



Coping with Coronavirus Pandemic: Risk Perception Predicts Life Optimism

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Abstract

Given that the coronavirus pandemic has become a severe concern worldwide, how can optimism be maintained during an outbreak of a collective pandemic? We propose that perceived control and negative affect could be potential explanatory factors for optimism in the face of a pandemic. In Study 1 ($N=599$), through a large-scale cross-sectional design, we showed the indirect effect of risk perception on optimism through perceived control and negative affect with structural equation modeling. In Study 2 ($N=191$), we manipulated perceived risk of the pandemic and determined that experiencing a high-risk pandemic psychologically led to decreased optimism. Finally, through Study 3 ($N=186$) and Study 4 ($N=217$), we revealed that the effect of risk perception on optimism can be extended to overall subjective well-being and confirmed the indirect effects via perceived control and negative affect. These findings indicate that risk perception can make a difference in one's life optimism during a high-risk pandemic. Moreover, perceived control and negative affect are notable intermediary variables. Measures that strengthen publicity and transparency regarding recovery rates should be taken to help reduce public perceptions of risk and promote an optimistic life attitude.

Keywords COVID-19 · Risk perception · Perceived control · Negative affect · Optimism

1 Introduction

Since the beginning of 2020, individuals worldwide have been confronted with the coronavirus pandemic (COVID-19). Shortly after the emergence of the pandemic, a collective panic widely spread at the social level, which may have contributed to psychological distress (Ayadi et al., 2017; Lahav et al., 2021; Västfjäll et al., 2013). Optimism, which refers to having generalized positive expectations about the future (Carver et al., 2010), is considered to

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be imperative when experiencing health risks (e.g., Hajek & König 2019); thus, identifying the predictors of optimism during an overwhelming pandemic has become a crucial issue (Gubler et al., 2021; Wang et al., 2021; Stieger et al., 2021). However, as COVID-19 has presented an unknown risk to the vast majority of people worldwide, the underlying mechanism of how to improve optimism remains unknown due to the lack of evidence (Hong & Collins, 2006). Research on coping behavior has shown that negative affect and perceived control, which are negatively related (Leotti & Delgado, 2014), can be influenced by perceived health risks (Arslan & Allen, 2021; Smyth et al., 2008; Viscusi & Zeckhauser, 2015) and can be strong predictors of optimism (Muyan-Yılık & Demir, 2020). Therefore, the combined roles of perceived control and negative affect in enhancing optimism need to be investigated. To address these gaps, this study aimed to explore the influences of perceived control and negative affect in the link between pandemic risk perception and optimism.

2 Theoretical Background and Hypotheses

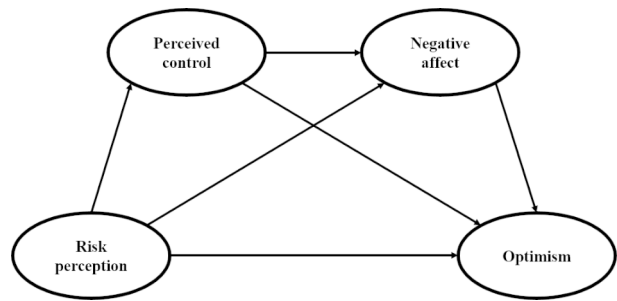
2.1 Risk Perception and Optimism

Risk perception has been conceptualized as the subjective experience of risk in potential hazards (Brown & Groeger, 1988). We define risk perception as a state variable in the context, as it could be affected by disaster exposures in specific situations (Gierlach et al., 2010; Slovic, 1987). Mental-health-related problems can arise following natural disasters (Xu et al., 2016), which could be associated with decreased levels of optimism. During the COVID-19 outbreak, people are supposed to be in high-risk environments (Arslan & Allen, 2021), wherein their distress and anxiety could last longer (Rudisill, 2013). Drawing upon the health belief model, more maladjustment might occur (e.g., Calandri et al., 2018; Carver et al., 2010; Chang et al., 2013; Hirsch et al., 2014) and less active coping strategies maybe adopted when individuals perceive that they are personally susceptible to a disease (Ho et al., 2010). Hence, a high-level risk perception related to COVID-19 may deteriorate one's level of optimism, which is an important component of subjective well-being (Kjell et al., 2016) and is associated with positive psychological adjustment as well as disaster resilience (e.g., Chang et al., 2011; Gero et al., 2021; Liu et al., 2017). Thus, it is reasonable to predict that a high-level risk perception is negatively related with optimism and is likely to weaken one's level of optimism (Hypothesis 1).

2.2 Risk Perception, Perceived Control, and Optimism

Perceived control may be an intermediary variable in the link between risk perception and life optimism. It refers to an individual's belief in his or her ability to influence the internal states and behaviors as well as one's external environment (Langer, 1977). Perceived control during health threats has been shown to be negatively associated with risk perceptions for flu and related diseases (Brassey & Kruyt, 2020; Sandler, 2001). Furthermore, individuals with adequate control appraisal and expectancy have a greater sense of life satisfaction, which could be linked to higher levels of optimism (Escoffery, 2002; Grob, 2000; Infurna & Infurna, 2017). Moreover, drawing upon the coping contextual framework (Coyle & Vera, 2013), people have a tendency to engage in problem-focused coping strategies when faced

Fig. 1 The hypothetical model about the serial effects via perceived control and negative affect on the relationship of risk perception with optimism



with risks, which could lessen people's stress levels in uncontrollable stressful conditions (Jónsdóttir & Ruthig, 2020; Phan, 2013; Torres-Marín et al., 2022). This might imply a strong sense of control over life events and environments, and may denote the central role of perceived control in combating life stressors, which is in accordance with studies that established perceived control as a promoting factor of resilience for public well-being during SARS (Shi et al., 2006). Thus, greater risk perception might explain lower levels of life optimism during a pandemic by reducing the levels of perceived control (Hypothesis 2).

2.3 Risk Perception, Negative Affect, and Optimism

Negative affect may be an intermediary variable in the link between risk perception and optimism. Research concerning the risk perception of disasters has revealed that in risky environments, individuals are likely to suffer from serious distress and anxiety (Arslan & Allen, 2021; Geng et al., 2013), which could further influence their psychological health and could be related to optimism (Daukantaitė & Zukauskienė, 2012; Denovan & Macaskill, 2017). From the perspective of coping behaviors, in addition to the above-mentioned problem-focused coping, emotion-focused coping strategies constitute psychological adjustments (Gubler et al., 2021; Pavani et al., 2016). When experiencing stressful events, individuals are likely to engage in emotion-focused coping strategies to lessen their negative affect, further boosting their confidence in uncontrollable stressful conditions (Schoenmakers et al., 2015). Thus, greater risk perception might explain decreased life optimism stemming from increased negative affect during the pandemic (Hypothesis 3).

However, there is insufficient evidence about whether perceived control and negative affect individually influence the relationship between risk perception and psychological well-being. Previous studies has proposed that the perception of control over health problems is closely associated with affective experience (Leotti & Delgado, 2014) and that affective experience could be an intermediary variable in the effect of perceived control on hedonic well-being (Kraft et al., 2005). This could imply that perceived control and negative affect may not be independent. Based on the above discussion, risk perception may indirectly influence life optimism through the intermediary variables of perceived control and negative affect (Hypothesis 4).

Figure 1 displays the hypothetical model. In Study 1, cross-sectional analyses were performed on large samples during the COVID-19 outbreak to examine the model in real-life contexts. Then, via experimental manipulation, in Study 2, we ascertained whether experiencing different levels of pandemic risk influences optimism. In Study 3, we further aimed to test the intermediary variable of perceived control. Finally, in Study 4, we tended to

provide evidence for the intermediary variable of negative affect and the indirect effect via perceived control and negative affect.

3 Study 1

With a cross-sectional design, Study 1 examined the effect of risk perception on life optimism during the COVID-19 outbreak. The survey conducted for this study took place just after the COVID-19 outbreak in China; thus, it provides insights into the crucial period when people perceive certain novel risks. Furthermore, we explored the indirect effect of risk perception on optimism through perceived control and negative affect.

3.1 Methods

3.1.1 Participants and Procedure

Previous literature (e.g., Rudisill 2013) suggests that a small to medium relationship exists among the various predictors of optimism. According to G*power, a priori power of 0.95 can be achieved with 571 participants with a bivariate correlation $r=.15$ (two-tailed). We decided to recruit a slightly larger sample of approximately 700 participants to be conservative. We finally received 599 valid questionnaires from Chinese participants ($M_{age} = 32.76$, $SD=12.37$; 64.8% females; response rate of 91.5%; 64 responses were removed due to failure of a carefulness check according to the instructions for response items). Among the participants, 89 were located in Wuhan Province, where the COVID-19 outbreak was first detected and subsequently spiraled; 246 were located in provinces adjacent to Wuhan, and 264 were located farther away from the pandemic center.

The survey was conducted online from February 11, 2020, to February 23, 2020, i.e., shortly after the COVID-19 outbreak. This timing provided us reliable insights into how individuals feel and react to pandemic risks. Participants were recruited via a survey link in online forums and were informed about the purpose of the study and data confidentiality procedures, and online written informed consent was requested and provided. All studies in the research obtained ethics approval by the Institutional Review Board for Human Participants.

3.1.2 Measures

Risk perception. The measure of risk perception was adapted from the Risk Perception Scale (Xie, 2005; Liu et al., 2021) to specifically assess the risk perception level of COVID-19 during the natural pandemic outbreak. Eleven questions (e.g., “Perceived probability that I get infected with COVID-19”) were answered using a 7-point Likert scale ($\alpha=0.74$).

Perceived control. Apart from general scales, such as the Internal-External Locus of Control Scale (Rotter, 1966), specific perceived control scales, such as the Perceived Control over Stressful Events Scale (Frazier et al., 2001), have been used in various situations. Herein, perceived control was measured using an adapted version of the Perceived Control over Stressful Events Scale (Frazier et al., 2011), which comprises 17 items (e.g., “I could have done something to prevent this event from happening”) to measure perceived control

Table 1 Descriptive statistics and correlations of the measures in Study 1

	M	SD	1	2	3	4
1 Risk perception	4.41	0.82	1			
2 Optimism	3.60	0.45	-0.12**	1		
3 Perceived control	2.43	0.40	-0.34**	0.23**	1	
4 Negative affect	2.71	0.78	0.40**	-0.25**	-0.35**	1

* $p < .01$, ** $p < .001$

under COVID-19. Respondents rated their agreement on a 4-point Likert scale ranging from “strongly disagree” to “strongly agree” ($\alpha=0.77$).

Negative affect. The negative dimension of Positive and Negative Affect Scale (Kuppens et al., 2008) was used to measure how often people felt the 11 kinds of negative emotions (e.g., distressed, upset) in the last week. Participants were responded based on a 5-point Likert-type scale ranging from “not at all” to “all the time” ($\alpha=0.88$).

Life Optimism. The 24-item Unrealistic Optimism Scale was developed to assess participants’ life optimism (Weinstein, 1980). Unrealistic optimism refers to an optimistic level in one’s tendency to believe that one is less at risk than their peers. This scale is frequently used to assess the optimism about future vulnerability when people encounter health problems and environmental hazards (Shepperd et al., 2013; Weinstein, 1987). Using a 5-point Likert scale ranging from “much lower” to “much higher” ($\alpha=0.79$), participants were instructed to make comparisons with their peers regarding the probability that they would encounter 12 positive life events (e.g., win lotteries) and 12 negative events (e.g., suffering from fractures).

3.1.3 Analysis Strategy

A two-step analysis was conducted with a structural equation model (SEM) using Mplus 7.0 to analyze the indirect effects. The SEM was used if the measurement model was satisfactory, and 95% bias-corrected bootstrapping was used to analyze the significance of the indirect effects (Fang et al., 2014). Two parcels were created for each factor to control for the inflated measurement errors caused by multiple items, as is common in previous SEM studies (e.g., Zhao et al., 2018).

3.2 Results

3.2.1 Measurement Model

Analysis of the zero-order correlations showed that all the study variables were significantly positively correlated, as predicted (Table 1). The results revealed that all factor loadings for the indicators of latent factors were significant ($p < .001$), denoting that all the latent variables were well represented by their respective indicators. The measurement model exhibited a highly satisfactory fit, $\chi^2=26.82$, $df=14$, $p=.002$, RMSEA (90% CI)=0.039 (0.015, 0.061), CFI=0.99, TLI=0.96, and SRMR=0.019.

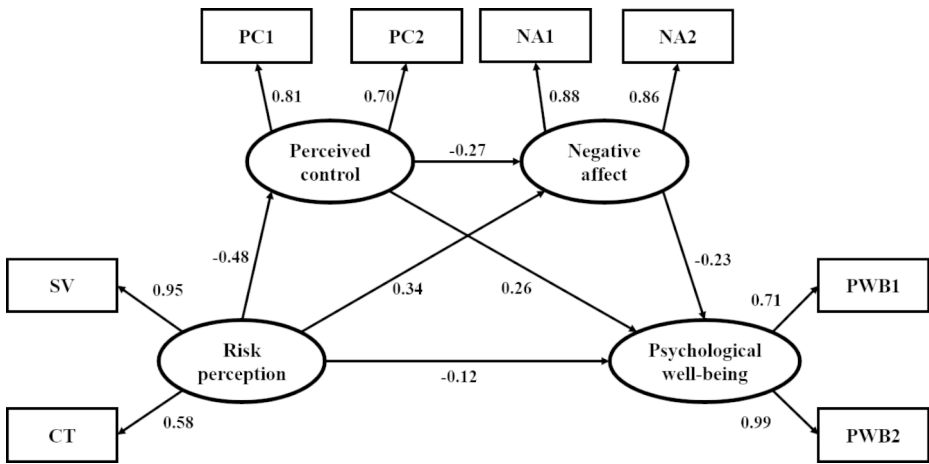


Fig. 2 The final mediation model (N = 599) in Study 1. Note: Factor loadings are standardized. SV and CT are two dimensions of risk perception; PC1 and PC2 are two aspects of perceived control; NA1 and NA2 are two aspects of negative affect; O1 and O2 are two aspects of optimism; and all the path coefficients are significant at the 0.05 level

Table 2 Standardized indirect effects and 95% confidence intervals in Study 1

Model pathways	Estimated	95%CI	
		Lower	Upper
RP→PC→LO	-0.12 ⁺	-0.179	-0.066
RP→NA→LO	-0.08 ⁺	-0.120	-0.036
RP→PC→NA→LO	-0.03 ⁺	-0.047	-0.012

RP risk perception, PC perceived control, NA negative affect, LO life optimism

⁺ Empirical 95% confidence interval does not overlap with zero

3.2.2 Structural Model

Following the confirmatory factor analysis, a model with two sources of intermediary variables (negative affect and perceived control) exhibited a good fit to the data: $\chi^2=46.67$, $df=15$, $p<.001$, RMSEA (90% CI)=0.059 (0.041, 0.079), CFI=0.98, TLI=0.97, and SRMR=0.041. Further analysis showed that the relationship between risk perception and optimism intensified when perceived control (95% CI = [-0.233, -0.091]) and negative affect (95% CI = [-0.217, -0.089]) were introduced into the model.

To determine the optimal model, a path linking perceived control and positive affect was added. The following model exhibited a better fit: $\chi^2=26.82$, $df=14$, $p=.020$, RMSEA (90% CI)=0.039 (0.015, 0.061), CFI=0.99, TLI=0.99, and SRMR=0.019. Then, the serial indirect effect model was compared to the previous multiple indirect effect model: $\Delta\chi^2=28.55$, $\Delta df=1$, and $p<.001$. The results showed that the fit of the serial indirect effect model was more satisfactory than that of the previous multiple indirect effect model, and thus, this model was selected as the best model (Fig. 2). As predicted, perceived control (95% CI = [-0.204, -0.076]) and negative affect (95% CI = [-0.140, -0.045]) were significant intermediary variables in the risk perception–optimism link (Table 2). Notably, perceived control

had a significant effect on negative affect (95% CI = $[-0.057, -0.016]$), which supports the hypothetical model. Finally, an indirect effect comparison analysis revealed that perceived control contributed more toward the indirect effect than negative affect (95% CI = $[0.020, 0.068]$).

3.3 Discussion

An analysis of the cross-sectional data provides evidence for the hypothetical model, indicating that risk perception can indirectly affect life optimism via perceived control and negative affect. Under COVID-19, individuals with a higher level of risk perception could perceive lower control over their health and thus experience fewer positive feelings than those with a lower level of risk perception, thereby leading to a decline in life optimism. Moreover, the relationship between risk perception and life optimism intensified with increasing perceived control; thus, perceived control may play a more prominent role in the relationship than affective experience.

4 Study 2

Although Study 1 acknowledged the hypothetical model, the cross-sectional design was descriptive in nature. To investigate the impacts of risk perception on life optimism, we determined whether experiencing a high-risk pandemic (vs. a low-risk pandemic) psychologically may result in decreased life optimism.

4.1 Methods

4.1.1 Participants

G*Power stated that 88 participants per condition were required for the study to be powered at 95% for a medium-sized effect. Based on past experiences with online data collection (Ward et al., 2012), we aimed to recruit 10 extra participants per condition. Participants were recruited by posting the survey link in online participant pool forums regardless of their region of residence. After screening for carefulness, 191 participants ($M_{age} = 23.76$, $SD = 7.87$; 69.6% females; 96 in high-risk condition and 95 in a low-risk condition; all the participants passed the screening tests) completed this study in exchange for compensation. The study was conducted from May 25, 2020, to May 31, 2020, when the COVID-19 spread had already been effectively controlled in China. Therefore, participants were more likely to consider the condition of an influenza pandemic and were not being completely affected by the wide-spread COVID-19.

4.1.2 Experimental Manipulation

Participants were randomly assigned and were instructed to imagine living in a country that featured either a high-risk or a low-risk influenza pandemic condition. The high-risk condition was one wherein the country was severely influenced by the pandemic and, over a 5-week period, 10% of the inhabitants of all ages were seriously ill with influenza, with

0.1% dying of the disease. The low-risk condition was one wherein the COVID-19 spread had been effectively controlled, with corresponding rates of 2.5% of the inhabitants of all ages becoming seriously ill with influenza and 0.025% dying of the disease. Participants were instructed to reflect on how they would feel if they were living in countries with these different conditions. As a manipulation check, participants were asked to numerically estimate the risk rate of being personally infected during the pandemic and the rate of an average resident of the country becoming infected; the estimates ranged from 0 (no risk) to 100 (extremely risky).

4.1.3 Optimism

The State Optimism Measure (SOM; Millstein et al., 2019) was adapted for pandemic conditions to assess life optimism; this measure comprises seven items (e.g., “Right now, I expect things to work out for the best under the pandemic”). Respondents were asked to evaluate their level of agreement from 1 (strongly disagree) to 7 (strongly agree) on a 7-point Likert scale. Cronbach’s alpha for the SOM in this study was 0.89, and higher scores indicated greater optimism.

4.2 Results

For the manipulation check, participants in the high-risk pandemic condition perceived themselves to be at greater risk of becoming infected ($M=41.77$, $SD=22.93$) than did those in the low-risk condition ($M=28.24$, $SD=21.97$): $t(189)=4.16$, $p<.001$, Cohen’s $d=0.60$. Additionally, imagining living in a high-risk country caused the participants to perceive a higher level of risk ($M=54.40$, $SD=24.05$) for an average resident to become infected than that in a low-risk country ($M=33.77$, $SD=22.51$): $t(189)=6.12$, $p<.001$, Cohen’s $d=0.89$.

As predicted, participants in the low-risk condition were significantly more optimistic ($M=3.47$, $SD=0.73$) than those in the high-risk condition ($M=3.21$, $SD=0.75$): $t(189)=2.40$, $p=.017$, Cohen’s $d=0.35$. This denoted that a lower perception of risk resulted in greater levels of optimism.

4.3 Discussion

Study 2 confirmed the effect of risk perception on life optimism. Particularly, the findings indicated that psychologically experiencing a high-risk influenza pandemic prevented people from being highly optimistic about life.

5 Study 3

Study 3 aimed to extend Study 2 by further exploring the indirect effect of risk perception on optimism. Previous studies have indicated that optimism is positively correlated with several measures of subjective well-being in adolescents, including life satisfaction (Gillham et al., 2011) and length of life (Diener & Chan, 2011). Therefore, this study aimed to investigate whether risk perception is associated with different approaches to overall subjective well-being apart from optimism. Second, perceived control was analyzed as a potential

intermediary variable in the link between risk perception and psychological well-being. Finally, the effect of the COVID-19 pandemic in real-life situations might be confounded by hypothetical risky scenarios with widespread COVID-19 outbreak; therefore, information was collected to address a comprehensive list of control variables concerning COVID-19.

5.1 Methods

5.1.1 Participants

G*Power was used to determine the sample size for a medium-sized effect, and it has revealed that 86 participants per condition are required for the study to achieve a power of 90%. To be conservative, 10 extra participants per condition were recruited. After the elimination of two participants who failed the carefulness screening and four participants who failed to follow the instructions, a total of 186 participants ($M_{age} = 19.91$, $SD = 1.27$; 28.5% females; 88 in a high-risk condition and 98 in a low-risk condition) from a university in China completed this study in exchange for compensation and course credits. The study was conducted from June 1, 2020, to June 5, 2020, and online informed consent was obtained before the participants took part in the study.

5.1.2 Experimental Manipulation and Measures

The experimental manipulation and manipulation check were the same as those in Study 2. Three measures were used to assess psychological well-being, namely Satisfaction with Life Scale (SWLS; Diener et al., 1985), SOM (Millstein et al., 2019), and Subjective Happiness Scale (Lyubomirsky & Lepper, 1999). The SOM scale was comparable to that in Study 1 ($\alpha = 0.92$).

The SWLS examines general life satisfaction and comprises five items (e.g., “In most ways my life is close to my ideal”). Participants were asked to rate their level of agreement with each item using a 7-point Likert-type scale (1 = strongly disagree to 7 = strongly agree), with higher scores indicating greater life satisfaction ($\alpha = 0.82$).

SHS assesses general happiness and comprises four items. Respondents were asked to assess each item using a 7-point Likert-type scale (e.g., “In general, I consider myself”; 1 = “Not a very happy person” to 7 = “A very happy person”). Herein, the Cronbach’s alpha for SHS was 0.78. Higher scores on the SHS indicated greater subjective happiness.

Then, perceived control was measured with eight items adapted from the dimension of the Present Control of Perceived Control over Stressful Events Scale (Frazier et al., 2011) to assess perceived control under the pandemic situation (e.g., “There isn’t much I can do to help myself feel better about the event”), with $\alpha = 0.87$.

5.1.3 Control Variables

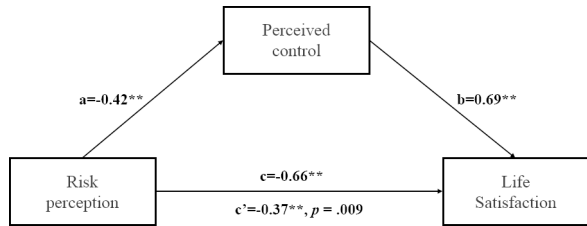
Since the psychological influence of the COVID-19 may interrupt the priming effect of pandemic risks on the subjective well-being, we controlled for the participants’ distance to the nearest COVID-19 case (from 1 = “at home” to 6 = “same province”), the province that participants lived in during the COVID-19 outbreak, and the level of impact that COVID-19 had on the place they lived in (1 = “hardly affected area” to 4 = “centrally affected area”).

Table 3 Descriptive statistics and correlations of the measures in Study 3

	M	SD	1	2	3	4	5	6
1 Perception of risk for themselves	35.02	23.93	1					
2 Perception of risk for an average resident	43.39	26.87	0.77**	1				
3 Perceived control	2.81	0.57	-0.48**	-0.47**	1			
4 Life satisfaction	3.84	1.01	-0.37**	-0.30**	0.47**	1		
5 State optimism	3.49	0.81	-0.50**	-0.43**	0.62**	0.49**	1	
6 Subjective happiness	4.25	1.09	-0.16*	-0.11	0.37**	0.54**	0.31**	1

* $p < .05$, ** $p < .01$

Fig. 3 Perceived control mediated the effect of risk perception on life satisfaction (95% CI = [-0.486, -0.138]) in Study 3



Individual-level demographic variables were also controlled, including sex, age, and native city of the participant.

5.2 Results

Table 3 presents the descriptive statistics and correlations. As a manipulation check, participants in the high-risk condition indicated a significantly higher risk of being affected by the pandemic ($M=47.27, SD=22.66$) than those in the low-risk condition ($M=24.02, SD=19.31$): $t(184)=7.55, p<.001$, Cohen’s $d=1.10$. Additionally, participants in the high-risk condition perceived a significantly higher risk of an average resident becoming affected during the pandemic ($M=56.97, SD=23.63$) than those in the low-risk condition ($M=31.19, SD=23.64$): $t(184)=7.42, p<.001$, Cohen’s $d=1.09$.

As expected, participants in the high-risk condition reported a significantly lower level of perceived control ($M=2.59, SD=0.55$) than those in the low-risk condition ($M=3.00, SD=0.52$): $t(184)=5.28, p<.001$, Cohen’s $d=0.77$. More importantly, t -tests revealed that participants in the high-risk condition reported lower life satisfaction ($M_{high} = 3.50, SD_{high} = 1.04, M_{low} = 4.15, SD_{low} = 0.88, t(184)=4.61, p<.001$, Cohen’s $d=0.67$), decreased optimistic tendencies ($M_{high} = 3.12, SD_{high} = 0.80, M_{low} = 3.83, SD_{low} = 0.67, t(184)=6.65, p<.001$, Cohen’s $d=0.96$), and lower levels of subjective happiness ($M_{high} = 4.04, SD_{high} = 1.14, M_{low} = 4.43, SD_{low} = 1.01, t(184)=2.46, p=.015$, Cohen’s $d=0.36$) compared to those in the low-risk condition. These results confirmed that the risk perception of the pandemic accounted for reduced psychological well-being.

To assess whether risk perception indirectly affected subjective well-being through perceived control, we followed the procedures suggested by Preacher and Hayes (2004). Figure 3 presents the results for predicting life satisfaction. Bootstrapping analysis (5,000 iterations) indicated that risk perception significantly influenced perceived control ($b=-0.42, SE=0.08, p<.001$), which consequently significantly affected satisfaction with life ($b=0.69, SE=0.12, p<.001$). Furthermore, the effect of risk perception reduced (from

Fig. 4 Perceived control mediated the effect of risk perception on state optimism (95% CI = [-0.477, -0.183]) in Study 3

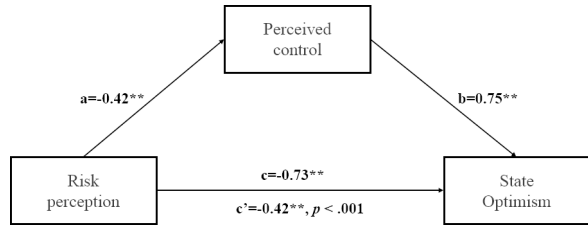
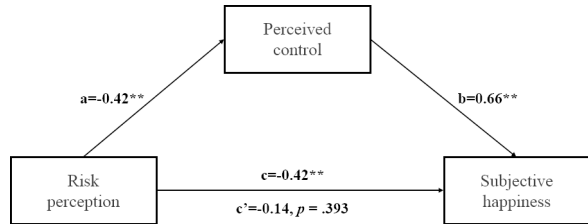


Fig. 5 Perceived control mediated the effect of risk perception on subjective happiness (95% CI = [-0.470, -0.129]) in Study 3



$b = -0.66$, $SE = 0.14$, $p < .001$ to $b = -0.37$, $SE = 0.14$, $p = .009$) when perceived control was included. Bootstrap analysis illustrated that the bias-corrected 95% CI for the size of indirect effect excluded zero [-0.486, -0.138], signifying that perceived control was an intermediary variable in the indirect effect of risk perception on life satisfaction.

The results for predicting state optimism are presented in Fig. 4, which showed that perceived control significantly affected state optimism ($b = 0.75$, $SE = 0.09$, $p < .001$). Furthermore, the effect of risk perception decreased (from $b = -0.73$, $SE = 0.11$, $p < .001$ to $b = -0.42$, $SE = 0.10$, $p < .001$) when perceived control was included. Additionally, risk perception had an indirect effect on state optimism via perceived control (bias-corrected 95% CI = [-0.477, -0.183]).

The results for predicting subjective happiness are presented in Fig. 5, which showed that perceived control significantly affected subjective happiness ($b = 0.66$, $SE = 0.14$, $p < .001$). Furthermore, the effect of risk perception reduced (from $b = -0.42$, $SE = 0.16$, $p = .009$ to $b = -0.14$, $SE = 0.16$, $p = .393$) when perceived control was included. Furthermore, perceived control was an intermediary variable in the relationship between risk perception and subjective happiness (bias-corrected 95% CI = [-0.470, -0.129]).

5.3 Discussion

Study 3 replicated the findings of Study 2 while using a different sample and stricter controls for confounding variables. The effect of risk perception was expanded to include different subjective well-being indicators. Additionally, it provided further evidence for a psychological mechanism involving the indirect effect of risk perception, namely, a higher level of risk perception discourages perceived control, which consequently decreases individuals' subjective well-being.

6 Study 4

Study 4 aimed to examine the emerging role of negative affect in the context of the model in Study 3. The serial indirect effect model employed in Study 1 was further explored with empirical investigations. Moreover, Study 4 was conducted a year after the COVID-19 outbreak, i.e., when available vaccines were widespread and healthy preventive measures were well developed. These changes highlight the importance of exploring whether the model provides a reasonable explanation in the context of not only the emerging pandemic but also times when the prevention and control for the pandemic have become normalized¹.

6.1 Methods

6.1.1 Participants

According to a Monte Carlo analysis of parameter estimation (Muthén & Muthén, 2002), approximately 205 participants are required for a study to achieve a power of 80%. After elimination of three participants who quit during the experiment, a total of 217 participants ($M_{age} = 21.28$, $SD = 2.56$; 66.4% females; 109 and 108 in the high- and low-risk conditions, respectively) completed this study in exchange for compensation and course credit. The study was conducted from May 15, 2021, to May 22, 2021, and online informed consent was obtained before the participants took part in the study.

6.1.2 Experimental Manipulation and Measures

All the experimental manipulations and measures were the same as those in Study 3. Cronbach's α scores for the SWLS, SOM, and SHS scales for examining subjective well-being were 0.88, 0.78, and 0.82, respectively.

However, three items from PANAS were excluded from the model's operationalization of negative affect (Kuppens et al., 2008) since they did not exhibit a significant correlation with the three measures of subjective well-being. Finally, eight items were used ("distressed," "upset," "scared," "hostile," "irritable," "nervous," "jittery," and "afraid") to measure the negative emotions when participants imagined that they were living in the situation. Cronbach's α was 0.79. The control variables were comparable to those used in Study 3.

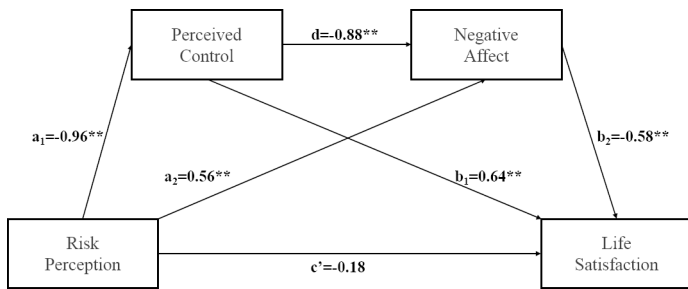
6.2 Results

Descriptive statistics and correlations are shown in Table 4. In the manipulation check, participants in the high-risk condition perceived a significantly higher risk of being affected by the pandemic ($M = 43.23$, $SD = 24.27$) than those in the low-risk condition ($M = 27.35$, $SD = 21.84$): $t(215) = 5.06$, $p < .001$, Cohen's $d = 1.10$. Additionally, participants in the high-risk condition perceived a significantly higher risk of an average resident being affected

¹ This refers to the recent days during which the screening and prevention of the pandemic have become regular, which is particularly the case in China. As the pandemic continues to spread, adherence to the overall prevention and screening measures for the coronavirus pandemic have been integrated into our daily life and become common. The need for such adherence has been determined by the long-term nature of the coronavirus pandemic.

Table 4 Descriptive statistics and correlations of the measures in Study 4

	M	SD	1	2	3	4	5	6	7
1 Perception of risk for themselves	35.33	24.28	1						
2 Perception of risk for an average resident	42.22	26.87	0.81**	1					
3 Perceived control	2.85	0.54	-0.36**	-0.27**	1				
4 Negative affect	2.89	0.94	0.52**	0.51**	-0.63**	1			
5 Life satisfaction	3.94	1.20	-0.35**	-0.30**	0.52**	-0.43**	1		
6 State optimism	3.50	0.77	-0.27**	-0.22**	0.39**	-0.38**	0.60**	1	
7 Subjective happiness	4.45	1.16	-0.19**	-0.13	0.46**	-0.30*	0.43**	0.52**	1

* $p < .05$, ** $p < .01$ **Fig. 6** The serial mediating effects of perceived control-negative affect on the impact of risk perception on life satisfaction (95% CI = [0.046, 0.218]) in Study 4

by the pandemic ($M=51.83$, $SD=26.22$) than those in the low-risk condition ($M=32.52$, $SD=23.97$): $t(215)=5.67$, $p < .001$, Cohen's $d=1.09$.

As expected, participants in the high-risk condition reported a significantly lower level of perceived control ($M=2.74$, $SD=0.55$) than those in the low-risk condition ($M=3.00$, $SD=0.51$): $t(215)=3.13$, $p=.002$, Cohen's $d=0.77$. Participants in the high-risk condition experienced stronger negative emotions ($M=3.29$, $SD=0.83$) than those in the low-risk condition ($M=2.47$, $SD=0.85$): $t(215)=7.17$, $p < .001$, Cohen's $d=1.03$. Notably, the t -tests revealed that participants in the high-risk condition reported lower life satisfaction ($M_{high} = 3.81$, $SD_{high} = 1.14$, $M_{low} = 4.07$, $SD_{low} = 1.26$, $t(215)=2.65$, $p=.010$, Cohen's $d=0.67$), decreased optimistic tendencies ($M_{high} = 3.30$, $SD_{high} = 0.78$, $M_{low} = 3.70$, $SD_{low} = 0.71$, $t(215)=4.04$, $p < .001$, Cohen's $d=0.96$), and lower subjective happiness ($M_{high} = 4.40$, $SD_{high} = 1.18$, $M_{low} = 4.49$, $SD_{low} = 1.14$, $t(215)=2.35$, $p=.045$, Cohen's $d=0.36$) than those in the low-risk condition. These results confirmed that a higher risk perception of the pandemic accounted for lower psychological well-being.

The results for predicting life satisfaction are presented in Fig. 6, which showed that the effect of risk perception on life satisfaction decreased (from $b=-0.41$, $SE=0.10$, $p < .001$ to $b=-0.01$, $SE=0.10$, $p=.919$) when perceived control and negative affect were included. The bootstrap analysis indicated that perceived control (95% CI = [0.008, 0.168]) and negative affect (95% CI = [0.200, 0.470]) were intermediary variables in the indirect effect of risk perception on life satisfaction. Notably, the serial indirect effect of risk perception on

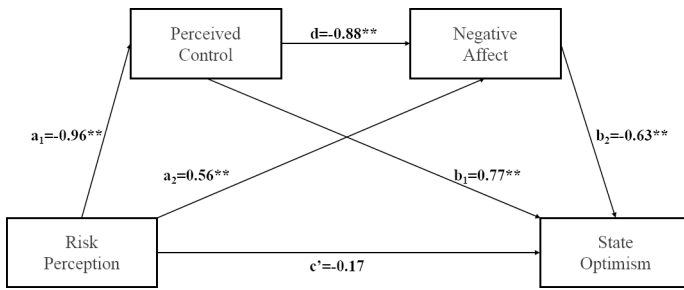


Fig. 7 The serial mediating effects of perceived control-negative affect on the impact of risk perception on state optimism (95% CI = [0.005, 0.135]) in Study 4

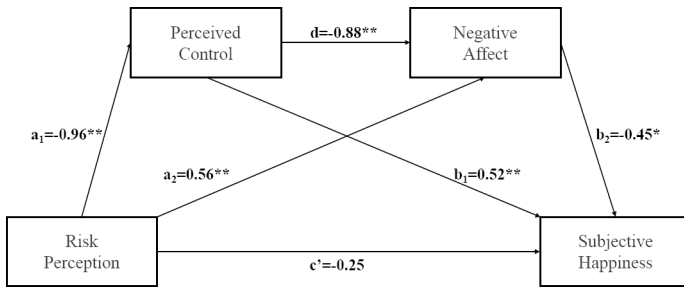


Fig. 8 The serial mediating effects of perceived control-negative affect on the impact of risk perception on subjective happiness (95% CI = [0.016, 0.167]) in Study 4

life satisfaction via perceived control and negative affect was significant (95% CI = [0.046, 0.218]).

The results for predicting state optimism are presented in Fig. 7. The bootstrapping analysis (5,000 iterations) indicated that the effect of risk perception on state optimism decreased (from $b = -0.231$, $SE = 0.16$, $p = .015$ to $b = -0.12$, $SE = 0.17$, $p = .487$) when perceived control and negative affect were included. The results denoted that risk perception indirectly affected state optimism through perceived control (95% CI = [0.022, 0.265]) and negative affect (95% CI = [0.023, 0.331]). Particularly, the serial indirect effect of risk perception on optimism via perceived control and negative affect was significant (95% CI = [0.005, 0.135]), which supported the serial indirect effect model.

The results for predicting subjective happiness are presented in Fig. 8, which indicated that the effect of risk perception on subjective happiness decreased (from $b = -0.37$, $SE = 0.16$, $p = .022$ to $b = -0.04$, $SE = 0.16$, $p = .791$) when perceived control and negative affect were included. The results denoted that perceived control ([0.025, 0.275]) and negative affect ([0.067, 0.366]) were intermediary variables in the indirect effect of risk perception on subjective happiness. Notably, the serial indirect effect of risk perception on subjective happiness via perceived control and negative affect was significant (95% CI = [0.016, 0.167]).

7 General Discussion

With four studies, the present research revealed that a high-level risk perception weakened life optimism during COVID-19. Moreover, perceived control and negative affect were notable contributing factors in this link. Based on these findings, during the pandemic, individuals who perceived higher risks felt a lower level of perceived control and thus experienced more negative emotions than those perceived lower risks, which decreased their life optimism.

The effect of risk perception on optimism is in accordance with earlier observations, which showed that risk perception was negatively related to life optimism (Chen et al., 2020; Fragkaki et al., 2021; Xu et al., 2016;). Particularly, regardless whether optimism scales or unrealistic optimism scales were used, the results yielded consistent conclusions. In fact, unrealistic optimism is pervasive in populations across diverse risky conditions (Kress & Aue, 2017; Jefferson et al., 2017). Previous studies have obtained consistent results showing that unrealistic optimism can cause an increase in personal satisfaction (Brnstrm & Brandberg, 2010) and a decrease in negative affective responses (Park et al., 2021). Thus, unrealistic optimism could also be a reasonable predictor of subjective well-being. Although the results of risk perception and unrealistic optimism should be interpreted with caution when further extending the effects to infer preventive behaviors (Kim & Niederdeppe, 2013), the results from different measures of optimism could contribute to a stable effect of risk perception on positive tendencies.

Perceived control was determined to be an intermediary variable in the relationship between risk perception and optimism. This finding broadly supports studies suggesting that when detrimental events frequently occur and come with severe consequences, people perceive higher risks for an event and thus lose control (Casali et al., 2021; Infurna & Infurna, 2017; Monzani et al., 2018; Stieger et al., 2021). Note that perceived control contributed more to the relationship between risk perception and life optimism, suggesting that problem-focused coping might play a more crucial role when dealing with high risks. To lessen stress levels in uncontrollable stressful conditions, problem-focused coping behaviors could be represented as a greater sense of control over life events and environments (Jónsdóttir & Ruthig, 2020; Phan, 2013).

The indirect effect of risk perception on life optimism through negative affect was shown to be significant. This finding corroborates earlier findings illustrating that affective experience is particularly important in determining one's level of life satisfaction (Garcia & Moradi, 2013). Although being reasonably conscious of risk factors is encouraged in responding to an impending crisis, excessive worry and irrational risk perception can result in emotional disorders and distress in feeling that one is at a loose end (Shi et al., 2006).

Notably, the results denoted that pandemic risk perception could account for life optimism through perceived control and negative affect. This finding may be attributed to the fact that the ability to maintain control and obtain information for one to feel in control is effective in improving one's affective well-being (Kishita & Shimada, 2011), especially when faced with new health risks (Chen et al., 2015; Torres-Marín et al., 2022; Wang et al., 2021). Additionally, some studies have found that problem-focused coping produces more negative affect (i.e., anxiety) in uncontrollable stressful conditions (Baker & Berenbaum, 2007), further supporting the idea of the interdependent roles of perceived control and negative affect.

The results also showed that the effect of risk perception was not limited to life optimism but it could be extended to the overall subjective well-being. Optimism has always been an important factor in predicting psychological well-being (e.g., Chang et al., 2020). It has conclusively been shown that optimism has indirect and direct effects on global life satisfaction and subjective well-being (e.g., Daukantaitė & Zukauskienė 2012). Our research has contributed to the research on approaches for promoting subjective well-being during the COVID-19 pandemic.

8 Limitations and Implications

Our results might be somewhat limited. First, although we used experimental and cross-sectional designs to estimate the effects over the specific duration of the COVID-19 outbreak (Robinson et al., 2005), future studies should be undertaken to combine multiple approaches (e.g., longitudinal approaches and experimental studies) to reduce the potential subjectivity and establish the direct and indirect relationships among the variables (Maxwell & Cole, 2007; Maxwell et al., 2011). Second, whether the findings are influenced by cultural variables and can be applied to populations outside China are important issues to consider in future research (Fischer & Karl, 2019; Paige, 1990). With the continuous spread of COVID-19 worldwide, cross-cultural research remains to be further validated (Vazquez et al., 2021). Finally, the self-reported measurement of perceived control was consistent through the four studies. Whether the results remain consistent when individuals are faced with different types of risk events or with different measures of perceived control is uncertain. Different measurements of perceived control could be integrated in future studies to verify the role of perceived control under different types of risk events.

Given the conceptual models and findings, this study provides important implications. First, as optimism has always been a major concept in health and positive psychology (Diener & Chan, 2011), the findings generate profound insights into maintaining life happiness under different risk scenarios. Second, our findings for Chinese participants contribute to not only the small but growing body of research findings involving subjective well-being in non-WEIRD (Western, educated, industrial, rich and democratic) societies (Rao & Donaldson, 2015) but also identify the consistent role of risk perception in certain situations with health risks. Moreover, although numerous psychological studies have demonstrated that optimism is associated with better task-related functioning and can increase the chance of achieving success (Seligman, 2002), some facets of optimism, such as unrealistic optimism, may cause adverse effects on promoting further healthy behaviors (Hanoch et al., 2019). Based on the current data, we may reasonably state that unrealistic optimism is positively related to subjective well-being; however, the issues of how different types of optimism are related to other behavioral outcomes need to be further investigated (Dolinski et al., 2020; Harris & Hahn, 2011).

Considering the possible implications for practice, measures should be taken to reduce public risk perception and promote perceived control over the risk, thereby resulting in increased optimism. For example, governments should strengthen the visibility and openness regarding recovery rates in a timely manner to lower the level of risk perception (Shi et al., 2006; Vermote et al., 2022). During the fight against COVID-19 in 2020, the active preventive measures and policies taken by the Chinese government helped allay public

panic. The measures included blocking the spread of the virus, restricting public movements, and setting up special hospitals to save lives. These measures helped boost people's feelings of safety and lessen their risk perception. Moreover, the results of this study suggest that healthy levels of perceived control may help prevent anxiety and fear when a novel pandemic appears. For example, conducting regular expert-led and science-based public briefings could help maintain an open line of communication with the public. Moreover, ensuring the availability and efficiency of vaccines might help restore positive social emotions. Responses that maintain the public's perceived level of control and positive emotions will help turn such a crisis into a challenging but manageable situation.

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Declarations

Conflict of Interest The authors declare that there are no conflicts of interest.

Ethical Approval It was ethically approved by the Institutional Review Board for Human Participants.

Informed Consent The participants were clearly informed about and provided their consent.

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