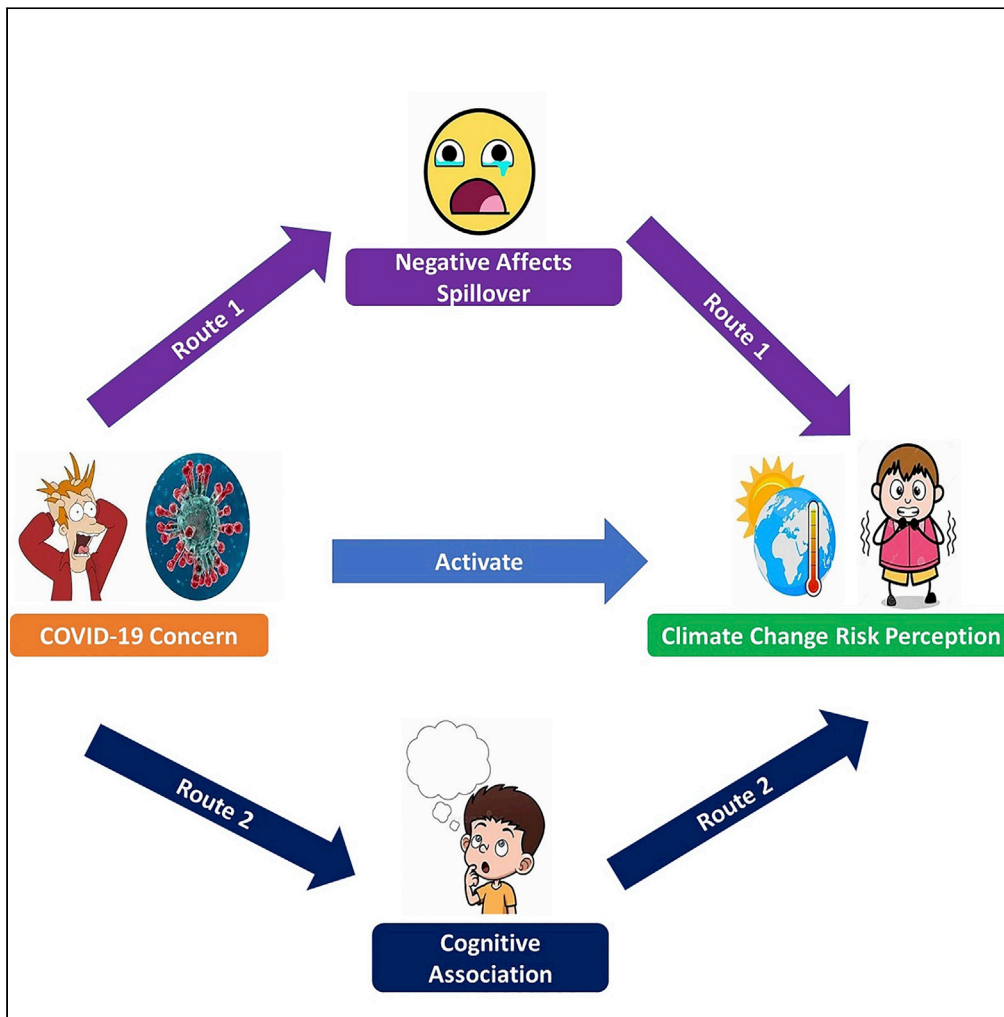


Article

Threats of COVID-19 arouse public awareness of climate change risks



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Highlights

Public COVID-19 risk perception arouses their climate change awareness

A longitudinal survey in China was conducted to verify this arousal effect

Generalized negative affect states explain the effect

Cognitive association also explains the effect



Article

Threats of COVID-19 arouse public awareness of climate change risks

Yuanhao Gong,^{1,2} Yang Li,³ Linxiu Zhang,^{4,5} Tien Ming Lee,⁶ and Yan Sun^{1,2,7,*}

SUMMARY

Public climate change awareness is indispensable to dealing with climate change threats. Understanding whether and how the COVID-19 pandemic impacts on individuals' climate change risk perception would thus be critical to green economic recovery. We conducted a longitudinal survey study in China when the pandemic was at its height and when it was mitigated. The cross-lagged analysis confirmed our assumed "arousal" effect of perceived COVID-19 risks on climate change risk awareness. We further tested and verified the proposed "dual-pathway" mechanisms of affective generalization (i.e., negative affective states aroused by COVID-19 "spillover" to the assessment of climate change risk) and cognitive association (i.e., the outbreak of COVID-19 awakens people's recognition of the human-nature-climate issues) via multiple mediation analyses. Our results implied that climate policies could be integrated into pandemic control, and that the public should be more awakened to confront multiple crises with proper guidance.

INTRODUCTION

According to the Sixth Assessment Report on the physical science basis of climate change of the Intergovernmental Panel on Climate Change, the scientific community has strengthened its consensus that climate change would further intensify in terms of frequency and severity without proper responses (Arias et al., 2021). Worse still, the emergence of COVID-19 pandemic (although the World Health Organization (WHO) declared COVID-19 as a "pandemic" on March 11, 2020, and this time point was amid our survey (after the first wave of the survey but before the follow-up), in order for consistency, we refer to COVID-19 as a "pandemic" throughout the paper) at the close of 2019 may have exacerbated the challenges of tackling global climate change (Phillips et al., 2020). Besides the obstacles facing climate policy measures, whether and how the onset of a similarly calamitous threat of COVID-19 influences people's attitude of the lurking threat of climate change is one of the crucial prerequisites for successful policy implementation and risk management, yet it has received scarce research attention (Bostrom et al., 2020). Here, we focus on the heightened impact of perceived COVID-19 risk on people's awareness or alertness of climate change crisis (or as we put it in the following sections, the COVID-19 serves as a risk "arousal" for climate change), and further test two proposed pathways to the "arousal" effect. Considering the other emerging high-consequence biological threats concurrent with climate change nowadays, such as the recent evolving spread of monkeypox of global relevance (Bunge et al., 2022), scientists and policy makers are obliged to understand public attitude toward multiple intertwined crises in order to maximize coordinated responses.

Perceived COVID-19 risk "arouses" climate change threat awareness

Despite of its severity and urgency, climate change is usually deprived of its salience for laypeople in most of the time, because it tends to be perceived as happening elsewhere, to others, and in the future (i.e., psychologically distant) (Spence et al., 2012). However, the occurrence of some extreme events that vividly signal the dangers of climate change would arouse people's concern about climate change threats from their usual ignorance of the issue. For example, extreme weather events in local areas—such as floods (Spence et al., 2012), temperature abnormalities (Zaval et al., 2014), hurricanes (Rudman et al., 2013), heat-waves (Dai et al., 2015), storms (Demski et al., 2017), and hot dry days (Marlon et al., 2021)—would significantly increase people's climate change concern, motivating adaptive and mitigative actions.

Besides the direct climate change concern "arousal" by warning signals from the climatic system, emerging evidence has implied that the COVID-19 pandemic could probably also serve as an alert to people's climate change risk perception. For example, a national survey experiment in the USA found that

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respondents who were supportive of the policies aiming for pandemic control were disproportionately more willing to accept policies combating climate change risks (Bostrom et al., 2020). More direct evidence comes from the longitudinal data in a UK national survey before and after the outbreak of the COVID-19 pandemic. Public climate change belief increased after the pandemic outbreak, and people tended to identify climate change as a bigger threat than the COVID-19 pandemic during a rather severe phase of the outbreak (Evensen et al., 2021).

Cross-national research added more support to display the pandemic's awakening impact on people's climate change awareness. For instance, in a nationally representative survey including 28 European countries, individuals' fear of COVID-19 was found to be positively associated with climate change awareness and risk perceptions (Stefkovics and Hortay, 2022). More strikingly, results of a cross-national survey (Sisco et al., 2020) revealed that worry about COVID-19 would lead to higher support for climate change policies implying "spillover" of the COVID-19 worry to climate change worry.

These findings that COVID-19 might reverse individuals' indifference to climate change crisis, to some extent, reflect the rationale underlying the "social amplification of risk" (Kasperson et al., 1988), which demonstrates that perception of risk has extended negative impact on other spheres of the society. For example, perceived risks of terrorism might signal disasters everywhere, thus producing strong psychological responses to other types of mishaps, like the ripples spreading outward from the stone (i.e., the initial extreme event) dropped in a pond (Slovic and Weber, 2002). More closely related, Mi et al.'s research has suggested that the COVID-19 arouses public's emergency relevance perception as well as environmental affective reactions, which in turn contribute to an increased sense of necessity to cope with other environmental issues (Mi et al., 2021). In a similar way, we propose the "arousal" or "trigger" effect of the sudden extreme event (i.e., the COVID-19 pandemic) on consequent psychological impact (i.e., improvement in climate change risk perception). We hypothesize that the perceived threats of the COVID-19 pandemic would arouse people's alertness to climate change risks.

Affective generalization

Extant research has shown that the affective factor contributes greatly to individual perception of climate change risk. In the integrative climate change risk perception model, affect is the strongest single predictor of climate change risk perception (Van der Linden, 2015). According to the "affect heuristic" (Finucane et al., 2000; Slovic et al., 2002, 2004; Slovic and Peters, 2006), people tend to make risk assessments based on their instant feelings and affective states (Johnson and Tversky, 1983), and the more negative the instant feelings are, the higher risk people would perceive toward the target threat (Slovic and Peters, 2006). As a result, risk perception of a certain threat might be partially misattributed to the feelings aroused by another previous threat. For example, reading a sad story (e.g., a fatal stabbing) could increase the subsequent frequency estimates of closely related (e.g., homicide) or even not-directly related risks (e.g., natural hazards) (Johnson and Tversky, 1983; Lee et al., 2010; Slovic and Peters, 2006).

At the time of the COVID-19 outbreak, individuals received an excessively large amount of pandemic-related information from media coverage (Sheehan and Fox, 2020) which would lead to increased health risk perceptions (Kalichman, 1994), and these health risks, combined with social distancing, have caused multiple negative psychological impacts, such as anxiety, depression, and other negative emotional responses (Brooks et al., 2020). Consequently, when assessing risks of climate change under the COVID-19 threats, negative affective responses might be generalized, which may lead to elevated perceived risk of climate change compared to pre-pandemic.

Preliminary research findings have uncovered the potential spillover of negative affective states caused by COVID-19. For instance, research revealed that worry about COVID-19 would increase climate change worry, and that personal negative experience with COVID-19 was associated with climate change worry (Sisco et al., 2020), indicating a generalization of the negative emotion, "worry", from COVID-19 to climate change. The results of the cross-national survey in Europe also showed that fear triggered by COVID-19 could affect climate change awareness, concerns, and perceived negative consequences of climate change (Stefkovics and Hortay, 2022). Accordingly, we hypothesize that the arousal effect of perceived COVID-19 risk on climate change risk awareness is mediated by negative affective states generated by the pandemic.

Cognitive association

Climate change and COVID-19 are markedly similar in terms of causes, consequences (Botzen et al., 2021), and requirement for immediate government intervention (Goulder, 2020). More specifically, climate change and the pandemic are both caused, at least partially, by inappropriate human-nature interactions (such as intruding into wild animals' territory and emitting way too much CO₂ into the atmosphere). Meanwhile, they have both led to tremendous disaster to both the ecological and the human society systems, thereby in need of effective and immediate collective actions worldwide as coping strategies.

Besides shared roots and manifestation, the two crises are also inevitably intertwined and mutually affected by one another. On the one hand, with dramatically declined transport and altered pattern of consumption due to home confinement, by early April 2020, daily global annual CO₂ emissions was estimated to have decreased by 17% compared with the 2019 mean level (if some social restrictions could remain to the end of this year, the annual CO₂ emissions could be reduced by up to 7%) (Le Quéré et al., 2020) and the emission fall would be more than any year on record (Hepburn et al., 2020), while NO_x emissions also declined by as much as 30%, contributing to a cooling effect as well (Forster et al., 2020). However, the heating trend of climate never stops (United in Science 2020, 2020), and these seemingly positive effects on the mitigation of climate change by the pandemic are predicted to be temporary and even negligible if not accompanied by long-term supportive policies and practice (Forster et al., 2020; Hepburn et al., 2020; Le Quéré et al., 2020). In fact, the pandemic would pose drastic threats to climate change at the same time because sustainable development depends on sustained economic growth and globalization which have been going through crisis since COVID-19 outbreak (Naidoo and Fisher, 2020).

Climate change would also in turn intensify the negative consequences of COVID-19. Directly, global warming might have provided more suitable conditions for infectious diseases to outbreak (Altizer et al., 2013); indirectly, migrations driven by climate stressors (Abel et al., 2019) leave numerous homeless people who live in refugee camps without proper social distancing strategies or healthcare extremely vulnerable to epidemics (Phillips et al., 2020). Actually, climate change and the pandemic are markedly similar in terms of devastating global impacts and demand for immediate government intervention (Goulder, 2020). Therefore, tackling climate change problem amid the pandemic and facilitating green socioeconomic recovery programs that address climate mitigation and other environmental goals has received increasing attention from policy makers and scholars (Barbier, 2020).

These objectively existing innate associations between climate change and the pandemic might have helped the public perceive less abstractness of climate change. This might partially result from scientists' and environmentalists' effort to communicate the links between pandemics and global environmental change (including climate change) (Rillig et al., 2021), which in turn contributes to cultivation of the public's "systems thinking". Simply put, systems thinking is a cognitive paradigm that involves individual's understanding of the whole environment (i.e., the society, nature, economic world, and all sorts of occurring phenomena as parts of an intertwined dynamic system (Davis and Stroink, 2016; Randle and Stroink, 2018)), which lays important foundation for individuals' climate change attitude and perception (Ballew et al., 2019). Research has indicated that cultivating individuals' systems thinking through education could increase understanding of climate change (Pallant et al., 2012).

For instance, the "One Health" approach (Messmer, 2020), recognizing that human beings' health is closely linked to the health of animals, plants, and our shared environment, is one of the hottest topics of public communication. This conceptual information is prevalent on mass media during the COVID-19 pandemic (e.g., Anwar et al., 2020). As people tend to seek information in times of public health crises to mitigate concerns or uncertainties (Lu, 2003), we infer that individuals' perceived risk of COVID-19 would trigger the understanding of (or cognitive association with) "unity of man and nature", thereby awakening their awareness of the climatic issue. For instance, people can learn from the social media that climate change worsens the health of the whole ecological system, which in turn causes more zoonosis that harms the health of animals as well as human beings. As a result, they might be induced to rethink the potential shared roots of the pandemic and climate change.

Recent research has indicated the promising fostering effect of individual's pandemic risk awareness on the realization of risks in the entire natural world, such as climate change risks (i.e., sensing pandemic risks might have elevated risk perception of climate change). For instance, an online survey in the U.S.A.

Table 1. Descriptive information of key variables across time (N = 1,266)

	T1		T2		t (df) ^a	p	Cohen'SD
	M	SD	M	SD			
COVID-19 risk perception	6.18	0.80	6.08	0.83	4.37 (1,265)	<0.001	0.12
Climate change risk perception	5.82	0.97	5.91	0.85	-3.52 (1,265)	<0.001	-0.10
Negative affective responses	4.71	1.22	4.29	1.38	12.72 (1,265)	<0.001	0.32
Cognitive association	5.55	0.92	5.52	0.94	1.24 (1,265)	0.22	-

^apaired-samples t tests.

revealed that people perceived a lot of similarities between COVID-19 and climate change risks, and this might be responsible for the positive relationship between public policy support for addressing COVID-19 and climate change (Bostrom et al., 2020). Similarly, a cross-national survey revealed that people who explicitly perceived more similarity between COVID-19 and climate change also had greater climate change awareness (Sisco et al., 2020). Nevertheless, longitudinal data would be necessary to test the causality as well as the associated cognitive mechanism. Based on the above reasoning, we further hypothesize a cognitive pathway where the arousal effect of perceived COVID-19 risk on climate change risk awareness is mediated by aroused cognitive association between the pandemic and climate change.

Experts in related fields, such as climate science, epidemiology, and policy-making have reached a consensus that the two crises should be confronted in a compounding way (Botzen et al., 2021; Phillips et al., 2020). To date, there has only been limited number of studies on whether and how public risk perception of the COVID-19 pandemic affects climate change awareness. Specifically, their causal relationship has not been disentangled, since the bulk of extant research has been based on cross-sectional data, therefore making the findings purely correlational in nature (Bostrom et al., 2020; Stefkovics and Hortay, 2022) and rendering the mechanism unexamined (Evensen et al., 2021; Sisco et al., 2020). Our research makes 2-fold contributions by (1) confirming the causal relationship between COVID-19 and climate change risk perception (i.e., the "arousal" effect) with longitudinal panel data from a large-scale survey, and (2) examining the hypothesized affective and cognitive pathways as the potential mechanisms.

RESULTS

Given the actual situation in China that the COVID-19 pandemic was on the mend during the time when the survey was conducted, the public risk perception of COVID-19 (Height phase of the pandemic, T1: $M = 6.18$, $SD = 0.80$; Mitigation phase, T2: $M = 6.08$, $SD = 0.83$; $t(1,265) = 4.37$, $p < 0.001$, Cohen'SD = 0.12) and negative affective responses (T1: $M = 4.71$, $SD = 1.22$; T2: $M = 4.29$, $SD = 1.38$; $t(1,265) = 12.72$, $p < 0.001$, Cohen'SD = 0.32) were both in decline (Table 1). On the contrary, climate change risk perception increased significantly (T1: $M = 5.82$, $SD = 0.97$; T2: $M = 5.91$, $SD = 0.85$; $t(1,265) = -3.52$, $p < 0.001$, Cohen'SD = -0.10; Table 1). And cognitive association on pandemic-related issues remained at the same level with the mitigation of the pandemic (T1: $M = 5.55$, $SD = 0.92$; T2: $M = 5.52$, $SD = 0.94$; $t(1,265) = 1.24$, $p = 0.22$; Table 1).

We then explored the relationship between COVID-19 risk perception and climate change risk perception. At each time point, the correlations between COVID-19 risk perception and climate change risk perception were significant and positive (T1: $r = 0.33$, $p < 0.001$; T2: $r = 0.45$, $p < 0.001$). Since age, gender (Lawson et al., 2019; Van der Linden, 2015), and income (Akerlof et al., 2013) are potential socio-demographic factors influencing individual climate change risk perception, we also included these demographical variables in the following analyses. From our cross-lagged model, after controlling for demographical variables and psychological covariates, we were able to determine the causal relationship between the two variables ($\chi^2(46) = 1698.29$, $p < 0.001$; CFI = 0.32; RMSEA = 0.17, 90% CI [0.16, 0.18]; Figure 1). Consistent with our hypothesis, COVID-19 risk perception at T1 did have a significant positive effect on climate change risk perception at T2 ($\beta = 0.17$, $p < 0.001$), but the reverse effect was absent (climate change risk perception at T1 on COVID-19 risk perception at T2; $\beta = 0.03$, $p = 0.17$). As such, the positive main effect of COVID-19 risk perception's "arousal role" in activating climate change alertness (i.e., H1) was supported.

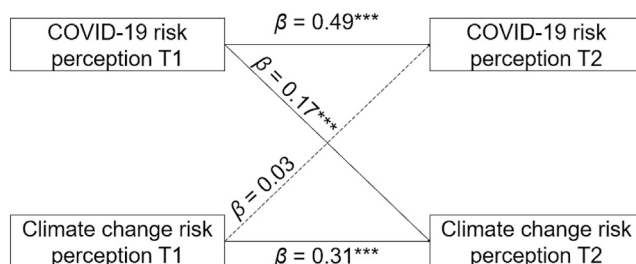


Figure 1. Standardized associations between COVID-19 risk perception and climate change risk perception over time.

Solid lines represent significant paths and the dotted line represents a non-significant path. *** $p < 0.001$.

We next examined the two proposed mechanisms of negative affective responses and cognitive association. We regarded the COVID-19 pandemic as a natural experiment and investigated the effect of COVID-19 risk perception on climate change risk perception by testing whether the change of the former was causally associated with the change of the latter (Van der Linden et al., 2015). As displayed in the results in Table 2 and illustrated in Figure 2, after controlling for demographical variables and psychological covariates, the total effect ($B = 0.27$, $SE = 0.03$, $p < 0.001$) and the direct effect ($B = 0.22$, $SE = 0.03$, $p < 0.001$) of change in COVID-19 risk perception on change in climate change risk perception were significantly positive, adding further evidence to the causal relationship revealed by the cross-lagged analysis. Although the trends of COVID-19 risk perception and climate change risk perception were in opposite directions (i.e., COVID-19 risk perception decreased from T1 to T2 while climate change risk perception increased during the same time period), the longitudinal change of the two risk perceptions was synchronized. That is to say, the more a person stayed alert to the pandemic threats (i.e., less decrease in COVID-19 risk perception over time), the more the person could also stay abreast of the latent climate change dangers (i.e., increased risk perception in climate change over time).

For our mediation analyses, we found that the association between change in COVID-19 risk perception and change in negative affective responses ($B = 0.25$, $SE = 0.04$, $p < 0.001$) and cognitive association ($B = 0.18$, $SE = 0.03$, $p < 0.001$) were also significantly positive; both also had significantly positive association with change in climate change risk perception ($B = 0.08$, $SE = 0.02$, $p < 0.001$ and $B = 0.17$, $SE = 0.03$, $p < 0.001$, respectively) (Table 2). We tested significance of their indirect effects with bias-corrected bootstrapping set at 5,000 to yield 95% confidence intervals (CIs) using PROCESS (Version 3.0), model 4 (Preacher and Hayes, 2008). The indirect effects via changes in negative affective responses ($\beta = 0.02$, $SE = 0.01$, 95% CI = [0.01, 0.04]) and cognitive association ($\beta = 0.03$, $SE = 0.01$, 95% CI = [0.02, 0.05]) were significant, supporting our H2 and H3, so was the total indirect effects ($\beta = 0.05$, $SE = 0.01$, 95% CI = [0.03, 0.08]). To summarize, our results imply that if people remain more alert to the pandemic threats overtime, they would also maintain more negative affective state and reflect more on the association between the pandemic and related human-nature issues. As a result, they eventually possess higher awareness of climate change threats.

DISCUSSION

In the last couple of years, preliminary research had provided some evidence that the emergence of the COVID-19 pandemic might have stirred individuals' usual indifference to the constantly lurking threat of climate change (e.g., Bostrom et al., 2020; Evensen et al., 2021; Stefkovics and Hortay, 2022; Sisco et al., 2020), and awareness of, belief in, as well as concern about climate change have been thus elevated. Yet, potential causal relationship between the two risk perceptions had not been evaluated. The current research built on these exploratory studies in carrying out a large-scale longitudinal survey and applying a cross-lagged panel analysis to demonstrate such causality. Consistent with these preliminary investigations, we confirmed the arousing role of COVID-19 risk perception on alertness to the threats of climate change. On the one hand, higher perceived risk of COVID-19 would bring about higher awareness of climate change risk over time; on the other hand, change in climate change risk perception was, to some extent, attributed to change in the perceived dangers of COVID-19 (i.e., a lesser drop in the latter led to higher maintained level of the former).

Table 2. Effects of Δ COVID-19 risk perception on Δ climate change risk perception^a

	Δ Negative affective responses (B/SE)	Δ Cognitive association (B/SE)	Δ Climate change risk perception (B/SE)
Δ COVID-19 risk perception	0.25 (0.04)***	0.18 (0.03)***	0.22 (0.03)***
Gender ^b	0.001 (0.07)	-0.04 (0.05)	-0.03 (0.05)
Age	-0.01 (0.01)	-0.01 (0.004)	-0.003 (0.004)
Monthly income (CNY) ^c			
3,000–6,000	-0.13 (0.10)	-0.14 (0.07)*	0.14 (0.07)
6,000–10,000	-0.13 (0.10)	-0.07 (0.07)	0.02 (0.08)
10,000–30,000	-0.24 (0.14)	-0.06 (0.10)	-0.03 (0.11)
>30,000	0.24 (0.68)	0.91 (0.47)	-0.40 (0.51)
Ecological worldview (T1)	-0.14 (0.02)*	-0.01 (0.05)	-0.15 (0.05)**
Connectedness with nature (T1)	-0.02 (0.02)	0.003 (0.01)	0.01 (0.02)
Climate change knowledge (T1)	0.01 (0.02)	0.01 (0.02)	-0.06 (0.02)***
Δ Negative affective responses			0.08 (0.02)***
Δ Cognitive association			0.17 (0.03)***
R^2	0.05	0.05	0.12
F	6.25	6.27	13.54
p	<0.001	<0.001	<0.001

*p < 0.05; **p < 0.01; ***p < 0.001.

^aAll the coefficients are unstandardized.

^b0 = male, 1 = female.

^c"< 3,000" was set as reference.

Currently, the rapid spread of the more infectious and transmissible variants, such as Omicron and Delta, renders the situation of pandemic control worldwide fairly grim (Callaway, 2021). However, our study suggests that, meanwhile, the public risk perception of climate change may have leveled up. The increased public alertness to climate change, thus, might benefit the global post-pandemic green recovery (Barbier, 2020). Therefore, climate communication should integrate public concern for the pandemic to inspire more awareness and behavioral intention.

For example, while the media worldwide have been devoted to covering climate change-related issues (Hase et al., 2021), they might have limited effects on profound behavioral change because they tend to focus on specific adaptation as a response to immediate climate change threats (Richler, 2020). We think it would be insightful to combine update of the pandemic to climate change coverage so as to inform the public of the inseparableness of the whole natural system (for example, news coverage could communicate the information that climate change might cause pathogen sealed in the permafrost to be released (Wu et al., 2022) thereby higher risks of other pandemics resembling COVID-19). If the public are thus more capable of connecting these two types of risks in this way, instead of simply passively responding to climate change every time it causes visible threats (Richler, 2020), they might be motivated to take more thorough actions to combat climate change.

In the study of human cognition, the "dual-process" theory of thinking, knowing, and information processing pointed out that people comprehend reality with two fundamental systems (Kahneman and Frederick, 2012), the intuitive (i.e., heuristic and experiential) and the analytical system (i.e., logical and conscious), and these two systems also play important roles in risk assessments (Loewenstein et al., 2001). Echoing this perspective, affectively, we found that less decrease in COVID-19 risk perception overtime (i.e., sustained level of alertness to COVID-19 threats) led to less decline in negative affective responses (i.e., sustained level of COVID-19-caused affective states), and this in turn resulted in more increase in climate change risk perception (i.e., a more stably high level of climate change risk awareness). That is to say, even seemingly unrelated affect triggered by an anterior threat has the potential to heuristically alter risk assessment of a subsequent threat (i.e., the impact of the "generalized affect") (Slovic et al., 2004).

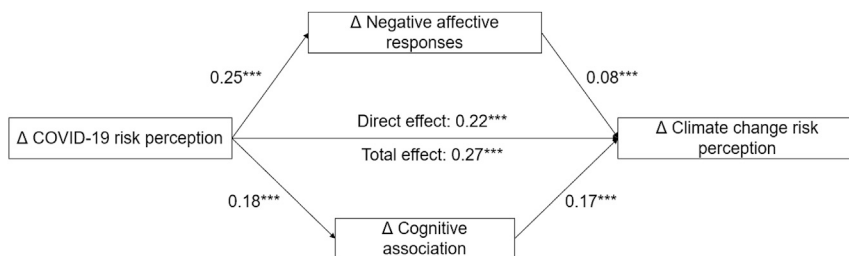


Figure 2. Mediation model with unstandardized coefficients (controlling for demographic variables and psychological covariates)

*p < 0.05; **p < 0.01; ***p < 0.001.

As has been warned by the World Health Organization, the COVID-19 pandemic would be with us for a long time (<https://www.cnbc.com/2020/04/22/world-health-organization-warns-coronavirus-will-be-with-us-for-a-long-time.html>), and local outbreaks occur constantly worldwide. Under this circumstance, the negative affective responses might linger as well. Although it is indispensable to relieve the public's unsettling mental states, it might also offer opportunities for climate communications. For instance, with heightened negative emotions generalized to domains beyond the pandemic, such as worry or anxiety, "motivated reasoning" (Druckman and McGrath, 2019) might cause people to accept the education about the severe consequences of climate change more readily, especially considering the fact that there is still a lack of climate change manifestation in some regions of the world (Leiserowitz et al., 2022). As demonstrated in Mi et al.'s study (2021) that people would perceive "the cognition of COVID-19 emergency makes me scared about the consequences of environmental damages", the negative affective reactions combining the pandemic and other environmental crises could be utilized in public education; for example, the media or other communication platforms could explicate to the public that "if no effective actions are taken against climate change, currently felt fear of the COVID-19 pandemic would also be the emotion attacking you when disastrous consequences of climate change occur".

The cognitive pathway focused on the analytical process could cause people to strengthen their awareness of the climate crisis because of their perceived risk of the pandemic. According to the dimensions based on which people usually characterize and evaluate hazardous events, a risk is judged as a combination of being unknown as well as dreaded (Slovic, 1987). When a risk is more familiar to people and when the risk can incur more dreadful consequences, it might signal more indirect harms for organizations (Slovic, 1987). Besides the direct impact of the outbreak of COVID-19 on infection risk perception and corresponding self-protecting health behaviors (Papageorge et al., 2021), it might have indirectly reduced the abstractness of climate change with a "close-up" or "firsthand experience" of hazards and have made people reflect over the disaster as an integrated human-nature system, extending the "signal" across different risks. As a result, risk analysis of climate change might become more sensitive, particularly if the similarities between COVID-19 and climate change are activated. Our novel result offered some preliminary evidence that perceiving COVID-19 risks would stimulate people to cognitively associate climate change with COVID-19, pointing to a "ripple effect" cognitive activation of assessing climate change risks.

Accordingly, public education during the pandemic time could be devoted to addressing the similarities between the two crises, such as human-caused origin, global consequences, and requirement of collective responses (Goulder, 2020), and also guide individual reflection on the interrelationship between the sustainable development of human society and protection of nature. Significantly, "One Health" (Messmer, 2020) education should be receiving more attention and better implementation both in schools and society, and on social media platforms. Particularly, people should be informed that any glitch of the natural system would eventually threaten well-being of human beings, and that the pandemic is a vivid demonstration of this interrelationship. Besides, cognitive route should suggest environmental communicators that in the era of incremental worldwide zoonosis (such as the recent monkeypox outbreak (Bunge et al., 2022)), linking the COVID-19 pandemic with other zoonosis and with climate change might ultimately enhance public climate action, if explicit knowledge education and behavioral guidance are provided.

Limitations of the study

There are also several limitations to be addressed so as to inspire future research. First, this work was conducted in China, where awareness of climate change is high and not affected by political polarization (Zheng et al., 2017). However, whether the discovered pattern would also fit other nations remains yet to be examined, especially for western countries with apparent difference in climate change beliefs across the political ideology span, such as the United States (McCright et al., 2016a) and some European countries (McCright et al., 2016b). Given the fluctuant recurrence of the pandemic worldwide, we think it is of critical importance to continue digging into the detected relationship with cross-country comparisons. For example, works could be done to explore whether people of different climate change belief baseline levels or of opposite political ideology stances would maintain, alter, or present different robustness of the discovered pattern of pandemic risk perception and climate change risk perception.

Besides potential regional differences, we highly suggest further examination of more diversified population, given the relatively limited diversity of sample composition (e.g., young, urban, and well-educated participants take up the majority of the survey sample) largely due to an online study design (e.g., Wang et al., 2020a). In the post-pandemic era, mixed-method research is made more possible with more effective pandemic control measures, so studies like field surveys targeting rural residents or interviewing adolescent school students should be carried out with delicate design. In addition, this study was conducted after the outbreak of the COVID-19 pandemic, and data of pre-pandemic baseline of climate change risk perception were not collected. However, future exploration could examine this discovered “risk perception spillover” and the underlying mechanism in other types of large-scale threats, such as environmental pollution.

Additionally, the current study only looked at the “severity” dimension of risk perception for the two threats, while researchers have assessed other dimensions, such as likelihood, preparedness (Mondino et al., 2020), and controllability (Ning et al., 2020), of COVID-19 risk perception. Although assessment of other dimensions would not nullify the discovery of the current study, we think it is interesting to investigate deeper into whether and how intricate evaluation of multiple risk perception dimensions of these two threats would interact, and it might even offer further guidance on how to better prepare the public for impending worse climate disasters in multi-risk context nowadays.

STAR★METHODS

Detailed methods are provided in the online version of this paper and include the following:

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 - Data analysis

SUPPLEMENTAL INFORMATION

Supplemental information can be found online at <https://doi.org/10.1016/j.isci.2022.105350>.

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AUTHOR CONTRIBUTIONS

Conceptualization, G.Y.C., L.Y., and S.Y.; Methodology, G.Y.C. and S.Y.; Investigation, G.Y.C., L.Y., and S.Y.; Writing – Original Draft, G.Y.C.; Writing – Review & Editing, G.Y.C., L.Y., Z.L.X., L.T.M., and S.Y.; Funding Acquisition, S.Y.; Resources, G.Y.C., L.Y., and S.Y.; Supervision, S.Y.

DECLARATION OF INTERESTS

The authors declare no competing interests.

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STAR★METHODS

KEY RESOURCES TABLE

REAGENT or RESOURCE	SOURCE	IDENTIFIER
Software and algorithms		
IBM SPSS Statistics 21	IBM Passport Advantage® Web Site	https://www.ibm.com/analytics/spss-statistics-software
IBM SPSS Amo 21	IBM Passport Advantage® Web Site	https://www.ibm.com/support/pages/downloading-ibm-spss-amos-21

RESOURCE AVAILABILITY

Lead contact

Further information and requests for resources should be directed to and will be fulfilled by the lead contact, Yan Sun (suny@psych.ac.cn).

Materials availability

This study did not generate new unique reagents.

Data and code availability

All original data is available for academic purposes upon reasonable request from the [lead contact](#).

METHOD DETAILS

Participants and procedure

The longitudinal panel survey was conducted online on the platform Credamo in China. The survey was first conducted at the height of the pandemic (i.e., 12 to 25 February 2020; T1), when the peak in incidence was identified (Zou et al., 2020). A total of 1,499 out of the collected 1,737 responses were deemed valid (the screening of validity was based on the criteria that (1) all questions should be answered and that (2) the ‘checking’ item should be answered correctly in order to ensure that the participants take the survey seriously; the wording of the checking item: “This is a checking item. Please choose ‘3’ as the answer. The follow-up survey (i.e., 25 to 28 March 2020; T2) took place when the domestic transmission of the pandemic was basically under control in China (Su et al., 2021), attracting a total of 1,266 out of the original 1,499 participants (a re-interview rate of 84.46%). As such, our analyses were based on the 1,266 participants’ longitudinal data (see [Table S1](#) in Supplemental Information). Significantly, for all the 1,266 participants, 1,254 of them had heard of climate change (99.1%) and 1,245 believed that climate change was happening (98.3%), indicating that climate change had become a consensus for the general public in China. This survey received Ethical Approval from the Chinese Academy of Sciences.

Specifically, participants were first provided with the survey guidance and informed of the approximate time (10 minutes) required to finish the questions. Next, measures of risk perception (COVID-19 and climate change), negative affective responses, and cognitive association were presented randomly (the core variables of the survey). Then, we also collected data of psychological covariates and socio-demographic information. Finally, they were debriefed and received the monetary reward of ¥2.

Measures

COVID-19 and climate change risk perception

By definition, risk perception is the individual’s judgement of the likelihood that a consequent loss would occur and of the consequence seriousness (Fischhoff et al., 1978). In the current study, we focused exclusively on the latter dimension (i.e., severity/consequence) of COVID-19 risk perception based on reasons from two perspectives. On the individual level, these two risks threat people in different ways—while currently people are surrounded by potential sources of infection and might get affected at any time and any place, the chances of encountering perceptible and visible negative consequences of climate change are much smaller. On the macro level, the pandemic is undergoing a massive outbreak worldwide, but disasters directly related to climate change occur sporadically in a certain place. In order to be consistent, the construct and wording of the items for the two variables are the same except for the target of the risks; that is, “COVID-19” was replaced with “climate change” when measuring climate change risk

perception. Adapted from Yu and Xie's risk assessment system (Yu and Xie, 2006) and referring to measurement of COVID-19 risk perception in extant research (Gong et al., 2021), we assessed individuals' risk perception of the pandemic and climate change with a total of three items—self-reported severity, perceived others' severity perception, and perceived strength of the risk's impact.

Negative affective responses

Numerous studies have confirmed the negative effect COVID-19 posed on individual emotional well-being and that discrete emotions approach is more informative than overall emotional well-being measures. Therefore, echoing Yang and Chu (2018) who examined how discrete negative emotions might impact epidemic risk perception, we also measured the five emotions respectively, which are also among the most frequently experienced negative emotional responses during the COVID-19 pandemic, including fear (Schimmenti et al., 2020), anxiety (Arapaci et al., 2020), anger (Brooks et al., 2020), disgust (Miłkowska et al., 2021) and sadness (Wang et al., 2020b).

Cognitive association

The cognitive pathway was examined by measuring whether and how much people had been thinking about the interconnection between human beings and the natural world. More specifically, we asked about people's reflection on the interrelationship among human beings, the pandemic, wild animals, nature systems.

Psychological covariates

We also measured three psychological covariates that might influence climate change risk perception. First, individual's ecological worldview has been proven to have positive association with climate change risk perception (Hornsey et al., 2016; Xiao et al., 2018). It was measured with the revised version of the New Ecological Paradigm (NEP) scale (Dunlap et al., 2000). Second, individuals' subjective sense of connection with the natural world (Capaldi et al., 2015) or the extent of belief that they are part of it (Schultz, 2002) have positive association with pro-environmental attitudes (Capaldi et al., 2014; Schultz et al., 2004; Zelenski et al., 2015), which might also be connected with climate change risk perception. We measured it with the Inclusion of Nature in Self scale (INS) (Schultz, 2001, 2002) with a single item consisting of seven pairs of overlapping circles labeled "self" and "nature". Third, self-reported knowledge is a significant predictor of climate change risk perception (Van der Linden, 2015) and we measured it by directly asking participants to assess their level of knowledge on a seven-point scale. All the covariates were measured at T1. The full information of the measured variables is presented in Table S2 in Supplemental Information. The value of each variable with several items (i.e., two types of risk perception, negative affective responses, cognitive association, ecological worldview) is calculated by summing up and then averaging the score of every item, respectively.

Data analysis

We used SPSS version 21.0 and Amos 21.0 to conduct data analyses. First, we calculated the descriptive statistics and Pearson correlation coefficients of the key variables (see Table S3 in Supplemental Information). Next, we clarified the causal relationship between risk perception of the COVID-19 pandemic and climate change by estimating a cross-lagged model using Amos 21.0. Moreover, we examined the hypothesized affective and cognitive mechanisms with a multiple mediation analysis using SPSS PROCESS macro version 3.0, model 4 (Hayes, 2013a; b). Additionally, the statistical significance of direct and indirect effects in the cross-lagged panel data analysis and in the mediation analysis were estimated with 5,000 bootstrap sample to create 95% bias-corrected and accelerated (BCa) confidence intervals (MacKinnon et al., 2004). If the 95% confidence intervals (CIs) do not include 0, the indirect effect is significantly differently from zero at $p = 0.05$.