# "Hello, Fellow Villager!": Perceptions and Impact of Displaying Users' Locations on Weibo

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**Abstract.** In April 2022, Sina Weibo began to display users' coarse location for the stated purpose of regulating their online community. However, this raised concerns about location privacy. Through sentiment analysis and Latent Dirichlet Allocation (LDA), we analysed the users' attitudes and opinions on this topic across 20,162 related posts and comments. We labelled 300 users as either supportive, critical, or neutral towards the feature, and captured their posting behaviour two months prior and two months post the launch. Our analysis elicits three major themes in the public discussion: online community atmosphere, privacy issues, and equity in the application of the feature, and shows that most people expressed a negative attitude. We find a drop in activity by objectors during the first month after the launch of the feature before gradually resuming. This work provides a large-scale firsthand account of people's attitudes and opinions towards online location privacy on social media platforms.

**Keywords:** location privacy, social media mining, sentiment analysis, Latent Dirichlet Allocation, Weibo

## 1 Introduction

Social media has become an integral part of our daily lives as a means to share daily activities, experiences, interests, and opinions [39]. At an average of 2 hours and 27 minutes per day, social media accounts for the largest single share (35%) of our online media time[4]. In China, one of the most popular social media platforms, Sina Weibo, reached 582 million monthly active users in the first quarter of 2022. However, the scale of the platform and the ease in which information can be shared and propagated has also led to significant issues regarding information quality, disinformation, misinformation, and fake news [16].

Recently, in what was portrayed as an attempt to tackle these issues, many popular Chinese social media platforms including Sina Weibo, WeChat, Douyin,

[4] https://datareportal.com/reports/digital-2022-global-overview-report

Little Red Book, and Zhihu, rolled out a new feature that displays users' coarse location. For Sina Weibo, this new feature shows the user's province or region in China, or name of country if overseas, on their profile page and next to their comments. This feature was touted by the platforms as a way to reduce the dissemination of malicious rumours, impersonation, and other negative behaviours, with the aim of increasing the authenticity and transparency of the disseminated content. However, the feature also raises significant concerns regarding the users' location privacy and self-presentation, and risks encouraging geographic discrimination and cyberbullying.

Previous studies have investigated users' perceptions towards location privacy on social media, exploring different platforms (e.g., MySpace, Yelp, Foursquare), genders [50], user groups [9, 13] and scenarios [58, 12, 21]. However, the majority of these studies were conducted on location-based social media platforms (i.e., those whose core function is to provide location-based information and services). The impact of increased location transparency on non-location-based, general-purpose social media platforms, however, remains poorly understood. Furthermore, most of the existing studies were conducted in a western cultural context. We need a better understanding of how location privacy is perceived by non-western cultures – a participant population that is often overlooked in HCI research [49]. The recent implementation of the user location information feature on Weibo offers a unique opportunity to conduct an in-depth investigation of users' perception of location privacy, and the impacts on their participation, on a large non-western general-purpose social media platform that does not use location information for its normal operation.

Based on the research gaps identified above, in this work, we focus on two research questions:

- **RQ1**. How do users perceive and respond to the adoption of a location display feature on the Chinese social media platform – Weibo?
- **RQ2**. Based on users' different attitudes (negative, neutral, positive) towards location display on Weibo, how does this feature affect users' posting behaviours?

For RQ1, in order to understand users' attitudes and opinions towards this new feature, we collected 16,199 comments from 19 announcement posts published by verified accounts and 4,043 users' posts from the 16 most popular related hashtag topics. Then we analysed their sentiment trends and key opinion topics that were frequently discussed by users. For RQ2, to detect user behaviour change after the implementation of this feature, we collected posts published by 100 supporters, 100 objectors, and 100 neutral users in the four months surrounding this new feature's launch. We analysed the changes in the posting behaviour of each group during this time frame.

Our main findings are the following: (1) Most users hold a negative attitude toward this feature as they feel it can risk amplifying geographic discrimination and cyberbullying, while also questioning its usefulness and accuracy. (2) We identified three major themes in the public discussion: online community

atmosphere, privacy issues, and equity in the application of the feature. (3) Furthermore, we found a decrease in activity from those that were critical of the feature for the month following its implementation and we also provide evidence of the existence of the location privacy paradox. Our research contributes to the growing body of work on the impact of location privacy in social media platforms by providing a large-scale investigation of this topic in a real-world scenario.

## 2 Related Work

Our work seeks to further our community's understanding of perceptions around online privacy and, more specifically, location privacy. In this section, we discuss the literature that our work builds upon.

### 2.1 Online Privacy and the Privacy Paradox

There are many online platforms or applications that involve the sharing of large amounts of personal information. This increased exposure has obvious privacy implications, which has been identified as a primary concern of citizens in the digital age [32]. Interestingly, the value people put on their online information can vary based on a number of different factors. For instance, users value interaction data on social media (e.g., browsing history, posting behaviours) higher (12 Euros) than search information (2 Euros) [6]. Along similar lines, Tsai et al. [55] conducted an experimental study on privacy information concerns on online shopping behaviour and found that participants were willing to pay extra to purchase from privacy-protective websites when privacy information is made more prominent and accessible.

Researchers have also investigated the impact of user demographics on proactiveness to safeguard personal information in online settings. For example, several studies have challenged the widespread belief that young people, the most active users on social media, do not sufficiently protect their personal information on social networking sites. Previous work has shown that young people are more likely to utilise different ways to protect their online information, such as not giving the right information or using pseudonyms [40]; opening the setting that only their friends can access their recent post [35]; deleting their names from images that friends have posted by untagging themselves [65]. Nevertheless, neglecting one's online privacy remains a pervasive challenge across all types of users [1].

Based on previous research, users are increasingly aware of the possibility of privacy violations on social media [28, 64], even though they still post their real-time location information and personal information online and few of them take all the required precautions to protect their sensitive data [15]. The phenomenon of the difference between users' stated privacy concerns and their real behaviour is called the "privacy paradox" [42]. In other words, although users may claim they are concerned over their online privacy, they simultaneously are willing to provide important personal information through social media in order to gain

a benefit [23]. Although the "privacy paradox" has been widely investigated, the findings remain contradictory and inconsistent [32]. Some studies indicate a widespread occurrence of this phenomenon [66, 56] while other studies provide evidence against it [65, 10].

In this paper, we explore people's reactions to online privacy in a naturalistic environment where we collect their organic attitudes, opinions and behaviours towards this highly-debated feature introduced by Weibo. In addition, we provide additional evidence towards the privacy paradox hypothesis, especially within the context of geographic information.

### 2.2 Perceptions on Online Location Privacy

With the rise of location-based games (LBGs) (e.g., Pokémon GO), versatile location-based applications (LBAs) and various location-based services (LBSs) (e.g., location-based advertisement) embedded in traditional social media platforms, users' geographical location information is more widely used than ever before. Unfortunately, the increased ease of sharing this information online can lead to breaches in location privacy, which in turn can have significant negative implications such as stalking, tracking people's movements, exposing a user's true identity or geographical discrimination [7]. Thus, understanding how users perceived the risk of location information and disclosure intentions is crucial.

Researchers have made a concerted effort in studying users' attitudes and behaviours towards location privacy from a variety of different angles. However, people's opinions on online location privacy has been shown to vary. Some are more concerned about the possible dangers of revealing their location data, while others are more tolerant when there are clear advantages offered by location-based services. For example, Gana and Thomas [19] studied consumers' perspectives regarding location-based advertising where they expressed concerns about disclosing personal data to unknown agencies and organisations which might be used without permission. Interestingly, the same consumers appreciated the ease of using their location information for travelling activities. This dichotomy showcases the importance of value proposition for the willingness of users to share their location information. Furthermore, through a study conducted by Fisher et al . [17], the researchers examined the use of location controls on iPhone devices and found users fall into different categories, including those who deny all apps access, those who allow all apps access, and those who selectively permit certain apps to access their location.

Other studies found that users tend to pay more attention to their own geographical location information compared with other types of information. Furini and Tamanini [18] investigated 122 participants' opinions after showing them the amount of personal and sensitive information that a simple application can access by browsing content publicly available on social media platforms. Their findings show that those who were originally unconcerned about privacy ended up being the most concerned about location privacy breaches. In another example, participants expressed that they were much more concerned about dynamic privacy (location-tagged) leaks when compared to their static private

information on Facebook (e.g., personal information including real names, fan pages joined) [9]. Similarly, Hecht et al. [25] examined location field usage in Twitter user profiles and found that 34% of users provide inaccurate location information, and when accurate, location is often limited to the city level.

The previous examples showcase how location information raises important privacy concerns among online users due to its sensitive nature and the subsequent implications of having this information shared with malicious parties. As a result, many studies have explored different ways to alleviate users' concerns regarding their location information on LBAs. Existing research suggests that the LBAs with various levels of location granularities are more welcomed and accepted [54, 11]. Similarly, researchers have proposed using more transparent and straightforward location privacy settings to mitigate users' concerns regarding their location information [30, 3]. The authors also propose the use of interventions such as third-party seal programs provided by platforms to enable increased users' trust [63].

Despite the fact that substantial research has been conducted on user attitudes and behaviour towards location privacy, the majority of this work focuses on general views around location privacy, and self-reported intention to provide location information through a user study. The recent implementation of the location disclosure function by Sina Weibo provides a unique possibility to conduct an in-depth exploration of location privacy with a large user base in a naturalistic scenario, which will help us better understand social media users' perceptions and opinions on online location privacy. The generated insights can in turn be used to inform the design of social media platforms to better safeguard user's location privacy.

## 3 METHODOLOGY

We conducted an exploratory analysis of publicly available data on Weibo to better understand people's reactions to their coarse location being made visible on the platform. This included sentiment analysis, topic modelling and user behaviour analysis. Figure 1 shows the methodological framework of this work, which we explain in further detail next.

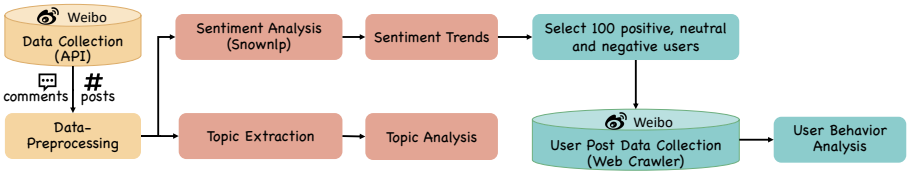


**Fig. 1.** Methodological framework of our work

### 3.1 Data Collection

On April 28th 2022, the official Sina Weibo account published a post regarding the rollout of the location display feature. To gather a wide variety of user's opinions on this matter, we employed two data collection mechanisms. First, we collected user comments through Weibo's API[5] from the original Weibo post that initially publicised the change. Then we carefully selected an additional 19 posts regarding this announcement published by different verified organizations (i.e., news outlets) that all have at least 1 million followers. These 19 posts paraphrased or repeated the original official announcement posts by the Sina Weibo administrator account, explaining the feature and its implementation, without any personal sentiment or bias.

Second, we collected users' original posts from relevant hashtags topics with a web crawler[6]. We crawled hashtags and filtered the results based on keywords, including "IP territorial", "IP address", and "IP". From all the hashtag topics we acquired, we chose 16 relevant hashtag topics that were established in response to this new feature in Sina Weibo and with a high number of occurrences (the lowest number of posts in these topics is greater than 100), such as "#Weibo fully open IP territorial function#", "#Weibo full open comments show IP territorial function#", "#the personal homepage of Weibo will display the IP territory#". It is important to note that hashtags on Weibo are often long and presented in sentence formats, and not restricted to a single word or short sentence as commonly seen on Twitter.

### 3.2 Data Pre-processing

As content originating from microblog platforms (e.g., Twitter, Weibo) are known to contain a large amount of noise and errors, we conducted data pre-processing before proceeding with our analysis. The following steps were used in our data pre-processing process.

The first step is duplication and noise removal. We manually deleted the posts or comments that were obviously irrelevant to the topic (e.g., advertisements and irrelevant news posts). In addition, we deleted redundant posts that were collected due to the use of multiple relevant hashtags. The next step is non-Chinese character filtering and conversion. We removed information from each individual post and comment that was not relevant to our analysis, such as hashtags (narrative sentences describing this transition), username handles, URL links, or system-generated GPS location information. Then we performed word segmentation. We used a custom Python program based on the Jieba package[7], a popular Chinese word segmentation tool. We split the text string into individual words and removed stop words. Stop words refer to functional words that have no concrete meaning, such as prepositions [61]. We used the Baidu stop word

[5] https://open.weibo.com/wiki/API/en
[6] https://github.com/Python3Spiders/WeiboSuperSpider
[7] https://github.com/fxsjy/jieba

list[8] during this process. Finally, in order to protect users' privacy in the latter analysis, we omitted personal privacy information in our datasets like post ID or username. All posts involved in our analysis only contained textual contents that were posted publicly.

### 3.3 Sentiment Analysis

We used SnowNLP[9] to conduct text sentiment analysis. SnowNLP is a third-party Python package that can perform segmentation of Chinese words, part-of-speech tagging, sentiment analysis, text categorisation, pinyin conversion, simplification of traditional text, extraction of keywords, extraction of abstracts, segmentation of sentences, and text similarity calculation. It has been frequently and successfully used to analyse Chinese natural language in different fields [59, 60, 43, 37]. We also leveraged emoticons present in the text for our sentiment analysis, as they have been shown to contain important sentiment information [33].

The original model of SnowNLP is based on a naive Bayesian classification method using Chinese E-commerce, book and movie reviews as the dataset for training and prediction. This particular dataset includes 16,548 positive and 18,574 negative sentiment sentence data [29]. For that reason, this dataset might not precisely reflect posts and comments appearing on Weibo. Therefore, we randomly selected 20% of the dataset as the training dataset and two native speakers manually annotated the posts/comments. The annotators worked independently and labelled the text into two categories: positive and negative. After finishing the annotation, we calculated the degree of inter-rater reliability ($\kappa = 0.93$), which indicates that there was a high level of agreement between the annotators. We then updated the data with the labelled information and trained it accordingly to achieve the new model.

### 3.4 Topic Modelling

We used Latent Dirichlet Allocation (LDA) – a common method of topic modelling to extract the underlying topics from text documents. It has been used broadly in previous HCI research. For example, to study privacy-related issues on Stack Overflow [53], to investigate working from home challenges differences between Weibo and Twitter users [20], and to analyse what parents discuss on Reddit [4].

LDA is an unsupervised method used to create generative probabilistic models, it estimates the chances for combinations of words (topics) to repeatedly appear together, and that are similar to each other using Bayesian inference [48]. A topic can be described as a combination of strongly related words that appear at a statistically significant rate in a text corpus [38]. Put differently, these words frequently appear together in the texts, i.e., comments and posts. Since different topics can appear in one piece of text and different texts can contain the same

[8] https://github.com/goto456/stopwords/blob/master/baidu_stopwords.txt
[9] https://github.com/isnowfy/snownlp

topic, topic modelling can theoretically produce two clusters: one presenting clusters of topics based on the similarity of words, and one presenting clusters of texts based on the similarity of topics [2]. The advantage of this model is that it allows us to analyse a larger dataset than is feasible with manual annotation.

To determine the optimal number of topics we looked at the topic quality. For this, we consider both the coherence score and the perplexity score. Topic coherence is a measure of semantic similarity of the words comprising the topics. High coherence scores indicate high topic quality. The perplexity score, on the other hand, describes the generalization of a topic model. In order to make sense of the perplexity score, different models have to be run to obtain different perplexity scores. A lower perplexity score describes a better model [5]. Deciding the optimal number of topics, therefore, does not only require a combination of high coherence and low perplexity scores, but also the intuition and domain expertise of the researchers. Once the optimal topic number was decided, we visualised the topic extraction result using the LDAvis[10] python package. The visualisation provides an overall view of the topics and how they differ and overlap from each other [48]. Finally, we used the words that are most indicative of each topic to interpret the topics identified by the model.

### 3.5 User Behaviour Analysis

To understand the change in user behaviour that may have been caused by the introduction of this feature, we randomly selected 100 users from each of these groups: supporters and objectors of this feature, and neutral users who neither expressed support or objection towards this feature. We collected the posts they published in the time period of two months before and after the location display feature was implemented on Sina Weibo.

Previous work has shown that the message volume of microblog users follows power-law distribution [46]: a small number of users tend to generate a large proportion of posts on social media, while the majority of users generate relatively few posts. This phenomenon is often referred to as the "long tail" of user activity. In particular, when examining the relationship between the social network of microblog users and their behaviours, the distribution exponent of message volume is shown to be inversely proportionate to the interaction exponent of each user [46]. First, to verify the reasonableness of our sampling, we fit the volume of posts of each user through power-law distribution. Furthermore, we produced a time-series graph of the original and retweeted posts of each of the three groups of users mentioned above. It is important to note that the frequency and time of users' usage of Weibo (i.e., how often they tweet) are affected by many factors (e.g., public events and holidays) and have a certain degree of randomness. Therefore, when analysing the sample data, we labelled important events in relevant peaks on the time series graph.

[10] https://github.com/bmabey/pyLDAvis

# 4 Results

## 4.1 Sentiment Analysis

**Dataset** The collected data for this analysis pertains to the period between 0:00 on April 28, 2022, and 23:59:59 on May 28, 2022 (Beijing time). A one-month time frame was chosen as previous work has shown that the active period for most microblog topics lasts for about a month, after which these topics are typically replaced by new topics [36]. The data included 16,799 comments originating from the 19 verified account posts and 4,624 posts with relevant hashtags. After data preprocessing, a total of 20,162 valid textual data were retained for our analysis. The metadata only contains text content attributes as we removed partial user attributes.

In order to further verify the validity and reliability of our collected dataset, we calculated the relationship between the number of responses we collected from all provinces in mainland China and current population figures. The Pearson correlation coefficient between these two datasets is 0.81, indicating that our dataset sufficiently reflects the characteristics of the Chinese population and can be used to draw valid conclusions about general Chinese social media users.

**Sentiment Distribution** After manually annotating data and training it, the sentiment distribution of the posts/comments of our dataset is shown in Figure 2. The sentiment analysis value outputs are in a range between 0 and 1, with 0 representing a negative sentiment, 0.5 representing a neutral sentiment, and 1 representing a positive sentiment. As shown in Figure 2, the majority of posts/comments are negative towards the implemented feature, with a high prevalence of extremely negative opinions. We can also observe a similar number of neutral and positive posts/comments.

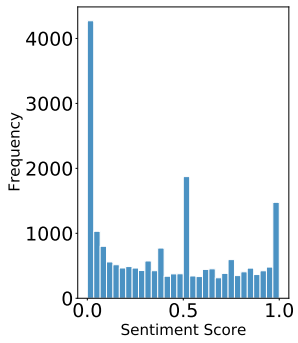


**Fig. 2.** Histogram of sentiment of posts/comments

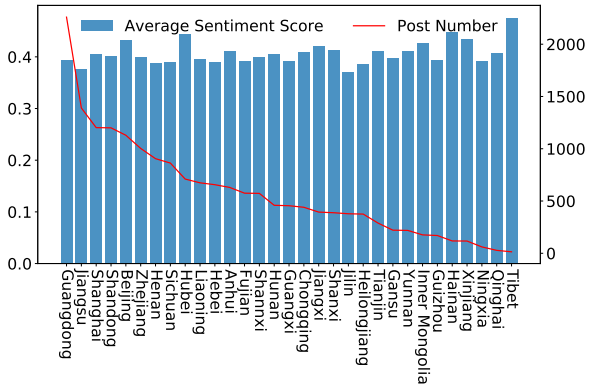


**Fig. 3.** Average sentiment score and total post/comment number of each province

According to the general sentiment classification criterion used in previous research [34, 44], we categorised all posts/comments into three categories based on their sentiment value: negative (0 to 0.3), neutral (0.3 to 0.7), and positive (0.7 to 1). This resulted in 4,834 (24%) positive posts/comments, 8,777 (43.5%) negative posts/comments, and 6,551 (32.5%) neutral posts/comments. By dividing the users into two categories based on their current location: those from mainland China and those from overseas. Among the 18,071 posts/comments made by users from mainland China, 4,333 (24%) were positive, 8,049 (44.5%) were negative and 5,689 (31.5%) were neutral. Regarding the overseas users', there were 2,091 posts/comments in total. Among these, 501 (24%) were positive; 728 (35%) were negative and 862 (41%) were neutral.

In addition, Figure 3 illustrates the average sentiment score and number of posts/comments from 31 provinces in mainland China. The average score of all provinces ranged between 0.371 and 0.448. In general, we can observe that all provinces demonstrate a negative sentiment towards location display on Weibo. The four provinces with the highest sentiment scores are Hainan (0.448), Hubei (0.444), Xinjiang (0.434) and Beijing (0.433). The four provinces with the lowest sentiment scores include Jilin (0.371), Jiangsu (0.376), and Heilongjiang (0.386) and Henan (0.389). In our subsequent analysis, we only consider provinces with the number of posts/comments above 100.

### 4.2 Topic analysis

**Topic Number Choice Based on LDA models** Before conducting topic analysis, an important step in LDA analysis is determining the appropriate number of topics to optimise the processing time and accuracy of the model [24]. We achieved this by using perplexity scores, coherence scores and model visualisation.

The results of perplexity and coherence scores for various numbers of topics are shown in Fig. 4(top) and Fig. 4(bottom). First, we calculated the perplexity scores with a range of different number of topics settings. As described in section 3.4, the lower the perplexity score, the better the model. Figure 4(top) shows a continuously decreasing perplexity score until running the model with 19 topics. While a higher number of topics leads to a smaller perplexity score indicating a better model performance [62], a large number of topics can result in model over-fitting. Furthermore, it is crucial to account for the coherence score when choosing the optimal number of topics. The higher the coherence score, the better the topic quality. We find three global peaks (6, 11, and 17 topics) in the range of 1-19 topics, as presented in Figure 4(bottom). Therefore, we use either 6, 11, or 17 topics to train our model. To choose the optimal number of topics among those three choices, we additionally inspected high-frequency keywords and visualisations generated for each of the topic models. Each circle in Fig. 5 represents a different topic and the size of the circle represents number of words in our corpus that belong to that topic. The distance between each topic roughly represents the semantic relationship (the closer the circles, the more words they

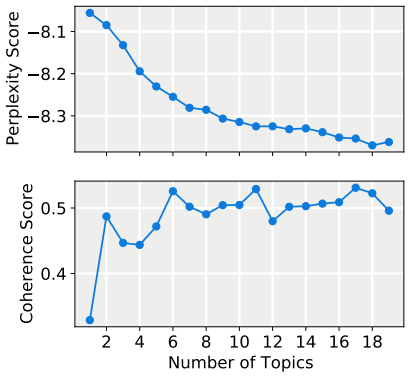


**Fig. 4.** Perplexity and Coherence scores with different settings of number of topics

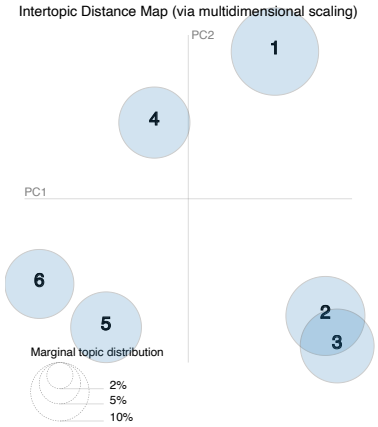


**Fig. 5.** LDA model visualization containing all six selected topics

have in common) between the topics, while the overlap of circles means the topic shares some common words as opposed to non-overlapping topic. This enabled us to determine 6 as the optimal number of topics for our sample, based on the high distance between the topics and the absent overlap (except for topics 2 and 3).

**Topic Clusters** In this section, we summarise the content of the six topics based on the most frequently used words generated from each topic. We note that these keywords are grouped together (based on their latent meanings) because they are commonly featured in the posts/comments clustered together. Consequently, words that seem unrelated to one another might be categorised together.

**Topic 1 (22.4%)** consists of postings that express curiosity and a desire to experiment with the new feature. Some posts just contain random short content without any meaning. As users can see the approximate location of other users through comments, some of them greet each other in their posts and try to engage with users from the same province. A few representative words/expressions selected from this topic are: "let me have a try" (users checking if their location would be displayed), "city", "Fellow Villager", "been to" (users stating they have been to the shown location).

**Topic 2 (18.3%)** consists of postings that contain concerns and involve discussion on privacy leaks and violations. These users feel uncomfortable about the platform showing their geographic location information without their consent, likening the experience to "streaking" (i.e., running naked) on social media. They also worry that more personal information might be shown in the future, such as more detailed location information and/or other privacy-related data. Nevertheless, the users did not have a unified opinion on privacy matters. Some

view the feature as an invasion of personal privacy and would uninstall the software and stop using it, while others do not consider showing provincial address as leaking privacy due to a large number of users in each province. A few representative words selected from this topic are: "personal privacy", "real-name system", "violation", "streaking", "rights".

**Topic 3 (16%)** consists of postings concerned with the aggravation of regional discrimination, cyberbullying, and doxing. Some users feel that the implementation of this feature will deepen geographic stereotypes, and foster the growth of cyberbullying and doxing. Also, some users say that people from certain provinces (e.g., Henan, Heilongjiang, Jilin and Liaoning), which are traditionally discriminated against [45, 8], may suffer from the same social stereotyping online with this new feature. Overseas users also express concerns that the feature may limit their freedom of speech and cause their posts to be labelled as "foreign criticism" due to the displayed location. As a result, these users may be more cautious when posting on social media platforms in the future. A few representative words selected from this topic are: "regional discrimination", "cyberbullying", "attacking", "exposure".

**Topic 4 (14.8%)** contains postings containing self-declarations and the questioning of the accuracy and usefulness of this feature. On the one hand, some users express that what they said on social media had nothing to do with their region and provinces, where they were born, received education and worked in totally different provinces. Some users even (jokingly) said "I hereby declare that I am not a well-mannered person, I am surfing online for fun and all my comments are unrelated to my real identity". On the other hand, some other users argue that location can easily be changed using virtual private network (VPN) tools so that they could hide their identities through proxy. Hence, this feature would not be effective in stopping those who try to spread rumours, as their locations would be fake. Nevertheless, others argue that this need of using VPN is still a hindrance for people who post with those purposes. Furthermore, many users have expressed dissatisfaction about the platform's low accuracy of displaying users' location information. A few representative words selected from this topic are: "speech", "VPN", "well-mannered", "proxy".

**Topic 5 (14.6%)** is related to the strong support of this new feature and the belief that it could make information on social media more authentic. These users believe this measure can help foster a better online community and is able to reduce rumours, cyberbullying, defamation, trolling, fake accounts, and will prevent the occurrence of other potentially harmful activities. They argue that Weibo users will treat the online community with more respect and will be mindful when publishing posts or comments that use offensive language. Furthermore, some users mention that this feature could effectively reduce the occurrence of malicious content and misinformation regarding the pandemic situation during the COVID-19 lockdowns, and increase bonding between users from affected cities. A few representative words selected from this topic are: "platform", "spreading rumours", "stir up", "no big deal", "responsibility".

**Topic 6 (13.9%)** discusses the theme related to celebrities, opinion leaders and social media influencers. Users of the platform raised an important point that many opinion leaders and influencers show geographic location of Hunan province; however, their posts show the content that has been created abroad (e.g., image or video taken in Europe, but location is shown as Hunan). The reason behind this phenomenon is that these accounts are managed by a number of Multi-Channel Network Companies in the Hunan province.

Another aspect that sparked discussion was that when the platform initially implemented this feature, verified celebrity accounts did not show their location information. As a result, users complained they feel treated differently–disadvantaged–as compared to verified account users. One more phenomenon users also mentioned is that through this feature they can know whether the celebrity's account is managed by themselves or by their agent company. This is similar to recent developments on Twitter (e.g. harsher stance on impersonation, charging users for the blue tick). A few representative words selected from this topic are: "celebrities", "Hunan", "influencer", "company", "ordinary people", "fake accounts".

### 4.3 User Behaviour Analysis

To investigate changes in user behaviour potentially caused by the introduction of this feature, we selected 100 users of the three user groups (supporters, neutrals, and objectors) and studied how their behaviour changed during the two-month period around the announcement and implementation of the location display feature in Weibo.

**Power-law Analysis** In Fig. 6, we present the cumulative complementary distribution function (CCDF) of the total number of posts per user and the percentage of users for selected three groups. As we can see in all the groups the distributions are skewed, demonstrating that the proportion of users who frequently publish posts is relatively small, while most users do not post often which aligns with the long-tail characteristic of power-law distributions.

We can observe from Fig. 6(a) that for the supporter group, the slope for posting behaviour before the feature's implementation is -0.54 ($R^2 = 0.72$); whereas the slope value for posting behaviour after the feature's implementation is -0.55 ($R^2 = 0.75$). The two values are close to each other indicating that the behaviour of this user group did not change significantly after the location display feature was introduced on Weibo.

A similar trend can be observed for the neutral group (Fig. 6(c)). To be precise, the slope of posting behaviour before the feature was implemented is -0.94 ($R^2 = 0.90$); whereas the slope for posting behaviour after feature's implementation is -0.90 ($R^2 = 0.87$). The two values are close to each other indicating that the behaviour of the neutral user group was not significantly affected after the location display feature was implemented on Weibo.

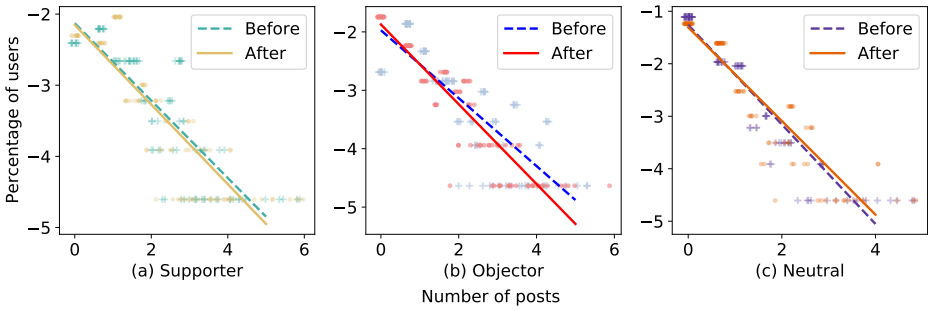


**Fig. 6.** CCDF of the number of posts per user group (log-log scale)

Interestingly, a slightly different trend can be observed for the objector user group. According to (Fig. 6(b)), the slope for posting behaviour before the location display was introduced is equal to -0.56 ($R^2 = 0.67$); whereas the slope value for posting behaviour was -0.65 ($R^2 = 0.85$) after the feature was implemented. In particular, the users who were against the implementation of displaying user coarse location, to some degree, decreased their activity on Weibo during the one month after the feature was introduced. From the power-law fitting result, the average $R^2 = 0.80$, which means our sample is well-suited for analysis.

**User Posting Behaviour Analysis Based on Time Series** We looked at user posting behaviour in the time period of two months prior- and post-implementation of the feature. We collected user posts starting from February 28th until June 28th and analysed the average number of posts per user per day for the three user groups and smoothed the results using a moving average function with the window size of 7 (to account for any differences between days of the week). Since users' posting behaviour can potentially be affected by many other factors (e.g., public events, holidays, etc), we took into account major events that took place around the time period used in our analysis and labelled these events on the graph (Fig. 7).

As can be seen from Fig. 7, in general, the behaviour of the supporter and neutral users did not exhibit a significant change in terms of the number of posts published per day prior- or post-implementation of the feature on April 28th. However, the behaviour of the objector user group did exhibit a change. Precisely, the objectors published fewer posts per day during the first month after the feature was implemented. Interestingly, in the second month after the feature was implemented the number of posts caught up with the values prior to implementation. This to some extent suggests that the impact of the location display feature on the posting behaviour of the objectors was temporary and the behaviour eventually returned to pre-implementation levels, while also noting the presence of a significant event around that period, which resulted in a flood of outrage on Chinese social media.

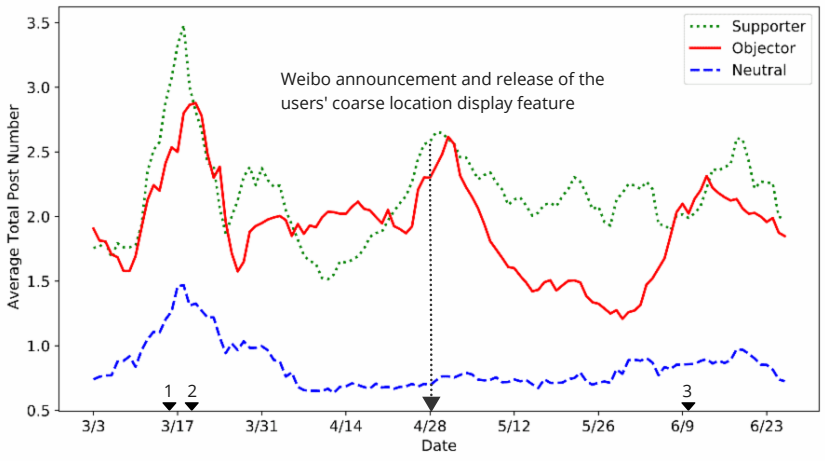


**Fig. 7.** Average total post number per user of the three selected groups. The dotted vertical line shows when the feature was announced and released. The first marker is China's Consumer Rights Day; the second marker is the China Eastern Airlines flight crash; and the third marker is the Tangshan restaurant attack incident.

## 5 Discussion

In this paper, we investigate people's attitudes, opinions and behaviours towards location privacy on social media in a naturalistic environment, following the widespread implementation of a coarse location display feature on Weibo. In this section, we discuss issues that arise due to the visibility of users' coarse location, including geographical discrimination and bonding, user self-presentation, change in user behaviour, and fairness within an online community.

### 5.1 Geographical Discrimination and Bonding

Our findings show that the overall sentiment towards this new feature was negative in all provinces. This indicates that, in general, Weibo users across China did not support the implementation of location visibility on the platform. Furthermore, we found that the three provinces with the lowest average sentiment scores are Jilin, Jiangsu and Heilongjiang—mostly located in North-Eastern China. This is an expected outcome as previous work has shown that there is widespread online regional discrimination against residents of North-Eastern China. For example, Sun and Liang [51] studied the reputation of North-Eastern Chinese social media users (from Liaoning, Jilin, and Heilongjiang) and found that users from those regions are often treated in a discriminatory and stereotypical manner. In addition, Henan, which exhibits an average sentiment score that ranks fourth from the bottom, also serves as an illustrative example of a province frequently subjected to geographical discrimination. Peng [45] analysed user comments under news related to regional discrimination against Henan

citizens, and found that the visibility of geographic location notably amplified discriminatory behaviours. Understandably, the level of disapproval towards this new feature can be explained by the fear of increased discrimination on Weibo based on the visibility of their geographic location (Topic 3).

Interestingly, the feature also led to unexpected bonding between users in Shanghai during the strict two-month long COVID-19 lockdown in the city (Topic 5). Many users from Shanghai argued that the feature helped them distinguish authentic Shanghai users whom they could directly communicate with during those challenging times, hence building a sense of community amongst the users. This finding is in line with what Miyabe et al. [41] found about Twitter users' behaviour in disaster areas during the Great East Japan Earthquake. Generally, individuals in the disaster area preferred to directly communicate with each other as they would be more empathetic towards their current situation. Nevertheless, one can argue that an opt-in approach for such situations would be preferred over a platform-wide implementation that may yield benefits in specific situations.

The sensitivity of geolocation information seems to have expanded the gap between users from different provinces, expressed by their opposing points of view. However, more importantly, it amplifies the risk of discrimination on social media platform discussions, solely on the basis of geographical location [45]. Location disclosure creates a path for discrimination to be extended to the virtual world if it exists in the physical world. As such, social media platforms should be aware of these scenarios in order to be able to effectively and proactively tackle the propagation of geographical discrimination. Platforms could selectively display location information when it is deemed beneficial, such as during the Shanghai COVID-19 lockdown (Section 5.1), when online social bonding may be enhanced. Conversely, a platform could automatically identify posts/comments that can potentially lead to instances of geographic discrimination, and subsequently hide location information or alert the user.

### 5.2 Erosion of User Self-Presentation

Social media platforms should also be aware of the potential impact of displaying the location information with regards to user self-presentation. For instance, our data highlighted an intended disconnect between users' online personas and their real personas (Topic 4), similar to Goffman's concept of the public and private persona in the dramaturgical lens of human behaviour [22]. People use social media to share views, information, jokes, etc., beyond that which they would feel comfortable sharing in person, whether maliciously or idealised [26]. As such, their online identity is not a virtual manifestation of themselves and exists only on the platform. As a result of this, tagging this virtual persona with a physical location seems nonsensical to those users. This could, for example, lead to a preference for some 'online-only' tag for a user's location. In reality, however, it is still likely that the user's physical location and context informs their online persona, whether intentionally or not, so there may yet be useful information in providing that coarse physical location.

As suggested in previous research [14], exploring users' performative selves is important as it shows they adjust their presentation when engaging with locative media. Further exploring this relationship between online-only personas and the physical location of their creator remains an interesting avenue for future work.

### 5.3 Privacy Concerns on Social Media Behaviour

One interesting aspect we noticed is that people who have a more polarized view of this new platform feature tend to be more active on social media than people who have moderate views. This implies people with extreme views tend to be more passionate about their beliefs and are more likely to use social media to express their opinions and engage with like-minded or opposite people.

Our results also provide evidence regarding the relationship between privacy concerns and users' online behaviour in social networks. We found that the group of people who expressed strong concerns about coarse location privacy changed their posting behaviour by significantly reducing the number of their original posts and reposts in the first month after the implementation of the feature. Prior literature shows that the ability to express oneself is the main factor that influences both increase in time spent on Sina Weibo and in posting behaviour [67]. Nevertheless, our findings demonstrate that the concerns related to the visibility of geographical location will inhibit both self-expression and interactivity, leading to reduced activity within the platform.

Furthermore, many previous studies described the "privacy paradox" in social media, namely the discordance between attitudes and behaviour [47, 52, 57]. In line with previous studies, our results show that the location privacy paradox was present within the objector group. However, we note that they substantially increased their activity during the violent attack incident that happened in a restaurant in Tangshan. In addition, Sina Weibo is by far the biggest microblogging system in China, and other similar microblogging services (e.g., Tencent Weibo, NetEase Weibo, and Sohu Weibo) have ceased operation in the past few years. Consequently, it is challenging for users to switch to a different platform, which could also contribute towards disgruntled users eventually coming back to Sina Weibo.

### 5.4 Fair Enforcement of Social Media Platform Policies

Social media platforms provide a crucial means of communication between celebrities/influencers and their fans [27]. It also helps fans to build a closer relationship with their favourite celebrities by having access to more content regarding the celebrities' personal lives [27]. The launch of the coarse location display feature on Weibo led to many discussions regarding displaying the locations of celebrities (Topic 6). On the one hand, if fans discover that the celebrities' locations on social media do not match their actual locations, it becomes clear to them that the account is managed by third-party agencies. This might reduce fans' loyalty and interaction with the celebrity, as fans feel closer to the celebrity when they are able to interact with them directly (e.g., commenting their posts) [31].

Interestingly, in the initial days of the launch of this feature, Weibo did not reveal coarse location of celebrities and influencers. However, this led to heated debates among netizens indicating that the public had a strong desire for equality in the online community, and a waning tolerance for preferential treatment that is typically given to celebrities and influencers. These discussions offer valuable lessons regarding the fairness in implementing functions across different types of users. Given a long-standing debate of online communities matching up the standards of real communities, fair application of policies across an entire online community is the basic requirement that social media platforms should strive to provide to their users.

### 5.5 Limitations & Future Work

We acknowledge several limitations in our study. First, due to restrictions in Weibo's API, we were unable to collect the number of comments made by individual users in addition to the number of posts/reposts for our behavioural analysis. This new feature displays users' coarse location not only on the personal homepage but also from comments. Therefore, we lacked an additional indicator to measure user engagement before and after the implementation of the feature. Furthermore, our behavioural analysis is limited to a period of four months (2 months prior- or post-implementation of the feature). However, due to a commonly used Weibo feature that allows users to hide posts older than six months, we were unable to reliably collect older historical data, thus settling for a time period that would yield more robust data.

In future work, researchers could conduct user studies to gather additional insights into how users perceive the implementation of this feature and what they consider to be the way forward in this space.

## 6 Conclusion

In this paper, we present a comprehensive sentiment and opinion extraction analysis related to users' attitudes toward displaying their coarse location on a social media platform, using large-scale data from Sina Weibo. We found that the majority of users hold negative sentiments towards this feature with substantial privacy concerns, and revealed a potential risk of amplifying geographical discrimination and doxing. Moreover, our findings suggest that those users who voiced their disapproval about this feature decreased their activity on Weibo. Through data collection from a naturalistic environment and data analysis based on organic attitudes and opinions of real users, we provide a better understanding of social media users' attitudes toward location privacy, the impact of location visibility's on user engagement, and user sentiment towards fair enforcement of social media platform policies. We hope that our results can inform the development of novel technology that can help promote a more connected online community while respecting users' privacy and autonomy.

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