

# How Collective Intelligence Restrains the Rumor Spreading in Emergencies?

## -- Taking the COVID-19 Pandemic as an Example

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**Abstract.** When communicating online under COVID-19 epidemic in 2020, all kinds of rumors are widely spread on the Internet. Coming with the spread of virus, the rumor spreading not only threaten the public health, but also facilitate panic and destroy the harmony of society. This study took the COVID-19 epidemic, a serious public health emergency, as an example. Firstly, we build up a Structural Equation Modeling (SEM) containing the influential factors of Collective Intelligence on unconfirmed information dissemination (UID) on social media, and then conduct an empirical test based on the survey data. The results show that the use of Collective Intelligence can restrain the spread of rumor in public health emergencies, among which critical thinking, collective refutation and proof, crowdsourcing and member heterogeneity are the main restraining factors. However, opinion leaders would facilitate the spread of rumor. This paper not only enriches the theory of Collective Intelligence and rumor management, but also has important practical significance for suppressing rumor spreading during the emergencies.

**Keywords:** Public Health Emergency; Collective Intelligence; Rumor Spreading; Unconfirmed Information Dissemination (UID); Structural Equation Modeling (SEM).

## 1. Introduction

At the beginning of 2020, the sudden COVID-19 epidemic had a huge impact on various countries around the world (Nikolopoulos et al, 2020), which has brought out "Infodemic" (Islam et al., 2020) referring to Internet rumor, making an unpredictable negative impact on epidemic prevention. (Mourad et al, 2020). According to the database released by the International Center of Cyber Law, beginning on January in 2020, there were 224 rumors published on Weibo, BBS and other major Internet platforms in 25 days, which indicates the unprecedented speed, scale and influence of Internet rumors.

Public health emergencies are major causes of social instability due to its sudden and enormous destruction. During the emergency, the public is eager to keep up to date, while there is little access to the official information. Meanwhile, there are more unconfirmed information than real news, which gradually cause rumors and do harm to emergency management. Therefore, analyzing the influencing factors of epidemic rumors spreading and exploring the effective mechanism to restrain the spread of rumor are of great guiding significance to control the emergency and avoid the negative impact of rumor spreading on the social stability.

In order to tackle such problem, more and more studies focus on preventing the unconfirmed information dissemination (UID). However, there still exists little researches on Collective Intelligence. Given that, this paper proposes the following questions: in the context of COVID-19, will the spread of rumor be affected by Collective Intelligence? If so, what are the specific channels? We aim to answer these questions by constructing SEM to explore the influence of Collective Intelligence on UID. The marginal contributions of this paper can be summarized as follows.

(1) This paper combines Collective Intelligence with social media to explore its application in the new era. It not only can enrich the theoretical research of Collective Intelligence, but also can improve the practical application value by providing the policy makers a more feasible tool with low cost, high timeliness and high realization to confront and control UID. (2) This paper creatively introduces

“Opinion Leader” to enrich the theory of rumor restraining methods. From the perspective of perceptual factors, the variable “opinion leader” is introduced to find out the “butterfly effect” caused by opinion leaders among their followers on social media, and investigate how their viewpoints promote the dissemination of rumor.

The remainder of this paper is organized as follows. The following section reviews relevant literatures, and Section 3 proposes research design. Section 4 conducts empirical analysis. Section 5 draws conclusions and offers suggestions.

## 2. Literature Review

### 2.1 Collective Intelligence

Since Dorigo proposed the theory of ant colony optimization in 1991, Collective Intelligence has gained great attentions, which can be divided into two categories:

(1) Definition of Collective Intelligence. The definitions of Collective Intelligence are mixed in previous studies. In 1964, Wechsler first proposed the unified concept of collective intelligence, literally describing it as: a group of individuals acting intentionally, thinking rationally, and dealing with their surroundings efficiently. Subsequently, with the multidisciplinary crossing, different scholars put forward various definitions on collective intelligence. For example, Hao (2011) proposed the concept of netizens’ collective intelligence, which is a more participatory, valuable, and indispensable representative of media culture. Although their focuses are different, what is widely accepted is that Collective Intelligence is superior to the individual or even equal to the sum of the individuals (Krause et al., 2010).

(2) Practical application of Collective Intelligence. It’s pointed out that the behavior, strategy, consciousness and control of the group are important factors to realize Collective Intelligence (Nance, 1995). In order to make the group smarter, scholars in various fields paid attention to the application of collective intelligence in practice. In financial field, Chen (2013) studied the recommendations of a US stock platform and found that Collective Intelligence can predict stock returns to a certain extent. In social field, Li and Sakamoto (2013) believed that Collective Intelligence is a combination of human cognition, behavior, and psychology, and found that collective intelligence can affect rumor spreading by experiments.

### 2.2 Rumor Governance

Online rumors are more likely to break through restrictions and expand its dissemination, which makes rumor governance a hot issue in many fields. The existing studies mainly discuss rumors governance from the following 4 aspects.

(1) Summarize the experience of rumors governance by case analysis. Tao (2012) took Hubei as an example, and pointed out that online rumors had exposed how local government weak in guiding online public opinion, and proposed measures. In short, Case Analysis can provide practical experience for suppressing the UID. However, due to the lack of theoretical support and data to verify the conclusion, the suggestion is likely to be unreliable, and the case studied cannot fully reveal the law of rumors spread, which leads to heterogeneity of the conclusion.

(2) Analyze the internal factors rumors spreading by constructing a model. By ameliorating an SEIR model, Chen et al. (2020) implemented numerical experiments to analyze the pseudo-scientific online rumors governance and put forward corresponding countermeasures. Supported by theoretical foundations, Model Construction can deeply explore the internal factors of rumors spread, and is conducive to exploring ways to restrain the rumors spread from the source.

(3) Intervene in the spread of rumors by establishing mechanisms. In order to control the spread of rumor on the Internet, Mendoza (2010) discusses the self-purification mechanism of social media based on the mutual complement and error correction relationship of user-generated content. However, the countermeasures proposed by such mechanisms, are poor in operability and timeliness.

(4) Utilize the internal mechanism of Collective Intelligence to control UID. Tanaka et al. (2013), further considering the group's critical thinking, made an investigation and analyzed the different psychological conditions when groupmates dealing with rumors, and found that the psychological factors are beneficial to slow down or even inhibit the rumors spread. Chen (2011) analyzed the influence of collective intelligence on rumors spread from the perspectives of group critical thinking and crowdsourcing, and believed that group members can influence each other's judgment of information and forwarding behavior.

### 3. Research Design

#### 3.1 Research Hypothesis

The concept of Opinion Leader initially refers to those active voters who showed high participation in the presidential election. Gradually, it is defined to people who have strong comprehensive capabilities, personality charm and social status or good sense of recognition (Ge, 2015). Additionally, their opinions will cause a Butterfly Effect among their followers by influencing followers' attitude and behavior.

Collective Intelligence is generated by some sharing mechanism between individuals but superior to individual. Considering the existing research, this paper chooses 4 major internal mechanisms as follows. (1) *Group refutation*: refers to behaviors that refuting unconfirmed information and contributing to generate group opinions relying on cooperation between individuals. If people have seen content that refutes the rumors before they learn it, and further counter unconfirmed information and provide evidence, the chances of the rumors spreading rumor spreading will be smaller (Zhang, 2012; Tanaka et al., 2013). (2) *Critical thinking* is a significant factor, which enables people to find the truth from unconfirmed information. Allport and Postman (1947) put forward a famous formula of rumor spreading: Rumor = Importance × Ambiguity. Based on it, Chen (2011) proposed a new idea that the spread of rumors is negatively correlated with Critical Ability, which revealed that the more critical the group, the harder the rumors spread. (3) *Crowd sourcing*: refers to the voluntary outsourcing of work performed by corporate employees to non-specific mass networks (Howe, 2006). Under the effect of crowdsourcing, members freely disclose their opinions and innovative ideas, forming a resource sharing area. In this case, crowd sourcing could make the public smarter, more sensible, and more capable of distinguishing authenticity (Zhang et al., 2012). Notably, a group with critical thinking itself is a crowdsourcing system with self-purification capabilities (Halpern, 2003), which proved that crowd sourcing can maximize the effectiveness of Collective Intelligence in controlling UID. (4) *Group heterogeneity*: is integrated by the distribution of people in different fields, who obtain diverse knowledge and identity backgrounds, which will improve the vitality and flexibility of the group and avoid group polarization (Tanaka et al., 2013). Organizational behavior expert March (2013) believes that with increasing group's diversity, it would make people more critical thinking.

Based on above analysis, we propose the following hypotheses.

H1: Opinion leader positively affects the UID.

H2: Refutation and Proof negatively affects the UID.

H3: Critical thinking negatively affects the UID.

H4: Critical thinking negatively affects the Opinion Leader.

H5: Critical thinking positively affects the group Refutation and Proof.

H6: Critical thinking positively affects Crowd Sourcing.

H7: Crowd Sourcing negatively affects the UID.

H8: Crowd Sourcing positively affects Group Heterogeneity.

H9: Group Heterogeneity negatively affects the UID.

### 3.2 Variables Measurement and Data Source

Our questionnaire consists of 4 parts. The first part is the basic personal information of the respondents, including gender, age, residence, education level, and occupation. The second part is the respondents' use of social media, including the frequency of surfing and commenting, and attitude on information. The third part is to measure the latent variables in the model of Collective Intelligence inhibiting UID, using the Likert 5-level scale (1=strongly disagree, 2=Disagree, 3=General, 4=Agree, 5=Strongly agree), shown in Table 1.

In our survey, Guangdong Province was chosen as the research site, due to its representativeness. Our ultimate number of valid samples is 1148, including 885 respondents in the online survey and 336 respondents in the field survey.

**Table 1.** Variable Measurement Indicators

Latent Variable	Coding	Problem of Measuring	Reference
Critical Thinking(CT)	CT1	I am a person who analyzes problems logically and methodically.	Chen (2011)
	CT2	I think this news is very important.	
	CT3	I am confident that I can correctly analyze the authenticity of this news.	
Crowd Sourcing (CS)	CS1	I would participate actively in discussing the authenticity of this rumor.	Tanaka et al.(2013) and Halpern (2003)
	CS2	I would consult others' opinions before judging the reality of content.	
	CS3	The public would play a role in filtering rumor.	
Refutation and Proof(RE)	RE1	I would collect information about this news.	Halpern (2003)
	RE2	I would question the authenticity of this news.	
	RE3	I would inform others about the authenticity of this news.	
Group Heterogeneity(GH)	GH1	Netizens would fiercely discuss the authenticity of this news.	Li & Sakamoto (2013)
	GH2	People with different professional knowledge and identity background would have different judgement.	
	GH3	People would express their opinions on the authenticity of this news.	
Opinion Leader (OL)	OL1	My attitude towards the news would be influenced by opinion leaders.	Li & Sakamoto (2013)
	OL2	The views and expressions of opinion leaders would make me unconsciously join the communication process.	
	OL3	My actions (reposting, sharing, discussing, etc.) on this news would be influenced by the online opinion leaders.	
Unconfirmed Information Dissemination(UID)	UD1	This news is a rumor.	Zhang (2012) and Zhang (2014)
	UD2	This news will be widely spread.	

### 4. Empirical Analysis

In this part, we first implement a reliability and validity test and found that the Cronbach's  $\alpha$  value and KMO value are 0.814 and 0.882 respectively, indicating that the stability and consistency of the data are very reliable and credible. Given that, we construct a SEM by applying Maximum Likelihood

(ML) to estimate the parameters of structural equation model. Then we constructed a theoretical model of the influence of collective intelligence on UID. After finding that critical thinking and crowd sourcing have no significant impact on UID, we deleted these two paths and optimize our model, which ultimately appeared no violation. The result is shown in Figure 3.

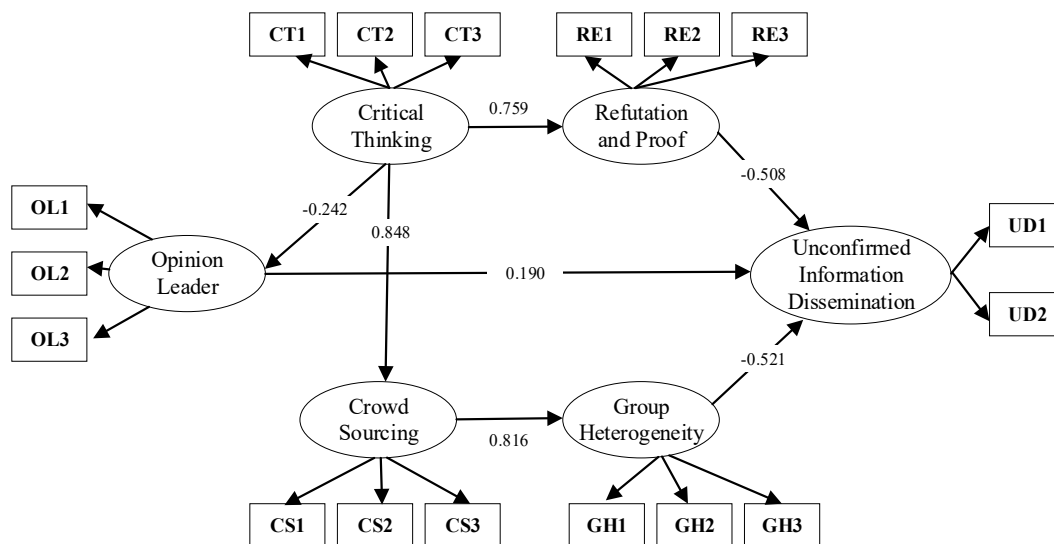


Figure 1. The Optimized Model Diagram

According to Table 2, it shows that all constructs satisfied the criterion that Average Variance Extracted score (AVE) above 0.5 and Composite Reliability score (CR) above 0.7, confirming that all items have adequate internal consistency to represent the corresponding constructs. In addition, shown in Table 3, all the fitting index, IFI, TLI and CFI are 0.952, 0.935 and 0.951 respectively, indicating that our model has a good fit. In conclusion, all relationships between the various influencing factors are summarized in Table 4.

Table 2. CR Score and AVE Score

Construct	Item	Factor Loading	CR	AVE
Critical Thinking	A1	0.898	0.9190	0.7910
	A2	0.882		
	A3	0.888		
Crowd Sourcing	B1	0.821	0.8620	0.6763
	B2	0.879		
	B3	0.763		
Refutation and Proof	C1	0.925	0.9271	0.8091
	C2	0.886		
	C3	0.887		
Member Heterogeneity	D1	0.920	0.9299	0.8156
	D2	0.895		
	D3	0.894		
UID	E1	0.860	0.8662	0.7641
	E2	0.888		
Opinion Leader	F1	0.966	0.9290	0.8157
	F2	0.980		
	F3	0.744		

**Table 3.** Modified Model Fitting Index

Index	CMIN/DF	RMSEA	PNFI	PGFI	RMR	IFI	TLI	CFI
Index Value	1.842	0.071	0.688	0.563	0.046	0.952	0.935	0.951
Suggested Value	1~3	<0.08	>0.5	>0.5	<0.05	>0.9	>0.9	>0.9

**Table 4.** Research Hypothesis Verification Results

Hypothesis	Path	Influence Direction	Results
H1	Opinion Leader → UID	Positive	Support
H2	Refutation and Proof → UID	Negative	Support
H3	Critical Thinking → UID	Negative	Not Support
H4	Critical Thinking → Opinion Leader	Negative	Support
H5	Critical Thinking → Refutation and Proof	Positive	Support
H6	Critical Thinking → Crowd Sourcing	Positive	Support
H7	Crowd Sourcing → UID	Negative	Not Support
H8	Crowd Sourcing → Member Heterogeneity	Positive	Support
H9	Member Heterogeneity → UID	Negative	Support

According to Table 4, it supports H1 regarding opinion leader as a positive promoter for UID, whose path coefficient is 0.19, indicating that opinion leader will influence others' attitudes and behaviors in the process of dissemination of unconfirmed information, which would work on rumor spreading. For group's ability of refutation and proof, as expected, it plays a relatively strong role in restraining UID (H2) with path coefficient of -0.51, indicating that the group's refutation and proof ability has a moderately negative effect on UID, which is consistent with the conclusion drawn by Zhang et al. (2012). In other words, when people have seen information refuting rumors or have collected and sorted out evidence to verify information, the probability of UID will decrease. H3, which assumes that group critical thinking restrains UID, has not been confirmed in this study. The reason for its insignificance may be that the samples do not fully utilize the critical thinking of individuals or others, which lessens the frequency of refutation and proof, which weakens the inhibitory effect of collective intelligence on UID.

The group critical thinking is found to have negative relationship with the opinion leader effect, thus supporting H4, with path coefficient of -0.24. It shows that critical thinking encourages people to find the truth from unconfirmed information. The stronger the critical thinking is, the more likely it is to question the opinion leaders and also the motivation behind the spread of information. Since we didn't predict a significant relationship between group critical thinking and group's ability of refutation and proof, and the results confirm this conjecture. It follows that hypothesis H5, which hypothesizes that group critical thinking positively affects the group's ability of refutation and proof, is also strongly supported with coefficient of 0.76. It indicates that group critical thinking has an obvious positive effect on the group's ability of refutation and proof. When people find that information does not conform to their own opinions, or even contradict their personal beliefs, or affect their own interests, they will question or refute. Besides, the group critical thinking is found to be positively associated with crowd sourcing, thus supporting H6, with path coefficient of 0.85. It denotes that group critical thinking has an obvious positive effect on crowd sourcing. The more people with critical thinking in a crowd sourcing system, the more effective the crowd sourcing, the better the group's ability to distinguish between true and false information.

Contrary to what we hypothesized; crowd sourcing didn't certify to restrain UID (H7) in this study. The insignificant reason may be that in the process of social media transmission, the news is mixed, in which the public feel hard to distinguish and more difficult to form rational thoughts. The inefficient crowd sourcing system makes it difficult for collective intelligence to restrain rumor spreading in social media. Next, the prediction that crowd sourcing has a positive impact on group heterogeneity (H8) is found to be extremely significant with standardized coefficient of 0.82. It indicates that crowd sourcing has a significant positive effect on group heterogeneity. This is

consistent with the conclusion drawn by Tanaka et al. (2013), in which demonstrates that the role of crowd sourcing is to gather individuals with various knowledge backgrounds and ensure voluntary participation in discussion. It will enhance the diversity of the group. This result shows that the crowd sourcing system is an important internal factor for the effectiveness of collective intelligence.

Finally, hypothesis H9, which predicted that group heterogeneity restrains UID, is supported with path coefficient of -0.52, indicating that group heterogeneity has a negative effect on UID. The diversity of group members will make the group acquire more critical thinking, which can promote the group members' behavior of refutation and proof, thus inhibits the spread of rumor.

## 5. Conclusion and Suggestion

Based on first-hand data collected in the form of questionnaire during COVID-19 epidemic, this paper conducted SEM method to make empirical analysis and drew the following conclusions. (1) From the perspective of rational factors, the 4 internal variables of collective intelligence: Critical Thinking, Crowd Sourcing, Refutation and Proof, Group Heterogeneity have a certain restraining effect on the dissemination of rumor, in which critical thinking inhibits UID by positively affecting refutation and proof, while crowd sourcing inhibits the UID by positively affecting group heterogeneity. (2) From the perspective of perceptual factors, opinion leader can facilitate rumor spreading. When most people tend not to express their opinion on social media, the few who hold opinions will become opinion leaders in the crowd and guide the public.

Based on the above conclusions, the paper puts forward the following practical suggestions. (1) Use the power of opinion leaders properly and appeal to the public to treat unconfirmed information rationally. Opinion leaders should forward the official news and meanwhile make positive comments, and appeal to the public to remain calm and rational when facing rumor. Meanwhile, the government should accelerate the popularization of Internet quality-oriented education, focus on strengthening and regulating the quality of opinion leaders. (2) Encourage the public to give full play to their professional abilities. The public should enhance their sense of responsibility, and improve their mind and quality through learning about Internet media. Also, they should make full advantage of their professional knowledge, analyze and consider rationally from different perspectives, express opinions actively and refute rumor by providing evidence. (3) Social media platforms should take the initiative to assume the social responsibility of restraining the spread of unconfirmed information and apply the collective intelligence mechanism to rumors governance. The media platforms can organize rumor refutation activities or construct incentive system to encourage people to actively express their views. Besides, social media can set up knowledge popularization column in the site, and share the knowledge of dealing with public emergencies.

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