to the question "To what extent are you bothered by outdoor air pollution" found that even when air quality was relatively good, respondents subjectively experienced annoyance from air pollution. In summary, public emotion under haze exposure has not reached a unified conclusion and requires further investigation.

Research has found that the effect of air pollution on public emotion is moderated by factors such as gender, age, and health status, with women, older adults, and individuals with poorer health being more susceptible to emotional impacts from air pollution. Zijlema et al. suggested that the relationship between air pollution and emotion is moderated by specific populations; their research on elderly individuals and women found correlations between air pollution and depressive mood, whereas studies on the general population did not. Overall, research on moderating factors in the relationship between air pollution and emotion remains limited and incomplete. Notably, the important factor of region has rarely been considered in the relationship between air pollution and emotion.

Different regions exhibit particularities in factors influencing public emotion, yet past research on the correlation between haze and emotion has often overlooked regional specificities. Moreover, domestic and international studies have rarely examined whether the relationship between haze and emotion is influenced by other variables. Research indicates that both haze and regional differences play roles in affecting public emotion. It is important to note that although haze may affect public emotion through indirect pathways, these effects may vary by region. How, then, does region moderate the impact of haze on public emotion? This study addresses this question.

To investigate the effect of haze on public emotion, this study employs a social big data approach, selecting social media—Weibo—as the source of public emotional information to explore the relationship between haze and public emotion. We propose the hypothesis that urban haze concentration is significantly positively correlated with negative emotion (and negatively correlated with positive emotion), and that region moderates the relationship between haze and emotion.

Method

2.1 Data Collection

This study collected two types of data: original Weibo posts and haze data (PM2.5 index). Weibo data were obtained from users registered in Beijing' s Chaoyang District and Chengdu, comprising original posts published during 2015-2016. Haze data (PM2.5 index) for these regions during 2015-2016 were obtained from http://www.stateair.net, with a total of 365$×2×$24 data points (hourly recordings for each day).

2.2 Data Processing

Weibo Data Processing. We aggregated Weibo data by timestamp to facilitate subsequent screening of major events and word frequency analysis. Regarding the selection of major events, we first identified social events during 2015-2016, then filtered them (by two researchers), and further selected events through interviews (assessing interviewees' awareness of major social events). Ultimately, 29 major social events were selected (see Table 1). We searched for keywords related to these events and deleted Weibo posts associated with them from the text documents for the corresponding dates.

Regarding the impact of holidays on word frequency, if word frequency values fluctuated significantly during a holiday period compared to before and after (e.g., Spring Festival, Qixi Festival), the word frequency data for that holiday were excluded from subsequent analysis.

For word frequency analysis, we first used the "Wenxin" text analysis system to analyze positive affect (PA) and negative affect (NA) in original Weibo posts, obtaining PA and NA data for different time periods (see Appendix 2). Positive and negative emotions were calculated by counting the frequency of positive and negative emotion word categories in the Wenxin system' s dictionary. However, due to the casual speaking style on Weibo and the timeliness of language expression, the values calculated by the Wenxin system were too small, with some days showing emotion values of zero. Therefore, we adopted an absolute word frequency method, directly counting the number of emotion words instead of calculating their proportion of total words.

For emotion word selection, we chose 15 positive emotion words (e.g., happy, joyful, touching) and 15 negative emotion words (e.g., sad, upset, conflicted) from the Weibo basic emotion lexicon. Selection criteria were: (1) Pleasure rating: positive emotion words had high pleasure ratings $(7.13\$\pm0.33), negative emotion words had low pleasure ratings (3.27\pm0.42), with significant differences between$ both positive (5.33 ± 0.53) and negative $(5.23\pm\$0.81)$ emotion words had high arousal ratings with no significant difference; (3) Frequency: selected emotion words had high frequency with almost zero occurrences of zero word frequency on any given day.

Haze Data Processing. Since the downloaded haze data had some missing

values, we filled and repaired the data, then calculated the average of 24 hourly values as the daily PM2.5 value. Missing data situations and filling methods were as follows: (1) If data for a single time point were missing with complete data before and after (values A and B), the missing value was filled with the mean of the surrounding values (A+B)/2; (2) If many data points were missing for a day, since averaging available time points could not accurately reflect that day' s haze condition (e.g., only early morning data), we used the average of adjacent days' PM2.5 values as that day' s haze value.

After data completion, we calculated daily haze averages for 2015-2016 as raw data for correlation analysis, then deleted haze data for holidays with significant word frequency impacts. The total number of data points per city was 695. Figure 1 [Figure 1: see original paper] shows the trend of haze levels in the two cities during 2015-2016. There was no significant difference in haze severity between the two cities during this period.

Results

3.1 Moderating Effect of Region

We conducted simple moderation model analysis using the PROCESS plugin for SPSS 22.0, with season as a covariate. After controlling for seasonal factors, region (Beijing vs. Chengdu) served as the moderating variable, PM2.5 values as the independent variable, and emotion word frequency (positive and negative) as dependent variables. The conceptual model is shown in Figure 2 [Figure 2: see original paper].

Substituting the variables into the model yielded regression equations for positive and negative word frequencies. In the regression model for positive word frequency, the coefficient for the interaction term (XM) was 0.834, which was statistically significant. In the regression model for negative word frequency, the coefficient for the interaction term (XM) was -0.138, which was also statistically significant. These results indicate that regardless of whether the dependent variable is positive or negative emotional word frequency, the effect of haze level (PM2.5 index) on emotional word frequency in Weibo posts depends on users' region (Beijing vs. Chengdu). In other words, region moderates the effect of haze level (PM2.5 index) on emotional word frequency in Weibo posts.

3.2 Interaction Analysis

Since the moderating variable (region) is categorical, we introduced a dummy variable where M=0 represents Beijing and M=1 represents Chengdu.

Analysis of Positive Emotion Word Frequency by Region. The visualization of region' s moderation on the relationship between PM2.5 index and positive word frequency is shown in Figure 3 [Figure 3: see original paper]. The slope indicates the change in positive word frequency when PM2.5 changes by one unit, under the joint influence of PM2.5 and region. Results show that for

each unit increase in PM2.5, positive word frequency in Beijing (M=0) increased by 0.034 units. This indicates a positive relationship between haze (PM2.5 index) and positive emotional word frequency in Beijing, though the difference from zero was not statistically significant. Meanwhile, for each unit increase in PM2.5, positive word frequency in Chengdu (M=1) increased by 0.868 units, showing a statistically significant positive relationship between haze (PM2.5 index) and positive emotional word frequency in Chengdu.

Analysis of Negative Emotion Word Frequency by Region. The visualization of region' s moderation on the relationship between PM2.5 index and negative word frequency is shown in Figure 4 [Figure 4: see original paper]. The slope indicates the change in negative word frequency when PM2.5 changes by one unit, under the joint influence of PM2.5 and region. Results show that for each unit increase in PM2.5, negative word frequency in Beijing (M=0) increased by 0.071 units, demonstrating a statistically significant positive relationship between haze (PM2.5 index) and negative emotional word frequency in Beijing. Conversely, for each unit increase in PM2.5, negative word frequency in Chengdu (M=1) decreased by 0.067 units, indicating a negative relationship between haze (PM2.5 index) and negative emotional word frequency in Chengdu that was marginally statistically significant.

Discussion

Previous research on haze and emotion has primarily considered only the effect of haze on emotional valence. This study incorporates region as a factor in examining the relationship between haze and emotion. Our analysis of the relationship between emotional word frequency (positive and negative) in original Weibo posts from Beijing and Chengdu and haze (PM2.5 index) reveals that region plays an important role in the process through which haze moderates emotion. Simple moderation model analysis shows that region' s moderating effect is significant in both positive and negative word frequency changes with haze (PM2.5). In Beijing, the relationship between emotion and haze (PM2.5) is consistent with previous research: as PM2.5 index increases, negative word frequency increases. However, in Chengdu, the pattern is opposite to previous studies: when haze (PM2.5 index) increases, positive word frequency actually increases.

These regional differences may be related to cultural and lifestyle differences between the two cities. Haze is more severe in winter, and Beijing' s winters are drier, more likely to cause discomfort and negative emotions. Chengdu, known as "the Land of Abundance," is associated with a slower pace of life, as reflected in the saying "the young should not enter Sichuan, the old should not leave it." During hazy periods, elderly people and women who do not need to work tend to spend time on indoor activities like playing mahjong. Differences in life rhythm and attitudes may explain these results. From a long-term perspective, Beijing residents face greater medical, economic, and housing pressures than Chengdu residents. To reduce medical expenses related to haze, people purchase air

purifiers and anti-haze masks, representing an economic loss that may increase negative emotions.

This study has several limitations. First, emotion word selection integrated word frequency usage, arousal, and pleasure ratings, using words with statistically equivalent arousal but different valence. While our results confirm the existence of regional moderation, it remains unclear whether similar moderation effects would be obtained using other methods, such as selecting another set of words based on our criteria. Future research should employ alternative methods to further verify the moderating role of region in the effect of haze (PM2.5 index) on emotion. Second, this study only examined two regions—Beijing and Chengdu. To further validate regional effects, future research should expand the scope to include multiple cities. Finally, further analysis of region and haze factors is needed to determine whether region' s moderating effect is influenced by haze severity. It is possible that when haze is severe, regional moderation effects disappear and all regions show consistent responses to haze. The impact of different haze levels on emotion across different regions represents a valuable direction for future research.

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Author Contributions

Ying Zhang, Yujie Chen, Junfang Chen, Xiaoju Wu, Yanman Long: Conceived research ideas and designed the study
Ying Zhang, Yujie Chen, Junfang Chen, Xiaoju Wu, Yanman Long: Implemented research procedures (e.g., conducted experiments or surveys)
Tingshao Zhu: Obtained Weibo data and overall design
Shengtao Wu, Ying Zhang, Yujie Chen, Junfang Chen: Data analysis
Ying Zhang, Yujie Chen, Junfang Chen, Xiaoju Wu, Yanman Long, Tingshao Zhu: Drafted or revised the final manuscript

Note: Figure translations are in progress. See original paper for figures.