Covid-19 increased collectivistic expression on Sina Weibo

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***Abstract*—parasite disease theory of collectivism contends that inhabitants in regions with high prevalence of infectious diseases would adopt collectivism than those in regions with low prevalence in the long-term. It is not clear whether or not outbreak of infectious disease one time would elevate collectivism. Here using millions of Sina Weibo active users' posts from January 20th, 2020 to February 16th, 2020, we constructed indicators of individualism and collectivism independently and found that the outbreak of COVID-19 increase collectivism and decrease individualism. Its theoretical contributions and implications to cultural psychology and big data are also discussed.**

Keywords— individualism, collectivism, Parasite diseases model, COVID-19, Sina Weibo

I. INTRODUCTION

The coronavirus disease 2019(COVID-19) pandemic is no end in sight. Parasite disease model of collectivism contends that inhabitants would adapt collectivistic values as behavior immune system to cope with the threat of infectious disease[1]. It hints that collectivistic values should be accepted after recurrent of parasite diseases. Will Collectivistic behaviors be elevated after the outbreak of infectious disease? There're seldom empirical evidences in real settings for lack of longitudinal studies which happened to collect data before and after the outbreak of infectious disease. Now along with the popular use of onlin social media, millions of users express their concerns and communicate with their friends in online social media platform with time label. It provides us an opportunity to test explore the relationship between collectivism and parasite disease.

A. Pathogen ecology of individualism/collectivism

individualism/collectivism is the most important cultural dimension to descript and prescript human behavioral differences in social environment. Individualistic culture such as USA embrace autonomy and striving for self-goals and put others as secondary. Collectivistic culture such as China put harmonious relationship with significant others and ingroup members at first and personal achievement as secondary. The attitude and behavior toward ingroup/outgroup members are also different in individualistic/collectivistic cultures. compares with those in individualistic culture, inhabitants in collectivistic cultures tend to make differentiation between ingroup members and outgroup members and treat them differently. For example, inhabitants in collectivistic cultures trust more on ingroup members and reward them more and punish them less compared with outgroup members. But the differentiation between ingroup and outgroup members are not so much in individualistic cultures. What caused individualism/collectivism differences between different cultures or nations or regions? many ecological factors had been explored such as modernity, subsistence system, climate and so on.

Parasite diseases hypothesis holds that individualism/collectivism could be explained by prevalence of parasite diseases in different nations or cultural groups historically and now. Higher prevalence of parasite diseases led to collectivistic culture while lower prevalence of parasite disease individualistic ones. From the evolutionary perspective, parasite diseases were severe threat to inhabitants. To cope with them successfully, inhabitants developed and adapted gradually behavioral strategic toolkit. For example, inhabitants treated strangers or outgroup members as possible infectious sources and rejected to contact with them, punish those ingroup members who did not follow sanctions and so on. At last collectivism was taken for granted to be social norms or rules in higher prevalence of parasite diseases step by step. Fincher and his colleagues has found that the regional prevalence of pathogen has a strong positive correlation with cultural indicators of collectivism and negative correlation with individualism[2, 3]; Pathogen prevalence positively predicts cultural differences in effect sizes that emerge from behavioral conformity experiments and in the percentage of the population who prioritize obedience and negatively predicted indicators of tolerance for nonconformity[4]; Pathogen prevalence positively predicts in family ties and religiosity both cross cultures and within-culture in US[1]. At individual level collectivism could buffer the xenophobia toward strangers when facing threat of Ebola in 2016[5]. These evidences mostly came from correlational studies which was difficult to make causal link. To overcome this shortcoming, pathogen threat was manipulated by pathogen priming and the results showed compared to neutral condition, participants reported higher prejudice toward immigrants which support that pathogen ecology caused collectivism. But there's one questions remained unclear until now. When outbreak of pathogen disease in real settings, people would elevate their collectivistic behavior. The pathogen ecology theory suggested but no empirical evidences. It may be difficult to do longitudinal design to test it for nobody know

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when the parasite disease would come and outbreak to the extent that it activates inhabitants' collectivistic-related behavioral immune system.

B. Online social media

Now millions of people all over the world have their accounts in online social media such as Twitter, Facebook and create big data of behavioral records with time and location labels. Scholars have proved that these datas could be used to predict users' psychological variables. For example, with Facebook users' digital records and their self-report and other-rating big-five personality, users' Facebook likes could predict personality similar with self-report and other-rating results and in some conditions such as likes over 25 more predictive[6]. Culture differences could also be found and constructed on digital records. With 26,847 Facebook users of 49 nations, it was found that users in individualistic cultures had more ego-centric networks (i.e., members of networks were connected via the self) than users in collectivistic cultures[7]. Posts in online social media usually had time label so that human behavior could be recorded and reconstructed along the time. It has advantage to explore the change trends of psychological characters and relation with other factors which was difficult to be done in other methods. For example, with the keywords or events on posts of online social media users, victim of domestic violence and the time when it happened were identified, scholars reconstructed their mental health statuses before and after when domestic violence happened and finally made the causal link between domestic violence and decreased mental health without intrusion of these victims[8].

According to previous research, many words have been constructed to be indicator of individualism and collectivism in big data pool such as Google N-gram database. For example, the first-person singular pronouns "I" as indicator of individualism and first-person plural pronouns "We" indicator of collectivism [9]. Based on these indicators, change trend of individualism/collectivism and its underlying mechanism had been explored [10].

C. China: a natural case

Sina Weibo is popular online social media platform in China which is similar to Twitter in the world. As a leading Chinese OSN, Sina Weibo has 516 million users registered and used. All of their microblogs are publicly available and can be used to reconstruct individuals' psychological traits, such as "mental health status"[8]. Furthermore, indicators of individualism and collectivism in Chinese words had been constructed in Sina Weibo text which includes 53 individualistic and 64 collectivistic words [1]. And these indicators got evidences from regional comparison in China [11].

Covid-19 at first outbroke in Wuhan, China in January 20th. At that time it had not been pandemic all over the world which is no doubt infectious disease. Whatever before and during COVID-19 phrase, Sina Weibo users posted lots of posts to express their feelings and behaviors on this platform. It gives us opportunity to test whether or not outbreak of COVID-19 would elevate collectivism.

Overall, our aim is to take the advantage of Sina Weibo platform to explore its effect on individualism and collectivism directly. The main hypothesis of our study is that compared with before outbreak phrase, people would be less individualistic and high collectivistic during-COVID-19 phrase.

II. DATA AND METHOD

A. Data collection

The present work is based on microblog of Sina Weibo active users for text analysis. We first sampled the active users from the original Weibo data pool (L. Li, Li, Hao, Guan, & Zhu, 2014). It should be noted that active users are defined as (1)10 or more original microblogs published in the above period, (2)the authentication type of them is non-institutional (such as individual user, etc.), and the regional authentication of them is not empty and not overseas or Hong Kong, Macao and Taiwan. Finally, 126,165 active users (94436 men, 31729 women; median age=29) were selected from 1.16 million Weibo users of 31 provincial administrative regions in mainland China. Then we fetched all their original posts published during December 1st, 2019 to February 16th, 2020 for the analysis.

B. Word selection

The present work counted the word frequency of some individualistic and collectivistic related words form active users' original posts. The word selection methods are as follows: (1) Based on previous research, they were constructed to be related to individualism and collectivism. Such as first-person singular and plural pronouns [12, 13], economic priorities and personal possessions words [13]. (2) this word pool had been verified to reflect regional differences of individualism and collectivism in China mainland [11].

III. RESULTS

In this study, the Text Mind system developed by the Computational Cyber-Psychology Lab of the Institute of Psychology, Chinese Academy of Sciences was used to extract text features [14]. The Chinese word segmentation embedded in Text Mind system can divide the text into independent words with linguistic characteristics according to Chinese grammar rules, so as to achieve the purpose of analyzing word frequency finally through the computer. In order to control the impact of daily total word counts changes, we got the word count of each word based on the psychoanalysis dictionary, and then calculated the ratio of the number of each word to the total number of each day. Then we divided whole time window into two phrase by January 20th on which National Health Commission of China identified COVID-19 as a B type infectious disease officially on January 20th (China, 2020a), Phrase One which was from December 1st was named before-COVID-19 and Phrase Two which was from January 20th, 2020 to February 16th, 2020 During - COVID-19.

Following this procedure individualism and collectivism were calculated separately. Then we transformed the raw score of individualism and collectivism multiple 100 to make it easily understood.

[1] These word pool could be got from corresponding author.

The change trend of I-C of these two phrases were showed in Fig. 1. Overall, individualism was higher (M = 0.731) than collectivism (M = 0.299). the score of individualism (M = 0.257) and collectivism (M = 0.126) on February 10th, 2020 were extremely low than the other days and deviant from the range of mean minus three standard deviations(M±3SD). We delete this day in the following before-and during-COVID-19 comparison.

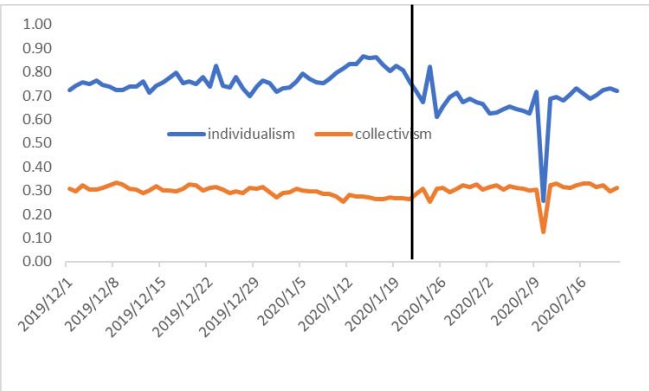

Fig. 1 change trend of Individualism and Collectivism before- and during-COVID-19 Phrase

Note: black line was the day of outbreak of COVID-19

Then the scores of I-C were submitted to a 2(value: individualism vs collectivism) X 2 (phase: before-COVID-19 vs during-COVID-19) repeated ANOVA. Value was considered as within-subject factor and phase as between-subject factor. The interaction effect of value and phase was significant, $F_{(1,80)} = 57.107$, $p < 0.001$, $\eta_p^2 = 0.417$. For individualism, independent t-test showed that individualism decreased after the outbreak of COVID-19, $t_{(1,80)} = 6.644$, $p < 0.001$, Cohen's d = 1.95. individualism in before-COVID-19 phrase (M = 0.768, SD = 0.041) was higher than during-COVID-19 phrase (M = 0.674, SD = 0.088). For collectivism, independent t-test showed that collectivism increased after the outbreak of COVID-19, $t_{(1,80)} = -3.185$, $p = 0.002$, Cohen's d = -0.72. collectivism in before-COVID-19 phrase (M = 0.296, SD = 0.019) was lower than during-COVID-19 phrase (M = 0.309, SD = 0.017).

IV. DISCUSSION

The present research found that outbreak of COVID-19 increased collectivism and decreased individualism. Sina Weibo users tended to use more collectivistic and less individualistic words during COVID-19 phrase than before COVID-19 phrase. it implied that people would activate collectivistic behavior to cope with the threat of COVID-19. When facing COVID-19, Government adopted rapidly many sanctions and policies such as quarantine of Wuhan city which transmitted a strong information that COVID-19 was very severe infectious disease[15]. It would make most of Chinese scared enough to use kinds of strategies to protest themselves far away from threat. Collectivistic behaviors would be reinforced. For example, keeping social distance and wearing masks and communicating more helpful tips with ingroup members. While at the same time, individualistic behaviors would be inhibited too. These findings made various theoretical implications.

A. *Pathogen ecology of collectivism*

First, our findings provide more evidences on pathogen ecology of collectivism [2]. Parasite disease model of collectivism contends that collectivism was developed as behavioral immune system to cope with the threat of infectious diseases [1]. It has been supported by evidences from worldwide cross-cultural correlational researches and experimental priming researches[1, 4]. But there's gap between them. As we know, this theory implied that behavioral immune system should be got gradually from recurrent of infectious diseases in prolonged time. What will collectivism elevate if infectious diseases outbreak once? Our results shed light on this gap to enrich pathogen ecology of collectivism.

B. *Advantage of online social media in psychology*

Second, our findings enrich the benefit of online social media. Previous studies in computational social sciences has found that digital records and profiles of users in online social media could be used to predict various psychological attributes such as life satisfactions and personality[6, 16]. Our findings extend its scope that individualism and collectivism could also be constructed. Furthermore, time labels of posts in online social media give the unique advantage to explore the effect of natural and social events on people's psychology and behaviors.

C. *Limitations*

Before closing, it is warranted to discuss some limitations of our findings. In our study, individualism scored higher than collectivism which is opposite to the previous studies. China has been taken for granted to be a collectivistic culture which means collectivism should be higher than individualism [17]. This inconsistency could be explained by the bias of online social media. Users probably are inclined to express more individualistic words in this kind of platform compared to traditional context. Furthermore, for example, Ren and his colleagues also found collectivism scored higher than individualism in Sina Weibo users[11]. Second, we did not include more days during COVID-19 phrase. what will it happen if more days included this change trend of individualism and collectivism? Would this change trend be temporal or permanent? In future it could be tested with more days included. Third, this finding was from Chinese and the Sina Weibo were mainly used by Chinese. Would this change trend be culture-universal or culture-specific? As COVID-19 worldwide pandemic, it could be done in other worldwide platform such as Twitter to test it.

V. CONCLUSION

Overall, we found when facing the threat of COVID-19, Chinese would increase collectivism and decrease individualism. Our findings support pathogen ecology of collectivism to the extent that even once outbreak of severe infectious disease collectivism would also be elevated.

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SARS-CoV-2 increased collectivistic expressions in People's Daily[1]

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***Abstract*—The aim of this paper was to further examine the parasite disease ecology of collectivism from longitudinal perspective. We used articles published in People's Daily of China between 2019 and 2020, and divided them into three stages, i.e., before, during and after SARS-CoV-2. It was found that collectivism was higher and individualism was lower during SARS-CoV-2 stage compared to before and during SARS-CoV-2 stages. These findings deepen the parasite-stress theory of collectivism from longitudinal perspective. The theoretical contribution toward ecological antecedents of collectivism and computational social psychology were also discussed.**

***Keywords*—collectivism, SARS-CoV-2, parasite-stress theory, People's Daily**

I. INTRODUCTION

Previous study found that outbreak of SARS-CoV-2 increased collectivism and decreased individualism on online social media [1]. Nonetheless, that study only drew conclusions from data collected on online social media, leaving it unclear whether these finding would still hold true for traditional media with more sanctions. Also, the outbreak of SARS-CoV-2 occurred concurrently during the Spring Festival, which also generated more collectivistic expressions. Thus, it is hard to judge whether the increase in collectivism and decrease in individualism resulted from the outbreak of SARS-CoV-2 or the Spring Festival or both. Finally, it is not clear whether or not collectivism expressions would fall back to normal as before. In order to clarify the aforementioned questions, we explored the relationship between SARS-CoV-2 and collectivism by using Chinese newspaper - People's Daily.

A. Parasite-stress theory of collectivism/individualism

Inhabitants from different continents or nations or regions differ from each other in their attitudes or behaviors towards in-group/outgroup members. Compared with their counterparts from individualistic cultures, inhabitants from collectivistic cultures are more ingroup favorite, patriotic, familism, ingroup assortative sociality and xenophobia [2].

Parasite-stress theory contends that prevalent rates of parasitic diseases such as malaria lead to increased collectivism. Collectivism could be a by-product of behavioral immune systems evoked to adapt to the parasite disease threat of environment. In regions with higher prevalence of infectious diseases, inhabitants are more prone to develop collectivistic values such as in-group favoritism or out-group exclusion as outgroup members are more likely to carry new pathogens, which inhabitants cannot resist or defense although they don't know the scientific mechanism of infectious disease. Numerous correlational studies between parasite-disease prevalence and various indicators of collectivism such as in-group favoritism, patriotism, familyism and similar have provided support for parasite-stress theory while controlling for other confounding factors such as GDP per capita and language and population density [2].

However, there is a lack of longitudinal empirical evidence on whether the outbreak of infectious disease would increase collectivism in one region or nation. Using Sina Weibo, a popular social media outlet in China, two studies have reported that the outbreak of parasitic diseases such as SARS-CoV-2 would increase collectivism and decrease individualism [1, 3]. Nonetheless, it remained unclear whether the same findings would be obtained with the use of different databases such as traditional media; and whether the levels of collectivism would remain high after the SARS-CoV-2 is successfully controlled, or they would return to levels before the outbreak. Furthermore, outbreak of SARS-CoV-2 in China occurred concurrently with the Spring Festival in 2020, which could also temporally promote collectivism; however, it was not controlled by previous studies. Consequently, further studies are needed to judge the relationship between parasite-stress and collectivism from the longitudinal perspective.

B. People's Daily

Along with the rising of computational social science and accessibility of online social media and Google N-Gram Database, traditional media have also been used to explore the changes in collectivism trends. For example, in their study, Liu et al. used the personal pronoun "we" (in Chinese character, "我们") as indicator of collectivism to explore the changing trends in collectivism in traditional media database between 1949 and 2010 [4].

Newspaper has always been the major carrier of mass communication, mainly carrying news and commentary that promoted the formation of social opinion. People's Daily is subordinated to the Central Committee of the Communist Party of China. It is distributed throughout China and in 132

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countries and regions around the world. As the most authoritative and widely circulated newspaper in China, People's Daily has been rated by UNESCO as one of the top 10 major newspapers around the world. People's Daily reports important events and communicates news and policies domestically and internationally. It is issued on a daily basis, and as such it is a valuable to record of the changing trends of many of social attitudes. Furthermore, the database of People's Daily is opened and easily accessible.

Compared with online social media, such as Sina Weibo, content in People' Daily is more regulated and sanctioned, which suggests that public opinion is less fluctuated in People's Daily than in Sina Weibo. It would be more robust if the trend of collectivism would be similar in both online social media and traditional media.

C. China: a natural case

Although SARS-CoV-2 has defined as a global pandemic, the severity of SARS-CoV-2 tends to drastically vary. Unlike in the other nations, which are still coping with thousands of new cases, the disease has been well controlled since May 15th, 2020. This indicates that China has experienced the different stages of SARS-CoV-2, which could be defined as before the SARS-CoV-2 stage, during SARS-CoV-2 stage and after SARS-CoV-2 stage. This gives us the opportunity to explore the changing trends of collectivism and the effect of SARS-CoV-2 on these trends.

In summary, the aim of this study was to examine the effect of SARS-CoV-2 on collectivism using People's Daily database. We assumed that the use of collectivistic words would be increased during SARS-CoV-2 stage compared with before SARS-CoV-2 stage, after which it would decrease in the after SARS-CoV-2 stage regardless of the effect of Spring Festival on the collectivism. Also, the use of individualistic words would decrease during SARS-CoV-2 stage compared with before SARS-CoV-2 stage, after which it would increase after SARS-CoV-2 regardless of the effect of Spring Festival on the collectivism.

II. DATA AND METHOD

A. Data collection

Two time points were used to segment three stages, which included before, during and after SARS-CoV-2 to explore the effect of SARS-CoV-2 on individualism and collectivism. January 20th, 2020 was used as cut-off point between before and during SARS-CoV-2 stage as SARS-CoV-2 was officially identified as a type B infectious disease on January 20, 2020 and three days later Wuhan was announced to be officially locked down. April 15th, 2020 was used as cut-off point between during and after SARS-CoV-2 stage as confirmed death cases decreased to zero on this day and lockdown of Wuhan ended one week before that.

Next, during SARS-CoV-2 stage was defined as a time period between January 20th and April 15th, 2020 which included 84 days. Next, same days were selected for before and after stages. As is well known, it is hard to judge which day near the cut-off point belonged to which stage as the disease had latent period and different resources list the different dates as the exact day of outbreak of SARS-CoV-2. To control for the potential obscure period, one month between different stages was excluded. Next, before SARS-CoV-2 stage was selected as time period from September 20th, 2019 to December 15th, 2019 and after SARS-CoV-2 stage from May 20th, 2020 to August 15th, 2020.

When three stages were defined, all People's Daily corpus during different stages was used to calculate the frequency of collectivism and individualism.

B. Word selection

Following Hamamura and Xu[5] and Zeng et al. [2], 17 individualistic and collectivistic words were selected. Individualistic words included: I(我), choose(选择), select(挑选), compete(竞争), race(竞赛), get(获得), acquire(获取), private(私人), personal(私家), freedom(自由), autonomy(自主), talent(天赋), flair(天份), reform(改革), innovation(创新), fairness(公平) and justice(公正). Collectivistic words included: we(我们), responsibility(责任), obligation(义务), distribution(分配), assignment(分派), payment(付出), giving(给予), public(公家), common(共同), obedience(服从), compliance(遵守), effort(努力), hardwork(刻苦), support(支援), help(帮助), sacrifice(牺牲) and devotion(奉献).

III. RESULTS

People's Daily corpus, which was used in the present study, included all the texts during 1949-2020 with time lag(day). The Text Mind system developed by the Computational Cyber-Psychology Lab of the Institute of Psychology, Chinese Academy of Sciences was used to extract text features [7]. The Chinese word segmentation embedded in Text Mind system can divide the text into independent words with linguistic characteristics according to Chinese grammar rules, so as to achieve the purpose of analyzing word frequency using the computer. Finally over 5 billion bytes corpus were obtained. In order to control the impact of daily total word counts changes, we obtained the word count for each word based on the People's Daily and then calculated the ratio of the number of each word to the total number of each day. Raw score of collectivism/individualism was the frequency of collectivism/individualism words divided by all the words per day separately. Also, they were transformed by being multiplied by 100 so as to be more easily understood. The change trend of collectivism/individualism is shown in Figure 1.

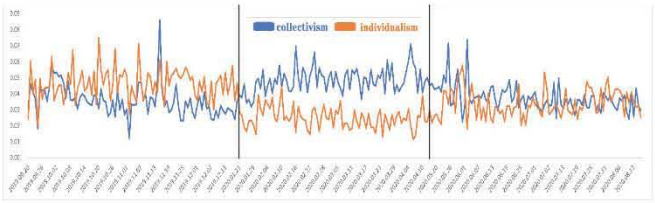

Fig. 1 change trend of collectivism/individualism words along with SARS-CoV-2

Note: left line is the day of outbreak of SARS-CoV-2 and right black line is the day SARS-CoV-2 well-controlled.

Table 1 descriptive statistics of collectivism/individualism at different stages

	before(M ± SD)	during(M ± SD)	after(M ± SD)	F	P
Collectivism	.036 ± 0.01	.048 ± 0.01	.037 ± 0.01	44.903	0.000
Individualism	.046 ± 0.01	.026 ± 0.01	.034 ± 0.01	121.98	0.000

Note: N = 262. Before stands for before SARS-CoV-2 stage, during stands for during SARS-CoV-2 stage and after stands for after SARS-CoV-2 stage.2

To examine the effect of SARS-CoV-2 on collectivism, we conducted a repeated measure ANOVA with collectivism/individualism as within-subject variable and stage as between-subject variable. The main effect of collectivism/individualism was significant, $F(1,259)=39.604$, $P<0.001$, $\eta^2=0.133$. Collectivism ($M_{collectivism}=.040$, $SD_{collectivism}=.01$) was higher than individualism ($M_{individualism}=.035$, $SD_{individualism}=.01$). The main effect of stage was significant; $F(2,259)=20.205$, $P<0.001$, $\eta^2=0.135$. The interaction of collectivism/individualism and stage was significant too; $F(2,259)=100.088$, $P<0.001$, $\eta^2=0.520$. Next, we separately analyzed the collectivism and individualism to explore the effect of SARS-CoV-2 on them.

Initially, the main effect of SARS-CoV-2 on collectivism was significant; $F(2,259)=44.903$, $P<0.05$, $\eta^2=0.257$. Simple effects tests by LSD showed that collectivism was higher during SARS-CoV-2 stage ($M_{during}=.048$, $SD_{during}=.01$) than before SARS-CoV-2 stage ($M_{before}=.036$, $SD_{before}=.01$), $p<.001$, 95% CI [-.014,-.009]. Also, it was higher than after SARS-CoV-2 stage ($M_{after}=.037$, $SD_{after}=.01$), $p<.001$, 95% CI [.008, .013] (table1), while there was no significant difference on collectivism between before SARS-CoV-2 stage and after SARS-CoV-2 stage, $p=0.324$, 95% CI [-.004,.001].

Second, the main effect of SARS-CoV-2 on individualism was significant; $F(2,259)=121.981$, $P<0.05$, $\eta^2=0.485$. Simple effects tests by LSD showed that individualism was lower during SARS-CoV-2 stage ($M_{during}=.026$, $SD_{during}=.01$) than before SARS-CoV-2 stage ($M_{before}=.046$, $SD_{before}=.01$), $p<.001$, 95% CI [.018, .023]. It was also lower than after SARS-CoV-2 stage ($M_{after}=.034$, $SD_{after}=.01$), $p<.001$, 95% CI [-.011, -.006]. Furthermore, individualism was lower after SARS-CoV-2 stage than before SARS-CoV-2 stage, $P<.001$, 95% CI [.01, .015] (table1). Our results showed that SARS-CoV-2 could increase collectivism and decrease individualism. Also, these effects decreased to the normal as before when SARS-CoV-2 was well-controlled.

Furthermore, to control for the confounding effect of Chinese Lunar New Year, we redefined the during SARS-CoV-2 stage by deleting data between January 20th, 2020 to February 8th, 2020.

To examine the effect of SARS-CoV-2 on collectivism, we conducted a repeated measure ANOVA with collectivism/individualism as within-subject variable and stage as between-subject variable. The main effect of collectivism/individualism was significant; $F(1,239)=52.672$, $P<0.001$, $\eta^2=0.181$. Collectivism ($M_{collectivism}=.040$, $SD_{collectivism}=.01$) was higher than individualism ($M_{individualism}=.036$, $SD_{individualism}=.01$). The main effect of stage was significant; $F(2,239)=18.226$, $P<0.001$, $\eta^2=0.132$. The interaction of collectivism/individualism and stage was significant too; $F(2,259)=137.292$, $P<0.001$, $\eta^2=0.535$. Next, we separately analyzed collectivism and individualism to explore the effect of SARS-CoV-2 on them.

Table 2 Descriptive statistics of collectivism/individualism at different stages

	before(M ± SD)	during(M ± SD)	after(M ± SD)	F	P
Collectivism	.036±0.01	.050±0.01	.037±0.01	44.698	0.000
Individualism	.046±0.01	.025±0.01	.034±0.01	112.31	0.000

Note: N = 242. Before stands for before SARS-CoV-2 stage, during stands for during SARS-CoV-2 stage and after stands for after SARS-CoV-2 stage. N stands for number of days included.

Initially, the main effect of SARS-CoV-2 on collectivism was significant; $F(2,239)=44.698$, $p<0.05$, $\eta^2=0.272$. Simple effects tests by LSD showed that collectivism was higher during SARS-CoV-2 stage ($M_{during}=.050$, $SD_{during}=.01$) than before SARS-CoV-2 stage($M_{before}=.036$, $SD_{before}=.01$), $p<.001$, 95% CI [-.016,-.01]. It was also higher than after SARS-CoV-2 stage ($M_{after}=.037$, $SD_{after}=.01$), $p<.001$, 95% CI [.009, .015]; however, there was no significant difference on collectivism between before SARS-CoV-2 stage and after SARS-CoV-2 stage, $p=.0.453$,95% CI [-.004,.002] (Table2).

Second, the main effect of SARS-CoV-2 on individualism was significant; $F(2,239)=112.314$, $P<0.05$,$\eta^2=0.485$. Simple effects tests by LSD showed that individualism was lower during SARS-CoV-2 stage ($M_{during}=.025$, $SD_{during}=.01$) than before SARS-CoV-2 stage ($M_{before}=.046$, $SD_{before}=.01$); $P<.05$, 95% CI [.019, .025]. It was also lower than after SARS-CoV-2 stage ($M_{after}=.034$, $SD_{after}=.01$), $p<0.001$, 95% CI [- .012, - .006]. Moreover, individualism was lower after SARS-CoV-2 stage than before SARS-CoV-2 stage, $p<.001$, 95% CI [.01, .015] (Table2). These results showed that SARS-CoV-2 would increase collectivism and decrease individualism, and that these effects would decrease back to the normal as before when controlling for SARS-CoV-2 and Spring Festival.

IV. DISCUSSION

Our results revealed that outbreak of major infectious disease such as SARS-CoV-2 would evoke the use of more collectivistic and less individualistic expressions in traditional media platforms. The effect of infectious disease was robust and was not likely to be led by other confounding factor such as Chinese Lunar New Year that was controlled for in this study.

A. Parasite stress theory of collectivism

Our results shed light on the parasite-stress theory of collectivism from longitudinal perspective. Previous evidence mostly came from cross-cultural comparisons between collectivism and prevalence of parasite-stress. For example, Fincher and his colleagues have found that the prevalence of historical and contemporary parasite-stress could positively predict collectivism and negatively individualism ~~of various resources~~ [2,8,9]. However, the ecological factors, which led to cross-cultural collectivism, may not be the same as those that led to longitudinal changes of collectivism [10]. In their study, Ren and his colleagues used Sina Weibo to prove that the outbreak of severe parasitic disease could also increase collectivistic and decrease individualistic use of expressions in social media [1,3]. Our results further supported their findings in relation to the traditional media. We also furthered the parasite-stress theory from longitudinal perspective. Initially, we observed longer time periods and more stages along with SARS-CoV-2. When SARS-CoV-2 was well-controlled, which means the threat decreased to the extent that could not have obvious effect on life, the use of collectivistic/individualistic expressions in the media returned back to the normal. This implied that collectivistic value as behavioral strategy did not easily change in view of ecological threat. This effect would probably occur following the prolonged or chronical reaction toward these threats. One or two outbreaks of pathogen disease could not lead to lasting elevation of collectivism. Secondly, unlike online social media, traditional media have more regulations on words used. For example, the use of obscene and swear words, which

could express extreme emotions, is prohibited in traditional media; however, these expressions are probably used in online social media. Also, unlike social media, traditional media have exact time label of the content distribution, which could be easily to be divided into different stages. These differences suggested that traditional media such as People's Daily would be less sensitive than social media toward public affairs. Thirdly, it is possible that Chinese Lunar has some effect on collectivism, which was not controlled by previous study. Nonetheless, our results revealed that the parasite stress still had effect on collectivism, even when controlling for the effect of Chinese Lunar Year. Our findings support the premise that parasite disease threat would temporarily elevate collectivism, at least during the severe stage. From the longitudinal perspective, parasite-stress would enhance collectivistic expression, particularly during the period when the disease was out of control.

B. Broaden the database of computational social psychology

Our research contributes to computational social sciences. Although computational sociology originated from Google N-gram database and online social media, more and more resources are being used to examine sociological theories. Here, People' Daily was used to further the parasite theory of collectivism from longitudinal perspective. The advantage of traditional media is in their longitudinal relationship between social psychological variables and their antecedents. Compared with social media and books, traditional media have refined time label, which makes it easier to explore the causal-link between different variables. Also, due to greater regulations on the usage of words, the changes in trends are more difficult to found and more persuasive. Furthermore, to control the confounding effect of Chinese Lunar New Year, we redefined the during SARS-CoV-2 stage by deleting data between January 20th, 2020 and February 8th, 2020.

C. Limitations

The present study has a few limitations that should be addressed. At first, our findings were based on Chinese cultural setting, thus it remains unclear if these findings are culture-free or cultural-specific. As stated before, the severity of SARS-CoV-2 varied globally. This issue could be tested by using other social media platform such as Twitter in future. Second, parasitic diseases are only one kind of ecological threat human-beings have to deal with. It remains unclear whether other ecological threats such as earthquake would have similar effect on collectivism or other cultural values. It could be examined using traditional media for it has recorded such kind of public affairs and inhabitants' emotional and behavioral reactions toward them. It sounds reasonable theoretically. Thirdly, there are lots of daily newspapers in China, which are published by central government and local governments. Previous studies reported regional differences on collectivism [11]. Further studies should investigate different traditional media from different provinces in China, especially those traditional media from southern provinces. Fourthly, there are differences on rules and words used in traditional and online social media. Future studies should investigate if both kinds of media showed the same trend or vary depending on different domain. Fifthly, our study period was segmented in three stages. Nonetheless, it needs to be acknowledged that there were new confirmed cases even in after- SARS-CoV-2 stage. However, as the number of new cases was very small in this period, reaching about 20 or so per day, we believe that it could not have notable effect on our findings. Sixthly, it probably exists the lag or delay effect between the process of SARS-CoV-2 and collectivism. Seventhly, as two months between different stages were excluded in this study, it remains unclear whether these findings would be robust if they were included. We have also reanalyzed the results by including these two months, finding no changes. However, it remains to be explored whether they should be excluded or not. Future studies should address the above listed questions.

CONCLUSION

In general, we found that collectivism increased and individualism decreased during SARS-CoV-2 stage compared with before and after SARS-CoV-2 stages. Our findings supported that parasite-stress would evoke collectivism from longitudinal perspective, at least during the period when these kinds of threat were not well controlled.

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SARS-CoV-2 outbreak uplifted collectivistic expression in the Hubei Daily

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***Abstract*—Following the outbreak of SARS-CoV-2, collectivistic words have been used more frequently on Sina Weibo and the People's Daily. However, the studies on Sina Weibo and the People's Daily can only reflect the overall impact by SARS-CoV-2 in China. To examine the influence of SARS-CoV-2 on collectivism/individualism, we first investigated the Hubei Daily, an authoritative local media in Hubei, the first province to discover SARS-CoV-2, to see the impact of SARS-CoV-2 on collectivism/individualism. We analyzed data from the Hubei Daily, using the same collectivistic/individualistic words identified in prior studies and found that the outbreak of SARS-CoV-2 increased collectivism and decreased individualism significantly. Next, we analyzed the same data using the individualistic/collectivistic word bank created in a different cross-culture study based on Sina Weibo posts. The results showed that, during the SARS-CoV-2, collectivistic words were used more frequently; no significant changes were seen regarding individualist words. Lastly, we created a COVID-19 word bank and conducted a regression analysis to examine the relationship between collectivistic word frequency and COVID-19 word frequency in the after-breakout period of SARS-CoV-2 and found that the severity of SARS-CoV-2 predicted collectivist word frequency change in the Hubei Daily.**

Keywords—Collectivism, Individualism, SARS-CoV-2, COVID-19, Hubei Daily, Pathogen Prevalence Theory

I. INTRODUCTION

Previous studies using data from the People's Daily [1], an authoritative traditional Chinese media outlet, and Sina Weibo [2], a popular social media site in China, have shown that the collectivistic word frequency increased while individualistic word frequency decreased during the COVID-19 pandemic (coronavirus disease caused by SARS-CoV-2, named by the International Committee on Taxonomy of Viruses). The results indicate that the onset of the pandemic increased collectivism and decreased individualism. The results also verify the pathogen prevalence theory from a longitudinal perspective based on both Chinese individual user data and Chinese central media data. In light of these reports, we asked ourselves, "Can we get the same result from Chinese local media data?"

Researchers in an earlier study based on the data from the People's Daily created a collectivistic/individualistic word bank [1] to represent people's collectivistic/individualistic psychological tendencies. However, it is not yet known if the same results would be found using a different word bank created based on cross-culture research [2].

After the outbreak of SARS-CoV-2, the Word Health Organization (WHO) and the International Committee on Taxonomy of Viruses (ICTV) announced new names. We used eight of the officially identified English and Chinese words related to COVID-19 to answer two questions: What changes would the COVID-19 word frequency show during and following the COVID-19 pandemic? Would such changes correlate with the collectivistic words?

To answer these questions, we analyzed online articles from the Hubei Daily and proposed two hypotheses: i) Collectivistic expression in Hubei Daily will increase during the COVID-19 pandemic. ii) Following the outbreak of SARS-CoV-2, words related to the virus and the disease it caused, positively predict the use of collectivistic words.

A. Pathogen Prevalence Theory

Studies on social culture often take variations in individualism/collectivism as measure. Some scholars believe that individualism/collectivism dimensions "may ultimately prove to be the most important dimension for capturing cultural variation" [3] (p. 189). To study the effect of pathogen prevalence on social culture, a lot of studies on individualism/collectivism change trends during and after pathogen prevalence were conducted. One of the most famous theories is the Pathogen Prevalence Theory which states that pathogen prevalence correlates negatively with individualism but positively with collectivism. The logical basis for this theory is that special psychological mechanisms and behaviors are needed to build anti-pathogen defense function in pathogen-prevalent environments [4]; thereby, these needs are reflected in social culture.

Many researchers tried to verify this theory; Fincher et al. conducted a cross-cultural study to test their proposal that worldwide variations in pathogen prevalence can predict

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societal tendencies toward individualism/collectivism; their findings validated the premise[4]. In another study, Cashdan et al. showed that cultures in high pathogen areas are more likely to socialize children toward collectivist values (obedience rather than self-reliance) [5]. This finding supports the hypothesis that pathogens have a promotional effect on collectivistic-value education.

There have also been many studies of how collectivistic/individualistic tendencies are affected by pandemics based on the Chinese social culture. The analysis of content from Sina Weibo, wherein the data reflect the points of view of individuals in China, showed that COVID-19 outbreaks increased collectivism and decreased individualism [6].

It is also meaningful to conduct research based on the language used by traditional local media, such as the newspaper articles written by professional journalists, to express the need to build psychological and behavioral anti-pathogen defense mechanisms. This is because publicity is an important channel through which governments influence the social-cultural atmosphere and promote socio-cultural development. The research based on the content from the People's Daily found that the COVID-19 pandemic promoted collectivistic words used in traditional national media coverage in China. Still, more empirical longitudinal evidence is needed to clarify what impact SARS-CoV-2 had on relatively small regions at the local level (e.g., in a province or city), because we cannot see this from the People's Daily.

B. COVID-19 Pandemic and the Defense of Wuhan

The COVID-19 is a global pandemic caused by SARS-CoV-2, initially discovered in December 2019 in Wuhan, a city in the Hubei Province in the People's Republic of China. The outbreak quickly spread to many countries throughout the world in early 2020, turning into a global plague described by many international organizations and media as the most severe crisis since World War II. It is also considered one of the most serious public emergencies in history.

As the first to discover the COVID-19 virus, the people of China, especially in Wuhan, Hubei province, experienced a life-and-death test. In the war against the pandemic, the population of the nation united and achieved decisive success in defeating the outbreak in Wuhan within approximately three months. In this war of defense, the promotion of collectivism stimulated efficient social mobilization, organization, and coordination in China's national governance system, and the Chinese people showed cohesion, self-control, and obedience, creating a unique test model [7].

C. Newspaper Selection

As a traditional medium, newspapers play a pivotal role in promoting socio-cultural values. Therefore, a study was conducted to analyze the content of the People's Daily, the official newspaper of the Central Committee of the Communist Party of China. The People's Daily actively promotes the policies and propositions of the party and the government, and reports on the changes in China. Nevertheless, as previously mentioned, the development of collectivism/individualism has regional characteristics. Additionally, pandemic prevention and control of the pandemic spread in China vary depending on the government of the administrative region, for which the local media is the major publicity channel. Thus, research is necessary to determine whether the pathogen prevalence theory can be verified using traditional local media coverage. Due to the particularity of Hu Bei in the COVID-19 pandemic, as mentioned in the previous section, we have chosen Hu Bei as a new region to test the pathogen prevalence theory.

In Hu Bei, Hubei Daily and Chutian Metropolis Daily are the most authoritative and popular newspapers. However, the articles published by the Chutian Metropolis Daily between January 24 and April 7, 2020 are not available online. Therefore, we selected the Hubei Daily, where we could get the entire collection of articles from 2018 onward.

D. Collectivistic/Individualistic/COVID-19 Words' Selection

We first used the word bank constructed during the research on the People's Daily [1] (named word bank A) to measure the collectivistic/individualistic word frequency level. In total, 17 collectivistic words and 17 individualistic words were included in word bank A, which was constructed by extending the word bank obtained from the research on China's cultural evolution over the last 40 years [8].

To validate the influence of SARS-CoV-2 on collectivism/individualism further, we selected a more comprehensive word bank to examine the influence of SARS-CoV-2 on collectivism/individualism (we named it word bank B). Word bank B includes 53 individualistic and 63 collectivistic words, defined by extending Chinese collectivism-/individualism-related words according to the collectivistic-/individualistic word bank which were constructed in historical cross-cultural research [2].

We also selected eight COVID-19 words to study the correlation between collectivism and COVID-19 words. Three of them were obtained from the official names of the virus and the illness, including "SARS-CoV-2," "COVID-19," and "2019-nCov," announced by the World Health Organization and the International Committee on Taxonomy of Viruses; the other five were obtained from the Diagnosis and Treatment Plan for Novel Coronavirus Pneumonia, which were officially used by the Chinese Health Commission to refer to the virus and the pandemic it caused, the five Chinese words were as follows: "新型冠状病毒肺炎," "新冠肺炎," "新型冠状病毒," "新冠病毒" and "冠状病毒."

II. DATA AND METHOD

A. Stage Definition

In the research on the People's Daily, two time-points were used to segment three stages: January 20, 2020 was used as a cut-off point between the before and during stages. On that day, SARS-CoV-2 was officially identified as a type B infectious disease by the Chinese Health Commission, and three days later, Wuhan was officially locked down. April 15, 2020 was used as the cut-off point between the during and after stages, as the confirmed death cases decreased to zero on this day, and the lockdown of Wuhan had ended one week before. Moreover, we skipped one month between stages to control for potentially obscure periods and obtain the same number of days in every stage.

In the research on the Hubei Daily, we followed the definition of the three stages in the research on the People's Daily. For the data with SARS-CoV-2, the timeframe of stage 1 (before SARS-CoV-2) was September 20 through December 15, 2019; the timeframe of stage 2 (during SARS-CoV-2) was January 20 through April 15, 2020; finally, the timeframe of stage 3 (after SARS-CoV-2) was May 20 through August 15, 2020.

While analyzing the data without SARS-CoV-2, we defined three stages of the same period one year ago: stage 1 was defined as the period between September 20 and December 15, 2018; stage 2 was the period between January 20 and April 15, 2019; stage 3 was the period between May 20 and August 15, 2019.

For clarity, we named the period with the effect of SARS-CoV-2 (from September 20, 2019 through August 15, 2020) the "pandemic year;" while the period without the effect of SARS-CoV-2 (from September 20, 2018 through August 15, 2019) is referred to as the "normal year."

B. Measure

We used each day's collectivistic/individualistic/COVID-19 word frequency to measure the level of collectivism/individualism/COVID-19 in the Hubei Daily. We calculated the word frequency of each day as follows: first, we counted the collectivistic/individualistic/COVID-19 words in the articles separately for each day. Considering that the number and length of articles vary each day, we used the total number of collectivistic/individualistic/COVID-19 words divided by the total number of all article words each day to represent the collectivistic/individualistic/COVID-19 word frequency of that day. Also, to understand the word frequency easier, we transformed the values by multiplying them by 100.

C. Data Collection

We made a web crawler to automatically collect the information on the newspaper webpage according to certain rules. It downloads all the titles and article contents of the newspaper and stored the data on a local disk.

We downloaded all articles from the three stages in the pandemic and the normal year. Then, we calculated each day's collectivistic/individualistic word frequency by both word bank A and word bank B and labeled them with stage ID. Thus, we compiled two sets of word-frequency data: those from the 262-day pandemic-year period and the 261-day normal-year period. Since there were two word banks to measure collectivism/individualism level, we used four data sets: normal-year data by word bank A, pandemic-year data by word bank A, normal-year data by word bank B, and pandemic-year data by word bank B.

Additionally, we calculated the COVID-19 word frequency with the same method for the pandemic year.

D. Method

We defined the variable "WithSARsCov2" to distinguish the word frequency data of the pandemic year from that of the normal year. For the normal year, WithSARsCov2 = 0 and for the pandemic year, WithSARsCov2 = 1.

Another variable was "stage," as we identified the date of collectivistic/individualistic word frequency as being in stage 1, stage 2, or stage 3.

The dependent variable was collectivism/individualism, meaning collectivistic/individualistic word frequency.

First, we used word bank A to examine the influence of SARS-CoV-2 on collectivism/individualism on pandemic year data. To exclude the influence of contemporaneous events, we examined the collectivism/individualism change trend for the normal year and compared the change trends between the two years. Afterwards, we repeated the examination using word bank B.

Then, we used the COVID-19 word bank to check the COVID-19 word frequency change trend during and after SARS-CoV-2. To further study the correlation between collectivistic words and COVID-19 words, we ran the regression analysis between the COVID-19 word frequency and collectivistic word frequency by both word bank A and word bank B.

III. RESULTS

A. Result by Word bank A

First, we figured word frequency change trend of pandemic year and normal year got by word bank A.

The collectivistic/individualistic word frequency change trend in the pandemic year got by word bank A, was showed in Fig. 1.

Fig. 1. Change trend of collectivistic/individualistic words along with SARS-CoV-2 (pandemic year, examined by word bank A)

Note: Left black line is the day of outbreak of SARS-CoV-2 and right black line is the day SARS-CoV-2 well-controlled.

The collectivistic/individualistic word frequency change trend in normal year got by word bank A, was showed in Fig. 2. (To better display the trend, we deleted the peak value of March 3rd, 2019. On that day, the Second Session of the Thirteenth National Political Consultative Conference was held in Beijing, and many articles used the word "改革"(reform), which is one of the collectivistic words in word bank A.)

Fig. 2. Change trend of collectivistic/individualistic words in three stages (normal year, examined by word bank A)

Note: Left black line is start of stage 2 and right black line is start of stage 3.

From Fig.1, we can see that during pandemic year, collectivism was higher in stage 2 comparing to stage 1 and stage 3, and individualism was lower in stage 2 than stage 1 and stage 3. However, this difference between the three stages was not significant in Fig.2.

We saw the same trend in the descriptive statistics of collectivism/individualism value at different stages in both pandemic year and normal year. Collectivism was increased in stage 2 and individualism was decreased in stage 2 in pandemic year, but not in normal year. (TABLE I)

TABLE I. DESCRIPTIVE STATISTICS OF COLLECTIVISM/INDIVIDUALISM AT DIFFERENT STAGES IN PANDEMIC YEAR AND NORMAL YEAR (BY WORD BANK A)

Period	Word	Stage 1 (M±SD)	Stage 2 (M±SD)	Stage 3 (M±SD)
Pandemic year	Collectivism	0.44±0.15	0.75±0.18	0.53±0.15
	Individualism	0.60±0.18	0.30±0.10	0.49±0.15
Normal year	Collectivism	0.47±0.14	0.49±0.16	0.51±0.17
	Individualism	0.76±0.21	0.67±0.33	0.66±0.22

Note: N = 523.

We conducted a repeated measure ANOVA with collectivism/individualism as within-subject variable， two variable： WithSARSCov2 and stage as between-subject variables for the two-years' data. The main effect of collectivism/individualism was significant. $F(1,517)=16.94, P<0.05, \eta^2=0.03$. Collectivism ($M_{collectivism}=0.54$, $SD_{collectivism}=0.18$) was lower than Individualism ($M_{individualism}=0.58$, $SD_{individualism}=0.26$). The interaction of collectivism/individualism and WithSARSCov2 and stage was significant. $F(2,517)=50.79, P<0.05, \eta^2=0.16$.

After that, we analyzed the change trend of collectivism and individualism separately to study the main effect of SARS-CoV-2 on them in pandemic year and normal year.

a. collectivism change trend in pandemic year

The main effect of SARS-CoV-2 on collectivism was significant in pandemic year: $F(2,259)=88.52, P<0.05, \eta^2=0.41$. Simple effects tests by LSD showed that collectivism was higher in stage 2 ($M_{stage2}=0.75$, $SD_{stage2}=0.18$) than stage 1 ($M_{stage1}=0.44$, $SD_{stage1}=0.15$) and it was also higher than stage 3 ($M_{stage3}=0.53$, $SD_{stage3}=0.15$). Collectivism was still higher in stage 3 than in stage 1: $p<0.05$.

b. individualism change trend in pandemic year

The main effect of SARS-CoV-2 on individualism was significant in pandemic year: $F(2,259)=90.13, P<0.05, \eta^2=0.41$. Simple effects tests by LSD showed that individualism was lower in stage 2 ($M_{stage2}=0.30$, $SD_{stage2}=0.10$) than stage 1 ($M_{stage1}=0.60$, $SD_{stage1}=0.18$) and it was also lower than stage 3 ($M_{stage3}=0.49$, $SD_{stage3}=0.15$). Individualism is still lower in stage 3 than in stage 1, $p<0.05$.

c. collectivism change trend in normal year

The main effect of SARS-CoV-2 on collectivism was not significant in normal year: $F(2,258)=1.45, P=0.24$.

d. individualism change trend in normal year

The main effect of SARS-CoV-2 on individualism was significant in normal year: $F(2,258)=3.75, P=0.03, \eta^2=0.03$.

Simple effect tested by LSD showed that individualism was higher in stage 1($M_{stagte1}=0.76$, $SD_{stage1}=0.21$) than stage 2 ($M_{stage2}=0.67$, $SD_{stage2}=0.33$) and it was also higher than stage 3 ($M_{stage3}=0.66$, $SD_{stage3}=0.22$). There was no significant difference between mean value of stage 2 and stage 3, $P=0.75$. The higher individualism in stage 1 was caused by other events, we will describe it later.

e. summary of the test result by word bank A

The result by word bank A in pandemic year showed that SARS-CoV-2 increased collectivism and decreased individualism. And the effects last till SARS-CoV-2 was well controlled. However, collectivistic/individualistic word frequency in normal year didn't show the same change trend. This showed that SARS-CoV-2 increased collectivism and decreased individualism significantly when examined by word bank A.

We further studied the reason for the higher individualistic word frequency of stage 1 in normal year and found that 2018 was the year of the 40th anniversary of China reform and opening-up policy. The celebration was held on December 18th, 2018 at 10:00 a.m. in the Great Hall of the People. A lot of reports on this event caused extensive use of the words "改革"(reform) and "创新"(innovation) in articles during stage 1, and these words were included in the list of individualism words of word bank A.

B. Result by Word bank B

We did the same examination with word bank B to see if we can get the same conclusion with that examined by word bank A.

We figured word frequency change trend of pandemic year and normal year by word bank B.

The collectivistic/individualistic word frequency change trend in pandemic year examined by word bank B, was showed in Fig. 3. (To better display the trend, we deleted the peak value of December 14th, 2019. The peak value was caused by an article on the annual inspection of social groups and private non-enterprise units in Hubei, which resulted in the word "湖北" being used more than 1000 times, and meanwhile, "北" is one of the individualistic words in word bank B.)

Fig. 3. Change trend of collectivistic/individualistic words along with SARS-CoV-2 (pandemic year, examined by word bank B)

Note: Left black line is the day of outbreak of SARS-CoV-2 and right black line is the day SARS-CoV-2 well-controlled.

The collectivistic/individualistic word frequency change trend in normal year got by word bank B, was showed in Fig. 4. (To better display the trend, we deleted the peak value of October 30th, 2018. The peak value was caused by an article with the list of "Contract-abiding and Credit-worthy" Enterprises in 2016-2017 in Hubei, which resulted in the word "湖北"(Hubei) being used more than 4000 times, and meanwhile, "北" is one of the individualistic words in word bank B.)

Fig. 4. Change trend of collectivistic/individualistic words in three stages (normal year, examined by word bank B)

Note: Left black line is start of stage 2 and right black line is start of stage 3.

From Fig.3, we saw that collectivism was higher in stage 2 comparing to stage 1 and stage 3. However, this trend was not significant in Fig.4. We do not see significant change in individualism in both pandemic year and normal year.

We saw the same trends in the descriptive statistics of collectivism/individualism values between different stages in pandemic year and normal year. Collectivism was increased in stage 2 in pandemic year, whereas individualism seemed not changed significantly. In normal year, it seemed that neither collectivism nor individualism showed significant change between the three stages. (TABLE II)

TABLE II. DESCRIPTIVE STATISTICS OF COLLECTIVISM/INDIVIDUALISM AT DIFFERENT STAGES IN PANDEMIC YEAR AND NORMAL YEAR (BY WORD BANK B)

Period	*Word*	*Stage 1 (M±SD)*	*Stage 2 (M±SD)*	*Stage 3 (M±SD)*
Pandemic year	Collectivism	0.98±0.11	1.24±0.13	1.08±0.12
	Individualism	1.23±0.30	1.29±0.19	1.22±0.21
Normal year	Collectivism	1.03±0.13	1.01±0.14	1.08±0.17
	Individualism	1.26±0.26	1.19±0.18	1.21±0.18

Note: N = 523.

We conducted a repeated measure ANOVA with collectivism/individualism as within-subject variable， two variable： WithSARSCov2 and stage as between-subject variables. The interaction of collectivism/individualism and WithSARSCov2 and stage was significant. $F(2,517)=4.60$, $P<0.05$, $\eta 2=0.02$.

After that, we analyzed the change trend of collectivism and individualism separately to study the main effect of SARS-CoV-2 on them.

a. collectivism change trend in pandemic year

The main effect of SARS-CoV-2 on collectivism was significant, $F(2,259)=100.11$, $P<0.05$, $\eta 2=0.43$ Simple effects tests by LSD showed that collectivism was higher in stage 2 ($M_{stage2}=1.24$, $SD_{stage2}=0.13$) than stage 1 ($M_{stage1}=0.98$, $SD_{stage1}=0.11$) and it was also higher than stage 3 ($M_{stage3}=1.08$, $SD_{stage3}=0.12$). Collectivism is still higher in stage 3 than in stage 1: $p<0.05$.

b. individualism change trend in pandemic year

The main effect of SARS-CoV-2 on individualism was not significant, $F(2,259)=2.34$, $P=0.10$.

c. collectivism change trend in normal year

The interaction of collectivism and stage was significant: $F(2,259)=4.49$, $P=0.012$, $\eta^2=0.03$. Simple effects tests by LSD showed that collectivism was higher in stage 3 ($M_{stage3}=1.08$, $SD_{stage3}=0.17$) than stage 1($M_{stagte1}=1.03$, $SD_{stage1}=0.13$) and it was also higher than stage 2 ($M_{stage2}=1.01$, $SD_{stage2}=0.14$). There is no significant difference between mean value of stage 1 and stage 2, $P=0.51$. The higher value of collectivism in stage 3 was caused by other events, we will describe it later.

d. Individualism change trend in normal year

The interaction of individualism and stage was not significant. $F(2,258)=2.25$, $P=0.11$.

e. summary of test result on word bank B

The result by word bank B showed that SARS-CoV-2 increased collectivism in Hubei Daily, and the effects last till after SARS-CoV-2 was well controlled. However, SARS-CoV-2 didn't affect individualism significantly, which was different from the result on individualism by word bank A.

The collectivistic word frequency was examined in the same period from September 20, 2018 to August 15, 2019 when there was no SARS-CoV-2 discovered in the word, and we didn't find the same change trend of collectivism, which excluded influence of contemporaneous events.

We further studied the reason for the higher collectivistic word frequency value in stage 3, and found that there were several important events reported in stage 3. The first one was in June 2019, the Commemorative Meeting of the 70th anniversary of the establishment of diplomatic relations between China and Russia. The second event was the 19th meeting of the Council of heads of state of SCO member state in mid-June. The third event was the 14th G20 summit on June 29th, 2019. These events caused more frequent usage of the collectivistic words such as "合作"(cooperation), "关系"(relationship), "我们"(we), "他们"(they) and so on. in stage 3, which explained the higher word frequency value of collectivism in stage 3 than in stage 1 and stage 2.

C. *COVID-19 word Frequency Change Trend and The Correlation Between Collectivistic Word and COVID-19 word*

To examine the correlation of collectivistic words and COVID-19 words, we conducted regression analysis on the two word banks.

First, we examined the COVID-19 word frequency change trend by COVID-19 word bank since the breakout of SARS-CoV-2. The trend was showed in Fig. 5.

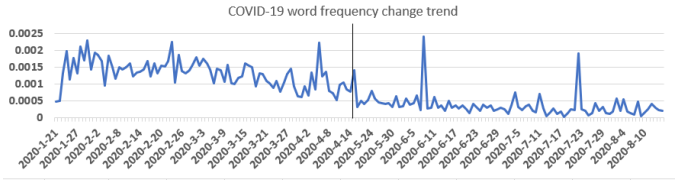

Fig. 5. Change trend of COVID-19 words along with SARS-CoV-2

Note: The black line is the day SARS-CoV-2 well-controlled. Left of the line is during SARS-CoV-2 stage and right of the line is after SARS-CoV-2 stage.

After that, we ran a fixed-effects regression test for COVID-19 words.

When examined by word bank A, collectivism was positively predicted by COVID-19 word bank, $B = 1.84$, $SE = 0.20$, $\beta = 0.57$, $t = 9.03$, $p < 0.05$, 95% CI = [1.44, 2.24].

When examined by word bank B, collectivism was positively predicted by COVID-19 word bank, $B = 1.19$, $SE = 0.16$, $\beta = 0.48$, $t = 7.27$, $p < 0.05$, 95% CI = [0.87, 1.51].

The regression analysis conducted by word bank A and word bank B showed that SARS-CoV-2 and collectivism changed with the same trend since the outbreak of SARS-CoV-2.

IV. DISCUSSION

A. *Contributions*

First, we conducted research on the influence of SARS-CoV-2 on collectivism by both word bank A, the word bank created for a longitudinal study of collectivism in China based on content from the central media outlet newspaper, the People's Daily, and word bank B, the word bank created based on cross-cultural collectivism/individualism research. Both analyses showed that the outbreak of SARS-CoV-2 increased collectivism in Hubei Daily, which was the first province to discover SARS-CoV-2 and was ever the most severe area of the COVID-19 pandemic in the world. This result further verified the pathogen-prevalence hypothesis that the prevalence of parasitic disease increases collectivism. However, we found that SARS-CoV-2 did not affect individualism significantly, which was different from findings about individualism based on word bank A. This could be explained by the fact that word bank A was constructed in the research of traditional media, and word bank B was constructed in the context of cross-cultural research. Thus, word bank A was more sensitive in the context of the Hubei Daily. Additionally, different from the findings based on the content of the People's Daily, the effect on collectivistic words lasted long after the pandemic had become well controlled in the Hubei Daily. This shows that the influence of the pandemic on collectivism/individualism may have regional differences. Additionally, to exclude the influence of contemporaneous events, we compared the results under the effect of SARS-CoV-2 with the results before SARS-CoV-2, which made the influence of SARS-CoV-2 more persuasive.

Second, we found that collectivism could positively predicted by COVID-19 words, which means that, the more SARS-CoV-2/COVID-19 was mentioned, the more collectivistic tendency was showed on the people. This result also verified that pathogen prevalence would correlate positively with collectivism from a longitudinal perspective.

Third, when conducting the examination by word bank A, we found that some words such as "改革" (reform) and "创新" (innovation) were frequently used in the reports when there were political events. This greatly affected the frequency of collectivistic word use. Similarly, when we examined individualistic word frequency by word bank B, we found that "北" was used often, as it is contained in the province name "湖北 "(Hubei), which greatly affected individualistic word frequency in articles reporting events in Hubei. To make the results more accurate, we eliminated the effect by deleting the word frequency peak values caused by these words before analyzing the collectivistic/individualistic word frequency change trend during different stages of SARS-CoV-2. In further studies, this should be addressed to eliminate the impact on specific region and specific word banks.

B. *Limitations*

Still, there are more areas that need further study. First, we only conducted research based on the content from one local media outlet—Hubei Daily. It remains unknown whether we would get the same result with content from the media coverage in other provinces and cities of China.

Second, globally, the pandemic is still ongoing. Would the influence last after a total and final-end of the pandemic? In some cities where the SARS-CoV-2 pandemic has recurred several times, would we see the same collectivistic/individualistic tendencies every time?

Third, the study on People's Daily and the study on Hubei Daily were conducted on Chinese traditional medias, while the study on Sina Weibo was conducted on Chinese social media. Would the collectivistic expression change seen in the content of traditional media correlate to that of social media?

Clearly, these are questions that need to be further studied so we may more fully understand the extent of the effect of pathogen prevalence on collectivism in China and elsewhere.

CONCLUSION

We conducted research on the collectivism change trend following the development of SARS-CoV-2 based on different word banks representing collectivism/individualism. Our findings show that SARS-CoV-2 increased collectivistic expression in the Hubei Daily, which further verified the pathogen-prevalence hypothesis that the prevalence of parasite disease increases collectivism.

We also found that the frequency of use of collectivistic words had the same change trend as that of SARS-CoV-2-related words. This provides an effective way for regional governments to carry forward the spirit of collectivism and unite the broad masses of people to fight the pandemic together in the severe period of the pandemic.

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