Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Emotion, analytic thinking and susceptibility to misinformation during the COVID-19 outbreak

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ABSTRACT

Misinformation has become prevalent since the beginning of the COVID-19 pandemic. To understand why people believe and share misinformation, we conducted a nationwide survey during the COVID-19 outbreak in China. We found the indirect effects of COVID-19 risk on people's information accuracy judgment and associated information sharing intention through people's emotional states. People faced with a higher level of COVID-19 risk (measured by a 7-day moving average of daily new deaths or new cases) experienced weaker positive and stronger negative emotions, and heightened emotionality (both the positive and negative emotions) was associated with increased belief in and greater likelihood to share the COVID-19 information regardless of veracity. We also found that only the negative emotion mediated the relation between the COVID-19 risk and the truth discernment regarding accuracy judgment. However, the mediating effect of negative emotion disappeared among people with high analytic thinking ability. These findings suggest that the analytic thinking ability could moderate the destructive relationship between negative emotion and accuracy discernment. Based on a large sample, our findings provide actionable insights for the policymakers to respond to the spread of misinformation appropriately and promptly during the pandemic.

Credit

Li-Lin Rao: Conceptualization, Supervision, Writing-Reviewing and Editing. Ming-Hui Li: Investigation, Formal analysis, Data curation, Writing-Original draft preparation. Zhiqin Chen: Conceptualization, Formal analysis, Writing-Original draft preparation, Writing-Reviewing and Editing.

1. Introduction

The ongoing COVID-19 pandemic has impacted over 200 countries and territories worldwide so far. As of January 17, 2022, more than 326 million cases of COVID-19 and over 5 million deaths from it had been reported all over the world (World Health Organization, 2022). To fight against this novel and infectious disease, people need accurate information to guide their behavior and protect themselves (Tangcharoensathien et al., 2020). Because of practicing physical distancing during the pandemic, people are heavily reliant on social media to obtain, share, and seek information about the virus (Limaye et al., 2020). However, social media platforms that allow people to express their (false) opinions and share (mis)information freely have become populated with various misinformation, which is a severe problem, especially in science communication during the COVID-19 pandemic (Bavel et al., 2020; Scheufele et al., 2021). Even worse, many false and misleading claims had easily triggered emotional thinking and behaviors that endangered oneself and others (Ahmed et al., 2020; Hou et al., 2020). For example, conspiracy theories about the cause and origin of the virus led the public to be angry with and distrust the government and health authorities, which hampered the implementation of containment measures (Limaye et al., 2020). It was also reported that the false rumors regarding a connection between 5G and the spread of the COVID-19 were trusted by many people and disseminated widely online. As a result, many phone masts were torched in the United Kingdom, including a mast serving a hospital in Birmingham (Page, 2020). This event is exceptionally harmful during such a special time when hospitals need to operate with maximum efficiency (Ahmed et al., 2020).

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Therefore, it is crucial to understand why people believe and share misinformation in the context of the pandemic.

Previous studies on severe pandemics (e.g., SARS, H1N1, Ebola) suggested that their outbreak had a tremendous psychological impact on individuals. People were observed to suffer emotional distress, such as anxiety, depression, panic, when faced with highly contagious diseases (Lau et al., 2010; Qian et al., 2005; Shultz et al., 2016). Currently, the influence of the COVID-19 pandemic on mental health is not only substantial and sustained but also complex and multifaceted, given the threat, uncertainty, and potential loss during the pandemic (Gruber et al., 2021). The pandemic contributed to a range of emotional reactions and reduced subjective well-being (Pfefferbaum & North, 2020). Meanwhile, the degree of emotional responses in public was highly associated with the severity of the epidemic locally. For example, a study conducted in China during the outbreak of SARS in 2003 found that college students in Beijing showed more negative emotions than those in Suzhou, where the SARS epidemic was less severe compared to that in Beijing (Qian et al., 2005). Based on a large-scale nationwide survey during the COVID-19 outbreak in China, Qiu et al. (2020) found that people from the most severely affected regions experienced the highest level of psychological distress. Besides, Zheng et al. (2020) also found that people who live in the provinces with a higher number of newly confirmed COVID-19 cases in China demonstrated a higher level of anxiety. Thus, we speculate that people faced with higher COVID-19 risk, i.e., more infections and deaths, are likely to experience more negative and less positive emotions.

Based on previous work, there are two main perspectives on the relationship between emotion and individuals' propensity to trust information. One perspective suggests different effects of positive and negative emotions on believing information. According to the assimilative-accommodative model (Bless & Fiedler, 2006), positive and negative emotions influence individuals' inclination to trust information by regulating their information processing strategies differently. Specifically, people in positive emotional states tend to employ more heuristic and less effortful strategies. In contrast, people in negative emotional states tend to use more analytic, detail-oriented, and effortful strategies (Bless et al., 1990; Bless & Fiedler, 2006; Fiedler & Bless, 2000). However, when encountering new information, people would automatically accept it as true during the comprehension process and reject the information that required additional cognitive resources and further processing (Gilbert, 1991). In this vein, when adopting more heuristic or less analytic strategies, people may be more likely to accept new information as true and worse at discerning true from false information. In line with this perspective, studies found that gullibility was increased by positive emotions and reduced by negative emotions (Forgas, 2019 for a review). Therefore, positive emotions that induce more heuristic information processing strategies may be positively associated with the perceived accuracy of COVID-19 information and negatively associated with truth discernment. Furthermore, since people are more likely to share the information they believe (Pennycook et al., 2021; Pennycook & Rand, 2020), positive emotions may also be positively associated with the information sharing intention. In contrast, negative emotions that activate more analytic information processing strategies may associate with increased truth discernment.

The other perspective is that positive and negative emotions promote the perceived accuracy of information by facilitating heuristic information processing strategies. According to the resource allocation model (Ellis & Ashbrook, 1988), both positive and negative emotions increased irrelevant thoughts, which occupied attentional resources (Seibert & Ellis, 1991) and further reduced the processing effort invested in the ongoing cognitive tasks (Ellis & Ashbrook, 1988; Ellis et al., 1997). Supportive evidence came from a previous study showing that positive and negative emotions measured by PANAS were positively associated with intuitive decision-making (Sinclair et al., 2010). Given that people by default accept new information as true (Gilbert, 1991; Lewandowsky et al., 2012), it seems that heightened emotionality would make people trust the COVID-19 information more regardless of information veracity. As reviewed by Scheufele and Krause (2019), emotional states, especially negative emotion, would intensify people's perceived accuracy of the (mis)information that is consistent with their beliefs or what they want to believe. Moreover, a recent study found heightened emotionality concerning both positive and negative emotions was associated with increased vulnerability to believing fake political news on social media (Martel et al., 2020). Therefore, emotionality (both positive and negative emotions) may positively relate to the perceived accuracy of COVID-19 information and the associated information sharing intention and negatively relate to truth discernment.

Overall, the above two perspectives provide valuable insights into the relationships among COVID-19 risk, emotion, people's perceived accuracy of the COVID-19 information, the associated information sharing intention, and truth discernment. Specifically, people with higher COVID-19 risk may experience lower positive and higher negative emotions. Furthermore, these emotions may associate with the extent to which people believe and share the COVID-19 information and the level of truth discernment. In other words, there may be indirect effects of COVID-19 risk on perceptions of the information accuracy, the associated information sharing intention, and truth discernment through individuals' emotional states.

Previous studies examined the effect of different emotions on people's vulnerability to misinformation. Some focused on global emotions (e.g., Forgas & East, 2008; Martel et al., 2020; Sanchez & Dunning, 2021), while others focused on specific emotions (e.g., Martel et al., 2020; Rosenzweig et al., 2021; Weeks, 2015). In the context of the pandemic, the COVID-19 risk could exert lasting influences on people's emotional states as the pandemic continues. Moreover, as a complex stressor, the pandemic has increased a range of negative emotions, such as anxiety, depression, worry, anger, and so on (Pedrosa et al., 2020 for a review). Thus, we focused on the global rather than specific emotions in the present study.

Based on previous studies about misinformation or fake news, analytic thinking is associated with the ability to discern between false and real information irrespective of information familiarity and political ideology (Bago et al., 2020; Pennycook et al., 2020; Pennycook & Rand, 2019, 2020; Ross et al., 2021). Analytic thinking could help stop, reflect on and modify incorrect intuitions effectively (Ross et al., 2021). Individuals who engaged more in analytic thinking performed better in truth discernment. Emotional and cognitive responses are two independent but interrelated elements and always work together to determine an individual's final actions (Lazarus, 1982). Considering the positive relation between analytic thinking and truth discernment, we thus hypothesize that the indirect link between COVID-19 risk and truth discernment through emotion would be moderated by analytic thinking. Specifically, if truth discernment is negatively related to positive emotion and positively related to negative emotion according to the assimilative-accommodative model, the indirect relation between COVID-19 risk and truth discernment through positive emotion would be weaker while the indirect relation through negative emotion would be greater or the same for people engaging more in analytic thinking. If positive and negative emotions are negatively related to truth discernment as suggested by the resource allocation model, the indirect relation between COVID-19 risk and truth discernment through emotions would be weaker for people engaging more in analytic thinking.

To sum up, the present study first examined how people's emotionality was associated with the COVID-19 risk. We then looked at how these emotions were associated with the extent to which people believe and share the COVID-19 information and the level of truth discernment. Furthermore, we were concerned about the role of analytical thinking in the indirect relation between COVID-19 risk and truth discernment via emotions.

2. Material and methods

2.1. Participants

We conducted an online survey through the Wenjuanxing platform (https://www.wjx.cn/) in China during the COVID-19 outbreak from February 20 to March 10 in 2020. When determining the sample and its size, we considered the following factors: (a) participants should be from different provinces and experienced different levels of COVID-19 risk, (b) data collection had to be completed in a month due to the timeliness of the COVID-19 news, (c) the cost should be within our budget, and (d) 3000 is a large sample size compared to existing studies (e.g., Martel et al., 2020; Pennycook & Rand, 2019). We recruited adults (aged 18 years and older) residing in China. The survey terminated if a participant did not respond correctly to an attention check item. Thus, participants who failed the attention check could not complete the study and were excluded from all the analyses.[1] In addition, one participant with missing age data and one completing the survey abroad were also excluded. The final sample consisted of 3066 participants covering 30 provinces and equivalent administrative units of China. There are 501 (16.34%) participants from Hubei province, the epicenter of the COVID-19 outbreak. Table S1 in the Supplementary Materials summarizes the main sample characteristics by province. The overall demographic characteristics of our sample are presented in Table 1.

2.2. Materials and procedure

This study was approved by the Institutional Review Board of the Institute of Psychology, Chinese Academy of Sciences. After reading and signing the informed consent form, participants were first asked to read 12 false and 11 true news headlines related to COVID-19 one by one. All the headlines were obtained from authoritative sources in China, including a well-known health expert website (https://dxy.com/) and a recognized fact-checking website (https://new.qq.com/omn/author/5107513). The headline presentation was in a format that appeared commonly on the Internet, and each was presented with a picture, lede sentence, and source (see Fig. 1). Following each headline, participants needed to judge the accuracy of the information and indicate their information sharing intention. To avoid the influence of information familiarity, they were also asked to report whether they had seen the news before or not. All news headlines were presented in a random order for each participant. After finishing all the questions related to the twenty-three news headlines, participants answered twenty questions about their mood state during the past few days and seven questions regarding their tendency to engage in analytic thinking. Upon completing the measures of emotion and analytic thinking, participants answered a one-item attention check to ensure that they paid attention to the survey and thoroughly read the materials in the questionnaire. Finally, participants completed demographic questions, including age, gender, the highest level of education, marital status, monthly personal income, and place of residence. Each participant received ¥25 (approximately US$3.85) upon the completion of the online survey.

Table 1
The demographic characteristics of all the participants.

Variable		*n* (*N* = 3066)	Proportion (%)
Gender	Female	1734	56.56
	Male	1332	43.44
Marital status	Married	1594	51.99
	Others	1472	48.01
Age group (years)	18–27	1310	47.91
	28–37	1301	39.40
	38–47	328	9.33
	48–57	110	2.97
	58–69	17	0.39
Occupation	Enterprises	1628	53.10
	Government and institutions	575	18.75
	Unemployed	300	9.78
	Farm	30	0.98
	Other	533	17.38
Education	Elementary school	2	0.07
	Junior high school	26	0.85
	Senior or vocational high school	174	5.68
	Vocational college	408	13.31
	Four-year college	2189	71.40
	Master's degree	248	8.09
	Doctoral degree	19	0.62
Monthly personal income	Less than 800 RMB	254	8.28
	801–1,500 RMB	200	6.52
	1,501–4,500 RMB	655	21.36
	4,501–9,000 RMB	1255	40.93
	9,001–35,000 RMB	659	21.49
	35,001–55,000 RMB	22	0.72
	55,001–80,000 RMB	11	0.36
	More than 80,000 RMB	10	0.33

2.3. Main measures

Dependent variables. For each headline, accuracy judgment was based on the rating of a four-point scale (1 = Not at all accurate, 4 = Very accurate). A higher score of perceived accuracy indicates a higher level of believing the headline. Sharing intention was evaluated by rating on a three-point scale (1 = No, 2 = Maybe, 3 = Yes). A higher score implies that people are more likely to share the headline.

Emotion. The participants' positive and negative emotions were assessed by the validated Chinese version of the Positive and Negative Affect Schedule (PANAS) scale (Huang et al., 2003; Watson et al., 1988). For each of its 20 items, participants were asked to rate the extent to which they had experienced the mood state during the past few days on a 5-point scale (1 = Not at all, 5 = Very much). Our choice of emotional states that people experienced during the past few days was due to the lasting influences from the COVID-19 risk. The degree of positive emotion (Cronbach's $\alpha = 0.87$) is represented by the average ratings across 10 words describing positive emotions (i.e., interested, excited, strong, enthusiastic, proud, alert, inspired, determined, attentive, active), while the degree of negative emotion (Cronbach's $\alpha = 0.86$) is denoted by the average across the other 10 words (i.e., distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, jittery, afraid). A higher emotion score indicates stronger feelings and emotions.

Analytic thinking. The propensity to engage in analytic thinking is measured by a seven-item version of the Cognitive Reflection Test (CRT, Cronbach's $\alpha = 0.64$; Frederick, 2005; Pennycook & Rand, 2019). We calculated the total number of correct answers as the CRT score for each participant. A higher CRT score implies higher analytic thinking ability.

COVID-19 risk. We adopted two widely used epidemiological indicators to assess the pandemic risk during the COVID-19 outbreak: 7-day moving averages of daily new deaths and new cases. The 7-day average is also more consistent with our measure of participants'

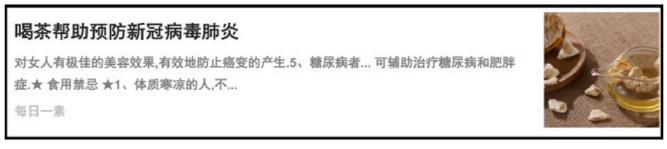

Fig. 1. Example news headline stimuli with picture, headline, lede sentence, and source.

[2] One thousand three hundred and nine participants failed to pass the attention check.

emotional states during the past few days than one-day or momentary mood. We calculated the two indicators for a specific area by averaging the associated local daily numbers in the past week, including the data collection day. Thus, we estimated the level of COVID-19 risk that each participant might experience based on their local daily new deaths and new cases (the 7-day moving average) in their living province. However, because participants from the same province might complete the survey on a different day, the levels of COVID-19 risk estimated for them would be different. In such a case, the level of COVID-19 risk we estimated in the current study would be better regarded as an individual-level rather than group-level variable. All the case-related data were obtained from the official websites of the health commission of each province, which published the daily briefings of the novel coronavirus cases (The website links are listed in Table S2 in the Supplementary Materials). In general, more daily new deaths and new cases in a province imply a higher level of the COVID-19 risk people could have experienced locally.

3. Results

3.1. Correlations

Table 2 provides basic statistics for the main measures and the bivariate correlations between the individual-level variables in the current study. We found that both the daily new deaths and new cases were correlated negatively with positive emotion and positively with negative emotion. Both positive and negative emotions were correlated positively with the perceived accuracy of the headlines and the associated sharing intention regardless of information veracity.

3.2. Relations between COVID-19 risk and emotions

To test the relationships between the COVID-19 risk and emotions rigorously, we ran linear regressions with positive emotion and negative emotion as the dependent variables separately. As participants were from different provinces, we first assessed the necessity of performing multilevel modeling by calculating intraclass correlations (ICCs), which quantified the proportion of the total variance of dependent variables accounted for by province differences. An ICC value near zero (smaller than 0.1) suggested that multilevel modeling would be unnecessary (Aguinis et al., 2013). We thus performed the null models with by-province random intercepts without any predictors to obtain ICCs. The results showed that 0.7% (ICC = 0.007) of the total variance in positive emotion and 0.9% (ICC = 0.009) of the variance in negative emotion were associated with province, indicating that single-level analyses were appropriate (Aguinis et al., 2013). We then ran the linear regressions that included the daily new deaths to measure the COVID-19 risk and control variables of age, gender, educational level, marital status, income, population density, and GDP.[2] All the variables were standardized.

The results are presented in Table 3. Similar to the bivariate correlations, we found that the daily new deaths were correlated negatively with positive emotion and positively with negative emotion. In addition, we obtained the same results with the daily new cases as the measure of the COVID-19 risk in the models (see Table S3 in the Supplementary Materials).

[3] The population density was computed by dividing population size by land area. The land area data was obtained from the Ministry of Civil Affairs of the People's Republic of China (http://xzqh.mca.gov.cn/statistics/2014.html). The local population size data and GDP per capita were from the National Bureau of Statistics of China (https://data.stats.gov.cn/easyquery.htm?cn=E0103).

3.3. Relations between the COVID-19 risk, emotions, perceived accuracy, sharing intention, and truth discernment

3.3.1. Perceived accuracy and sharing intention

To further examine how the COVID-19 risk and emotions predicted the perceived accuracy of the news headlines and the associated information sharing intention, we performed a series of linear mixed-effects models using *lme 4* and *lmerTest* packages in R (Version 3.1.2). Each headline was a single item in the models. Participants were from different provinces. Therefore, we first calculated ICCs by running the null models that included by-item, by-participant, and by-province random intercepts but without any predictors. The results showed that, for the variance in perceived accuracy, 36.9% (ICC = 0.369) was associated with item, 8.2% (ICC = 0.082) was associated with participant, and 0.04% (ICC = 0.0004) was associated with province. For the variance in sharing intention, 25.6% (ICC = 0.256) was associated with item, 17.8% (ICC = 0.178) was associated with participant, and 0.09% (ICC = 0.0009) was associated with province. Because of the near-zero ICCs for the province, we excluded by-province random effects. Still, we included by-item and by-participant random effects in the models to account for the nonindependence in the data (Brauer & Curtin, 2018). We then ran the mixed-effects models that included the daily new deaths, positive emotion, negative emotion, headline type, and three two-way interactions between headline type and the other three variables as fixed effects, as well as control variables of age, gender, educational level, marital status, income, population density, and GDP. Headline type was a dummy variable (0 for false headlines and 1 for true headlines). Besides, except for the headline type, we standardized all the other variables in the models.

Given that the models with maximal random effects structure did not converge, we simplified the random effects structure following previous work (Barr et al., 2013; Brauer & Curtin, 2018). We removed the random effects for covariates first. Then, we inspected the partially converged model and removed the slope for daily new deaths because its variance was the smallest. Finally, the model reached convergence and included the following random effects: (1) by-item random intercepts and its associated random slopes for positive emotion and negative emotion, and (2) by-participant random intercepts and random slopes for headline type. The entire model structures are available in the Supplemental Materials. To measure the proportion of the total variability explained by the model, we calculated two types of pseudo-R^2 for each model using the *MuMIn* package in R (Barton, 2020). Marginal R^2 represents the proportion of variability explained by the fixed effects, and conditional R^2 represents the proportion of variability explained by the fixed and random effects.

The results are presented in Table 4. For perceived accuracy, the results revealed that both positive and negative emotions positively correlated with the perceived accuracy of false headlines. In addition, the interaction between negative emotion and headline type was significant. Simple slope analysis revealed that the association between negative emotion and perceived accuracy of true headlines was positive ($b = 0.028$, $SE = 0.009$, $p = .003$). The interaction between positive emotion and headline type was not significant.

As shown in Table 4, both positive and negative emotions positively correlated with the likelihood of sharing false headlines for sharing intention. In addition, the interaction between positive emotion and headline type was significant. Simple slope analysis revealed a positive association between positive emotion and sharing intention for true headlines ($b = 0.107$, $SE = 0.013$, $p < .001$). The interaction between negative emotion and headline type was also significant. Simple slope analysis revealed a positive association between negative emotion and sharing intention for true headlines ($b = 0.127$, $SE = 0.012$, $p < .001$).

To sum up, these results suggest that heightened emotionality was associated with increased belief in and greater likelihood of sharing the news headlines regardless of the veracity of the information. We also

Table 2
Descriptive statistics of all the main variables and bivariate correlations between the variables.

			Correlations							
	M	*SD*	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Daily new deaths	12.44	30.74	.95***	-.08***	.07***	-.04*	-.00	-.00	.00	-.01
(2) Daily new cases	108.30	296.55		-.08***	.08***	-.04*	.01	.00	.01	-.00
(3) Positive emotion	2.63	0.74			-.23***	-.06**	.08***	.11***	.08***	.14***
(4) Negative emotion	2.19	0.73				-.08***	.10***	.18***	.05**	.17***
(5) Cognitive reflection test	4.15	1.71					-.08***	-.12***	.07***	-.01
(6) Perceived accuracy– false headlines	2.05	0.42						.68***	.31***	.30***
(7) Sharing intention– false headlines	1.38	0.34							.24***	.58***
(8) Perceived accuracy– true headlines	3.09	0.39								.58***
(9) Sharing intention– true headlines	2.08	0.49								

Note. Daily new deaths and new cases were 7-day moving average. *$p < .05$, **$p < .01$, ***$p < .001$.

Table 3
Results of linear regressions for the relationships between the COVID-19 daily new deaths (7-day moving average) and emotions.

Predictor	Positive emotion	*p*	Negative emotion	*P*
	b (*SE*)		*b* (*SE*)	
Intercept	−0.000 (0.018)	1.000	−0.000 (0.018)	1.000
Daily new deaths	−0.087 (0.018)	<.001	0.062 (0.018)	<.001
Age	−0.045 (0.024)	.059	−0.074 (0.024)	.002
Gender	0.046 (0.018)	.012	−0.045 (0.018)	.014
Education	0.042 (0.019)	.025	−0.005 (0.019)	.806
Marital status	−0.079 (0.024)	.001	−0.023 (0.024)	.347
Income	0.051 (0.022)	.023	0.081 (0.022)	<.001
Population density	−0.075 (0.027)	.006	−0.009 (0.027)	.742
GDP	0.019 (0.028)	.483	−0.054 (0.028)	.050
R^2	0.022		0.015	
Adjusted R^2	0.020		0.012	

Note. Gender: 0 = female, 1 = male. Marital status: 0 = married, 1 = others.

replaced the daily new deaths with the daily new cases as the measure of the COVID-19 risk in each model and obtained the same results. Besides, our findings were also robust after controlling for the familiarity of the news headlines in each model. All the related analyses and results can be found in the Supplementary Materials (Tables S4 and S9).[3]

3.3.2. Truth discernment

We wanted to understand further how the COVID-19 risk and emotions predicted the perceived accuracy and associated information sharing intention for different types of information. We thus calculated the truth discernment score by subtracting the z scores of the perceived accuracy or sharing intention for the false headlines from the z scores for the true headlines. A larger discernment score indicates a higher level of overall truth discernment in the perceived accuracy (accuracy discernment) or sharing intention (sharing discernment) of the true versus false news headlines (Pennycook & Rand, 2019, 2020). We performed linear regressions with accuracy discernment and sharing discernment being the dependent variable separately. Similar to the analyses above, we calculated ICCs. The results showed that 0.8% (ICC = 0.008) of the total variance in accuracy discernment and 0.7% (ICC = 0.007) of the total variance in sharing discernment were associated with province, indicating that single-level analyses were appropriate. We then ran the linear regressions that included the daily new deaths, positive emotion, negative emotion, and control variables of age, gender, educational level, marital status, income, population density, and GDP. All variables were standardized. The results are presented in Table 5. We only found a significant relationship between negative emotion and accuracy discernment. Stronger negative feelings were associated negatively with

Table 4
Results of linear mixed-effects models for how the COVID-19 daily new deaths (7-day moving average) and emotions predicted the perceived accuracy of and the sharing intention for the news headlines.

Predictor	Perceived accuracy	*p*	Sharing intention	*p*
	b (*SE*)		*b* (*SE*)	
Intercept	−0.000 (0.066)	1.000	−0.000 (0.054)	1.000
Type	0.516 (0.066)	<.001	0.435 (0.053)	<.001
Daily new deaths	0.007 (0.006)	.206	−0.002 (0.008)	.849
Positive emotion	0.038 (0.008)	<.001	0.085 (0.010)	<.001
Negative emotion	0.041 (0.007)	<.001	0.108 (0.009)	<.001
Daily new deaths × Type	0.001 (0.004)	.793	−0.003 (0.005)	.462
Positive emotion × Type	−0.005 (0.007)	.521	0.022 (0.007)	.002
Negative emotion × Type	−0.013 (0.006)	.027	0.019 (0.006)	.005
Age	0.042 (0.008)	<.001	0.005 (0.010)	.631
Gender	−0.014 (0.006)	.017	0.014 (0.007)	.050
Education	0.023 (0.006)	<.001	−0.010 (0.008)	.195
Marital status	−0.018 (0.008)	.018	−0.025 (0.010)	.009
Income	0.005 (0.007)	.471	0.037 (0.009)	<.001
Population density	0.014 (0.009)	.119	0.005 (0.011)	.665
GDP	−0.003 (0.009)	.756	−0.003 (0.011)	.776
Marginal R^2	0.271		0.208	
Conditional R^2	0.483		0.474	
Random effects (*SD*)				
By participant				
Intercept	0.281		0.403	
Type	0.183		0.199	
By item				
Intercept	0.317		0.254	
Positive emotion	0.028		0.024	
Negative emotion	0.018		0.021	

Note. Type represents headline type, with 0 indicating false and 1 indicating true headlines. Gender: 0 = female, 1 = male. Marital status: 0 = married, 1 = others.

enhanced ability in distinguishing false headlines from true ones in the accuracy judgment. The results remained that same when we took the daily new cases as the COVID-19 risk measure in the models (see Table S5 in the Supplementary Materials).

3.4. Mediating effects of emotions on perceived accuracy, sharing intention, and truth discernment

3.4.1. Perceived accuracy and sharing intention

To examine whether the association between the COVID-19 risk and the perceived accuracy of the news headlines or the associated information sharing intention is mediated by positive and negative emotions, we estimated a series of mediation models. Given that participants

[4] For readers interested in the effects of specific emotions, we reported the associated mixed-effects model results for each specific emotion measured by PANAS in the Supplementary materials (see Tables S10–S13).

Table 5
Results of linear regressions for how the COVID-19 daily new deaths (7-day moving average) and emotions predicted the truth discernment.

Predictor	Accuracy discernment	*p*	Sharing discernment	*p*
	b (*SE*)		*b* (*SE*)	
Intercept	−0.000 (0.018)	1.000	−0.000 (0.018)	1.000
Daily new deaths	0.019 (0.018)	.295	0.000 (0.018)	.990
Positive emotion	−0.017 (0.019)	.374	0.014 (0.019)	.456
Negative emotion	−0.049 (0.019)	.008	−0.013 (0.019)	.478
Age	−0.012 (0.024)	.622	−0.034 (0.024)	.157
Gender	0.017 (0.018)	.365	−0.000 (0.018)	.996
Education	0.090 (0.019)	<.001	0.083 (0.019)	<.001
Marital status	−0.027 (0.024)	.259	−0.072 (0.024)	.003
Income	−0.029 (0.022)	.203	0.021 (0.022)	.346
Population density	0.064 (0.028)	.021	0.058 (0.028)	.036
GDP	−0.017 (0.028)	.533	−0.060 (0.028)	.029
R^2	0.013		0.015	
Adjusted R^2	0.010		0.011	

Note. Gender: 0 = female, 1 = male. Marital status: 0 = married, 1 = others.

responded to multiple news headlines, we took advantage of the 2-2-1 multilevel mediation model to account for the clustering of items in participants (Preacher et al., 2010). We tested the mediation models in which one "Level 2" variable (COVID-19 risk) predicted other "Level 2" variables (positive and negative emotions), which in turn predicted the "Level 1" variable (perceived accuracy or sharing intention). To count the correlations between positive and negative emotions, we developed the parallel multiple mediator models to explore the indirect effects of emotions, allowing us to estimate the indirect effect of each type of emotion by controlling for the effect of the other type of emotion. The daily new deaths entered as the measure of the COVID-19 risk in the mediation models. Additionally, age, gender, educational level, marital status, and income were control variables[4] in the models. All of the variables in the mediation models were standardized. We performed the analyses using the *lavaan* package in R (Version 3.1.2). A bootstrap confidence interval did not include zero, suggesting the existence of an indirect effect. Full model structures are available in the Supplemental Materials. The results are presented in Table 6.

We can find that both the positive and negative emotions mediated the relations between the daily new deaths and the perceived accuracy of the news headlines and between the daily new deaths and the associated information sharing intention regardless of the information veracity. For both the true and false headlines, it appears that when facing more daily new deaths, people tended to have lower levels of positive emotion. Accordingly, they showed lower ratings of information credibility and a lower likelihood of sharing the information. In contrast, more daily new deaths would connect with a higher level of negative emotion. As a result, people tended to show increased belief in all types of information and a higher likelihood of sharing the information. These results supported our hypothesis that there were indirect relations between COVID-19 risk and perceptions of the information accuracy and the associated information sharing intention through individuals' emotional states. Similar results were obtained when we further used the daily new cases to measure the COVID-19 risk (see Table S6 in the Supplementary Materials).

3.4.2. Truth discernment

To examine whether positive and negative emotions mediated the association between the COVID-19 risk and the truth discernment, we

Table 6
Results of the 2-2-1 multilevel mediation models testing the indirect relations between the COVID-19 daily new deaths (7-day moving average) and the perceived accuracy of the news headlines/the associated information sharing intention through the positive and negative emotions.

	Perceived accuracy		Sharing intention	
	False headlines	True headlines	False headlines	True headlines
	b (*SE*)	*b* (*SE*)	*b* (*SE*)	*b* (*SE*)
IV → M				
Daily new deaths → positive emotion	−0.076*** (0.018)	−0.076*** (0.018)	−0.076*** (0.018)	−0.076*** (0.018)
Daily new deaths → negative emotion	0.069*** (0.018)	0.069*** (0.018)	0.069*** (0.018)	0.069*** (0.018)
M → DV				
Positive emotion → perceived accuracy/ sharing intention	0.050*** (0.009)	0.037*** (0.009)	0.082*** (0.010)	0.100*** (0.011)
Negative emotion → perceived accuracy/ sharing intention	0.061*** (0.009)	0.031*** (0.009)	0.115*** (0.010)	0.124*** (0.011)
Direct effect				
Daily new deaths → perceived accuracy/ sharing	0.004 (0.009)	0.009 (0.008)	0.001 (0.009)	−0.001 (0.010)
Indirect effect				
Positive emotion	−0.004 (0.001) [−0.006, −0.002]	−0.003 (0.001) [−0.005, −0.001]	−0.006 (0.002) [−0.009, −0.003]	−0.008 (0.002) [−0.011, −0.004]
Negative emotion	0.004 (0.001) [0.002, 0.007]	0.002 (0.001) [0.001, 0.004]	0.008 (0.002) [0.004, 0.012]	0.009 (0.002) [0.004, 0.013]

Note. IV = independent variable. M = mediator. DV = dependent variable. The coefficients are standardized. The 95% bootstrap confidence intervals are in brackets. *$p < .05$, **$p < .01$, ***$p < .001$.

developed and estimated the parallel multiple mediator models with 5000 bootstrapped samples (Hayes, 2013; PROCESS macro v3.5 for SPSS version 25, model 4). Table 7 displays the mediation model results with the daily new deaths as the measure of the COVI-19 risk. All the models incorporated the control variables of age, gender, educational level, marital status, income, population density, and GDP, and all the variables were standardized. We can find the only mediating effect from the negative emotion that mediated the relation between the daily new deaths and the accuracy discernment. While facing more daily new deaths, people tended to show stronger negative feelings. The negative emotions were negatively associated with distinguishing false headlines from true ones in the accuracy judgment. The results partially supported our hypothesis regarding indirect relations between COVID-19 risk and truth discernment through both positive and negative emotions. The results remained the same when we took the daily new cases as the COVID-19 risk measure in the models (see Table S7 in the Supplementary Materials).

Furthermore, to find out whether the mediating effects of positive and negative emotions on the relation between the COVID-19 risk and the accuracy discernment depends on the analytic thinking ability, we developed and estimated a moderated mediation model with 5000

[5] As the multilevel mediation models did not converge when we included population density and GDP as control variables, we did not control these variables in the models.

Table 7
Results of the mediation models testing the indirect relations between the COVID-19 daily new deaths (7-day moving average) and the accuracy discernment/sharing discernment through the positive and negative emotions.

	Accuracy discernment	Sharing discernment
	b (*SE*)	*b* (*SE*)
IV → M		
Daily new deaths → positive emotion	−0.087*** (0.018)	−0.087*** (0.018)
Daily new deaths → negative emotion	0.062*** (0.018)	0.062*** (0.018)
M → DV		
Positive emotion → accuracy/sharing discernment	−0.017 (0.019)	0.014 (0.019)
Negative emotion → accuracy/sharing discernment	−0.049** (0.019)	−0.013 (0.019)
Direct effect		
Daily new deaths → accuracy/sharing discernment	0.019 (0.018)	0.000 (0.018)
Indirect effect		
Positive emotion	0.001 (0.002) [−0.002, 0.005]	−0.001 (0.002) [−0.005, 0.002]
Negative emotion	−0.003 (0.002) [−0.006, −0.001]	−0.001 (0.001) [−0.003, 0.002]

Note. IV = independent variable. M = mediator. DV = dependent variable. The coefficients are standardized. The 95% bootstrap confidence intervals are in brackets. *$p < .05$, **$p < .01$, ***$p < .001$.

bootstrapped samples (Hayes, 2013; PROCESS macro v3.5 for SPSS version 25, model 14). The model included CRT score (continuous) as a moderator and age, gender, educational level, marital status, income, population density, and GDP as the control variables. With the daily new deaths being the COVID-19 risk measure, the path coefficients in the model are summarized in Table 8.

The results confirmed the moderating effect of the analytic thinking ability that it moderated the indirect link between the COVID-19 risk and accuracy discernment via negative emotion. We further probed the conditional indirect effects at different levels of the CRT score (mean ± one SD). Among people with relatively high CRT scores, the relation between the negative emotion and the accuracy discernment became non-significant ($b = 0.007$, $SE = 0.027$, $p = .803$). Meanwhile, the indirect effect of the daily new deaths on the accuracy discernment via the negative emotion was also non-significant ($b = 0.000$, $SE = 0.002$, CI [−0.003, 0.004]). Comparatively, among people with relatively low CRT scores, increased negative emotion was associated with decreased accuracy discernment ($b = −0.080$, $SE = 0.025$, $p = .002$), and the indirect effect was significantly negative ($b = −0.005$, $SE = 0.002$, CI [−0.010, −0.001]).

Table 8
Results of the moderated mediation model testing the indirect relations between the COVID-19 daily new deaths (7-day moving average) and the accuracy discernment through the positive and the negative emotions moderated by the Cognitive Reflection Test (CRT) score.

	b (*SE*)
IV → M	
Daily new deaths → positive emotion	−0.087*** (0.018)
Daily new deaths → negative emotion	0.062*** (0.018)
M → DV	
Positive emotion → accuracy discernment	−0.005 (0.019)
Negative emotion → accuracy discernment	−0.037* (0.019)
Positive emotion × CRT → accuracy discernment	0.037* (0.019)
Negative emotion × CRT → accuracy discernment	0.043* (0.018)
Direct effect	
Daily new deaths → accuracy discernment	0.022 (0.018)
Index of moderated mediation	
Positive emotion	−0.003 (0.002) [−0.007, 0.0002]
Negative emotion	0.003 (0.001) [0.0003, 0.006]

Note. IV = independent variable. M = mediator. DV = dependent variable. The coefficients are standardized. The 95% bootstrap confidence intervals are in brackets. *$p < .05$, **$p < .01$, ***$p < .001$.

In addition, the bootstrap confidence interval for the index of moderated mediation for positive emotion included zero, meaning no definitive evidence of moderated mediation effect (Hayes, 2015). Besides, we also found a significant interaction between positive emotion and CRT. However, when further probing this interaction, we found that the correlations between positive emotion and accuracy discernment were not significant at either level of the CRT score ($ps > .10$). The results from the moderated mediation model with the daily new cases as the measure of COVID-19 risk were the same as those above and presented in Table S8 in the Supplementary Materials.

4. Discussion

The primary purpose of the current study is to find out why misinformation had been believed and disseminated so widely online during the COVID-19 outbreak. We investigated the relationships between COVID-19 risk and people's vulnerability to believing and their likelihood of sharing the COVID-19 information based on a nationwide survey in China during February and March 2020. Our findings identified the indirect effects of COVID-19 risk (measured by the 7-day moving average of daily new deaths or new cases) on people's accuracy judgment of the COVID-19 information and associated information sharing intention through people's emotional state. We also found an indirect relationship between COVID-19 risk and accuracy discernment via negative emotion. Our results regarding the stable mediating role of emotional state fit well with the Stimulus-Organism-Response (SOR) theory (Mehrabian & Russell, 1974) in environmental psychology. According to the SOR theory, the path from environmental stimulus to behavioral response goes through people's internal states, such as primary emotional responses. In other words, when people received the environmental stimulus during the COVID-19 outbreak (the COVID-19 risk), they first reacted with internal processes (induced emotional state). They then responded to the uncertain risk (trusting and sharing the COVID-19 information) in a sequential manner.

In line with our hypothesis and previous studies on the psychological impacts of severe pandemics (Lau et al., 2010; Qian et al., 2005; Shultz et al., 2016), we found that people faced with a higher level of COVID-19 risk experienced weaker positive feelings and stronger negative feelings. Additionally, the hypothesis that emotionality would associate with the extent to which people believe and share the COVID-19 information was supported. People with heightened emotionality would be more likely to trust and share the COVID-19 facts and misinformation regardless of the emotional valence. These findings were inconsistent with the assimilative-accommodative model (Bless & Fiedler, 2006) but in favor of the resource allocation model (Ellis & Ashbrook, 1988), indicating that both positive and negative emotions were associated with increasing uncritical acceptance of information. As suggested by the resource allocation model, people with higher levels of emotionality would have more irrelevant thoughts that interfered with their cognitive processing. According to our findings, this interference seems to be further associated with higher perceived accuracy of the COVID-19 information and a higher likelihood of sharing it.

For the political news, Martel et al. (2020) found that heightened emotionality would make people trust the fake news more but have no effect on their perceived accuracy of facts. Together with their findings, our results further suggested that heightened emotionality played a harmful role in trusting and sharing the COVID-19 misinformation during the COVID-19 outbreak. Inconsistent with the findings of Martel et al. (2020), we found emotionality positively related to trusting and being willing to share the COVID-19 facts. The difference might be

mainly attributable to the information type. It is easy to detect that a lot of the COVID-19 information online was about recommendations to prevent people from infecting (Tangcharoensathien et al., 2020). Therefore, we consider that people with heightened emotionality showed increasing belief in and sharing intention for both true and false COVID-19 information could be explained as a protective behavior. Our results also supported the review argument by Scheufele and Krause (2019) that heightened emotionality would make people trust and share more about the information that they want to believe.

Our hypothesis that both positive and negative emotions would associate with truth discernment was partially supported. For the truth discernment regarding accuracy judgment, we found that negative rather than positive emotion mediated the relation between the COVID-19 risk and accuracy discernment. People from regions with a higher level of COVID-19 risk displayed stronger negative feelings, which related to a lower accuracy discernment between facts and misinformation. However, the resource allocation model (Ellis & Ashbrook, 1988) assuming that negative emotions would play a similar role as positive emotions in vulnerability to misinformation could not account for these results. Furthermore, although we observed different truth discernment results between the negative and positive emotions, our results also rejected the assimilative-accommodative model (Bless & Fiedler, 2006). The negative relation between negative emotion and accuracy discernment in the present study denies that negative emotion would provoke analytic thinking as found in other studies (e.g., Forgas & East, 2008). To measure the level of COVID-19 risk that people might experience locally, we applied the epidemiological index to represent it in the present study. A higher level of COVID-19 risk would undoubtedly associate with stronger negative feelings. Therefore, we would argue that it is reasonable that negative emotions played a dominant role in influencing people's judgment during the COVID-19 outbreak.

For the truth discernment regarding sharing intention, neither positive nor negative emotion showed the mediating effect on the relation between the COVID-19 risk and sharing discernment. For the information accuracy judgment, it is easy to determine if people trust misinformation or not. However, for the information sharing intention, its measurement in the present study mixed with the situation that people are too careful to share the information even for that they trust. In such cases, the reason why they do not share the information is not that they could not distinguish facts from misinformation. On the contrary, they might have already demonstrated truth discernment between facts and misinformation. To confirm the existence of this phenomenon, we further examined the percentage of news headlines that were judged as very accurate but assigned to no sharing intention for the associated information (see Table S14 in the Supplementary Materials). The results showed that there were 10.5% false headlines and 7.9% true headlines that people judged as very accurate but still chose not to share. Besides, information sharing involves social interactions and would highly depend on with whom people share, the information content, as well as the motivation of sharing, such as being kind, knowledgeable, etc. It might also be attributable simply to personal preferences (Pennycook et al., 2021). Therefore, it is appropriate that negative emotion served as a mediator on the relation between the COVID-19 risk and accuracy discernment rather than between the COVID-19 risk and sharing discernment.

Furthermore, it is worth noting that the mediating effect of negative emotion on the relation between the COVID-19 risk and accuracy discernment disappeared among people with high analytic thinking ability. The finding is consistent with our hypothesis and existing evidence that analytic thinking plays a positive role in resisting misinformation and increasing truth discernment on social media (Pennycook & Rand, 2019; Ross et al., 2021). Our results suggest that analytic thinking could weaken the destructive relationship between negative emotion and discerning between true and false information during the COVID-19 outbreak. From the perspective of the interaction between emotion and cognition, our results imply that even though emotional responses are often considered a faster response to risk than cognitive responses, specific cognition could help buffer the negative effect from emotional responses.

In sum, the present study highlighted the negative effect of heightened emotionality on trusting and sharing online misinformation during the COVID-19 outbreak. Meanwhile, though stronger negative emotions accompanying the COVID-19 risk were associated with lower accuracy discernment, the analytic thinking ability could help moderate the destructive relationship. Additionally, the present study performed a comprehensive examination of the interactive effects of cognitive ability and emotional responses on believing and sharing online health information. It complements existing studies that the effects of emotion and reasoning on fake news perception were often studied separately (e.g., Martel et al., 2020; Pennycook & Rand, 2019; Ross et al., 2021). Besides, another strength of the present study is that our findings shed light on considering both the individual and environmental factors to discover the cause of the COVID-19 infodemic.

Based on a large sample, our findings also provide actionable insights for the policymakers to respond to the spread of misinformation during the pandemic. According to our results, analytic thinking could buffer the destructive relationship between negative emotion and truth discernment. Thus, it would be helpful to instruct people to engage more in analytic thinking while making judgments and decisions regarding the information on social media. Researchers have attempted to develop effective interventions to encourage reflection before the decision of sharing, such as shifting attention to accuracy (Pennycook et al., 2020, 2021), to reduce the sharing of misinformation.

Some limitations of the present study and future directions merit note. First, in the survey, sharing intentions were always asked after headline accuracy, which might introduce an "accuracy nudge" prior to sharing choice and impact participants' sharing decisions (Pennycook et al., 2020, 2021). Therefore, while the accuracy judgments were reliable in this study, the results of sharing intention would require cautious interpretation. Future research should measure sharing decisions separately. Second, information sharing intention measured in the present study could not distinguish two common sharing motivations. People might share misinformation to correct misinformation, and others might share misinformation because they could not discern between facts and misinformation accurately. Though there was evidence showing that self-reported sharing intention collected via online surveys was associated with actual shares on Twitter (Mosleh et al., 2020), the particular motivation of sharing had always been ignored and should be considered in future misinformation studies to help understand the spread of online misinformation more accurately. Third, we measured individuals' emotional states after the news headlines exposure and evaluation questions in the survey. It was likely that the news headlines could have impacted the measured emotional states. However, it is worth noting that we instructed participants to report their feelings during the past few days as the influence of the COVID-19 pandemic on emotions was enduring (Gruber et al., 2021). This instruction might help mitigate the potential influence of news headlines on emotional states. Nevertheless, future studies are recommended to counterbalance the order of measures of emotion and information exposure to eliminate the potential influence. Fourth, because of the timeliness of the COVID-19 information during the outbreak, we could not perform a pretest for the news headlines. However, we selected the true and false news headlines from the same websites, and our findings were robust after controlling for the familiarity of the news headlines. Fifth, over 70% of participants in our sample at least had a college degree. The proportion is much higher than that among the average citizens in China. However, this group of people is active users of social media. Given that misinformation spreads widely on social media (Wang et al., 2019), studying this population for infodemic management seems to be crucial. Nevertheless, different samples are still needed in future studies to assess the generalizability of our findings. Sixth, we calculated the estimates of COVID-19 risk with province-level data in this study. This particular

choice was because no complete data was available for us to use at each specific administrative division (e.g., city level). However, we expect to have complete city-level data in the future to confirm influences of the infectious disease and emotional responses on accuracy judgment and sharing intention for misinformation. Finally, because the truth discernment score was at the individual level, analyses regarding truth discernment had to use aggregated scores rather than item-level scores. However, using the aggregate item-level scores as individual-level scores would likely produce biased standard errors and inflate type-I errors.

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Declaration of competing interest

The authors declare no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chb.2022.107295.

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