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The impact of uncertainty induced by the COVID-19 pandemic on intertemporal choice

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ABSTRACT

The coronavirus disease (COVID-19) pandemic has triggered a strong sense of uncertainty worldwide, which may lead to short-sighted behaviors. This study aimed to examine the impact of uncertainty induced by COVID-19 on intertemporal choice, as well as its underlying mechanisms, by conducting four experiments. Study 1a verified the causal relationship between uncertainty and intertemporal choice by showing that participants who feel more uncertain are more likely to choose smaller and sooner gains. Study 1b further confirmed this finding by conducting field experiments, which improved the ecological validity of the results. Study 2 not only replicated the results of Study 1 but also investigated the mediating role of future orientation between uncertainty and intertemporal choice. In Study 3, all participants experienced high uncertainty by recalling their own experiences related to COVID-19. The results showed that increasing future orientation reduced their preferences for smaller and sooner gains, further confirming the mediating role of future orientation. Overall, these findings indicate that uncertainty may lead to a present orientation, which in turn fosters preferences for immediate gains.

1. Introduction

The coronavirus disease (COVID-19) pandemic broke out rapidly worldwide in 2020. The most devastating features of this infectious disease is that it is highly contagious and poorly identifiable. Patients with COVID-19 may not show clinical symptoms, making it difficult for citizens to prevent its spread. The global economy also went into a sharp recession due to the impact of COVID-19, which eventually led to an increase in unemployment. Undoubtedly, people have suffered great uncertainty stemming from their concerns about being ill, dying, or becoming unemployed during this period. However, economic distress and the uncertainty of the epidemic have not prompted people to save money to cope with the unexpected situation. Instead, impulsive consumption during COVID-19 was prevalent (Xuan & Sun, 2020), which implies that individuals are attracted by immediate rewards while ignoring long-term gains (Ma, Xiao, Che, Wang, & Li, 2020). Also, tobacco sales increased rapidly in the first quarter of 2020 (China Xiangyan, 2020). It is well known that smoking is an immediate pleasure at the expense of long-term health (Barlow, McKee, Reeves, Galea, & Stuckler, 2017). These phenomena show that uncertainty and short-sighted behaviors are inextricably linked. In the context of the COVID-

19 crisis, this study explored the relationship between uncertainty and intertemporal choice, as well as the underlying psychological mechanisms of this relationship.

1.1. Uncertainty and intertemporal choice

The experience of uncertainty is common in our lives, especially now that COVID-19 is rampant. Uncertainty is defined as “when a person confronts an inability to predict the future or an incompatibility between different cognitions, between cognitions and experiences, or between cognitions and behavior” (Van den Bos & Lind, 2002, p. 4). People have basic strategies for reducing uncertainty: either they cope with uncertainty by seeking group affiliation (Hogg, 2014; Mullin & Hogg, 1998) and strengthening their belief in a cultural phenomenon (Van den Bos, Euwema, Poortvliet, & Maas, 2007; Wichman, Brunner, & Weary, 2014) or compensating for a psychological deficit by shopping (Chang & Arkin, 2002). These are indirect management strategies for alleviating subjective uncertainty (Yang, Bi, Li, & Huang, 2017). However, avoiding uncertain situations may be a more direct and effective way of reducing feelings of uncertainty, which also implies that individuals with high uncertainty tend to avoid ambiguous or risky situations in their decision-making.

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Intertemporal choice is, a type of decision-making and refers to “a decision involving tradeoffs among costs and benefits occurring at different times” (Frederick, Loewenstein, & O’Donoghue, 2002, p. 351). Two options are included in intertemporal decisions: “smaller-sooner” and “larger-later.” The former is the option in which the outcomes or benefits are less but can be received more quickly. The latter option receives more or better outcomes at a time cost (Read, McDonald, & He, 2018). Importantly, compared to the delay time in the larger-later option, the delay time in the smaller-sooner option is shorter or not at all (Chen & He, 2014). For example, people make an intertemporal choice when deciding between buying a new car immediately or saving for a new house in a few years.

Few studies have examined the relationship between a sense of uncertainty and intertemporal choice. Epper, Fehr-Duda, and Bruhin (2011) argued that perception of uncertainty may be an important factor influencing individuals’ assessment of future gains. Chen and He (2011) also suggested that true intertemporal decisions are often a combination of delayed and uncertain discounts. In previous experiments, although participants were usually informed that delayed rewards would be given with certainty (Frederick, Loewenstein, & O’Donoghue, 2002), it was unclear whether future rewards would materialize as expected according to evolutionary history (Fehr, 2002), as financial crises and other unforeseen disasters can wipe out gains. The influence of uncertainty on intertemporal decision-making cannot be ruled out in these experiments. Empirical studies that directly manipulate individuals’ sense of uncertainty to explore the relationship between uncertainty and intertemporal choice are still lacking. Meanwhile, some studies manipulated people’s perception of uncertainty by varying the probability of obtaining future gains (e.g., Hardisty & Pfeffer, 2017) and found that the greater the probability of uncertainty in choice, the more people tend to favor small and immediate returns. However, this confuses risky decisions with intertemporal choices.

There is some indirect evidence that implies a relationship between uncertainty and intertemporal choices. Li, Huang, and Zeng (2015) found that those who were more intolerant of uncertainty preferred smaller-sooner gains, and individuals raised in scare environments were also keener on seeking instant gratification (Griskevicius et al., 2013). However, these studies ignored how an individual’s sense of uncertainty induced by real-life situations influences their decision-making, especially during the COVID-19 pandemic. Uncertainty is an uncomfortable emotional experience (e.g., Hogg, 2007) and negative emotional valence. According to the appraisal-tendency framework (Lerner & Keltner, 2001), individuals who experience emotions with uncertainty as the primary cognitive evaluation dimension, such as fear (Xu, Zhang, Wu, Li, & Luo, 2014), are more likely to exhibit discounting of future outcomes. Uncertainty can also induce anxiety (Hogg, 2007; Van den Bos & Lind, 2002), an important factor that causes cognitive bias toward threatening information (Hartley & Phelps, 2012). Specifically, anxiety leads individuals to perceive future outcomes as difficult to achieve and exhibit more heavily discounted values for such outcomes (Calluso, Committeri, Pezzulo, Lepora, & Tosoni, 2015). Thus, we propose **Hypothesis 1: When people feel more uncertain, they prefer to choose the smaller-sooner benefit option.** That is, when people feel more uncertain, they prefer smaller benefits that can be received more quickly.

1.2. Future orientation as a possible mediating role

Future orientation refers to the orientation by which an individual’s thinking and behavior prefers to plan for the future (Liu, Huang, Pu, & Bi, 2010). A clear perception of time reflects not only an individual’s ability to manage the future and prepare for threatening events but also an individual’s persistent efforts to adapt to the external environment (Gan, 2018). Kruger, Reischl, and Zimmerman (2008) also highlighted time orientation as an important psychological mechanism between environmental perception and behavioral response. In an uncertain environment, future benefits may not be realized (Schechter & Francis,

2010). Therefore, individuals may think about and plan less for the future and allocate more resources and time to living in the present (Wu & Zhang, 2013), implying a low level of future orientation. Previous studies have shown that individuals raised in unpredictable environments showed present orientations (Amir, Jordan, & Rand, 2018), which is defined as enjoying the present moment more and not being bothered by future problems (Corral-Verdugo & Pinheiro, 2006) and negatively correlates with future orientation (Zimbardo & Boyd, 1999). Although few studies have been conducted on the relationship between future orientation and uncertainty, some were conducted by Feng, Gan, Liu, Nie, and Chen (2015). They found that feeling of uncertainty is a significant predictor of future orientation.

Existing research has thoroughly explored the impact of future orientation on intertemporal choices. Several studies have revealed the relationship between consideration of future consequences and intertemporal decision-making (Kim & Nan, 2016). They found that the lower the future orientation of an individual, the less concerned they are about future outcomes. Studies have also found that manipulating future orientation has a negative effect on the discounting rate (Li, Peng, & Xiong, 2015; Yang, 2017). In addition, the influence of future orientation on intertemporal choice can be understood from three perspectives: cognition, emotion, and volition. Regarding cognition, future-oriented individuals respond more positively to information about the future (Kim & Nan, 2016), preferring distant options in intertemporal choice (Ariely, Kahneman, & Loewenstein, 2000), and form heuristic thinking with regard to long-term preferences (Berns, Laibson, & Loewenstein, 2007). Second, previous research has shown that anticipated emotions about future events influence the discounting rate (Loewenstein, 1987). Individuals with a high future orientation hold optimistic expectations and aspirations for the future and, therefore, prefer to choose larger-delayed options (Li et al., 2015). In terms of willpower, those with a high future orientation can resist immediate temptations and make sacrifices for long-term gains, such as quitting smoking (Kovač & Rise, 2007) and consuming a healthy diet (Joireman, Shaffer, Balliet, & Strathman, 2012). Thus, we propose **Hypothesis 2: Future orientation mediates the relationship between uncertainty and intertemporal choice.** That is, people with higher uncertainty view the future more negatively, resulting in a greater preference for smaller benefits that can be received more quickly.

1.3. The current research

We conducted three studies to establish propositions that uncertainty affects intertemporal choice and that future orientation plays a mediating role between uncertainty and intertemporal choice. We first proved the causal link between uncertainty and intertemporal choice by inducing uncertainty in the general background before measuring temporal discounting (Study 1a), manipulating uncertainty in the context of COVID-19, and measuring intertemporal choice with a real decision task (Study 1b). In Study 2, we measured participants’ future orientation using a questionnaire and further examined whether future orientation was a mediator between uncertainty and intertemporal choice. Finally, in Study 3, we sought further support for the findings of Study 2 by testing whether increasing future orientation after uncertainty diminishes intertemporal choice.

2. Study 1a

In Study 1a, we sought to provide an initial test of whether people who feel more uncertain would prefer smaller benefits that can be received more quickly (Hypothesis 1).

2.1. Method

2.1.1. Participants

We recruited 91 college students from a university in Wuhan, China.

Fifteen participants were excluded, of which four did not meet the requirements on the writing task (the number of events was less than three, or the word counts less than 200), two pressed the wrong key in the intertemporal choice tasks, and nine wrote inconsistently with the theme (judged by two independent raters). The final sample consisted of 76 participants, ranging in age from 18 to 25 years ($M_{age} = 19.75$, $SD_{age} = 1.33$), of which 63 were female and 13 were male. G-power was used to determine the sample size to ensure adequate statistical power, and we did not purposefully increase the number of participants as a result of improving the power. With this sample size, it was estimated that Study 1a had 69% power to detect a Cohen's d of 0.5 and 96% power to detect a Cohen's d of 0.8 or higher, for mean level differences between conditions.

2.1.2. Procedure and measures

After reporting demographic information (gender, age, and grade) and signing the informed consent form, the participants were randomly divided into a high-uncertainty and low-uncertainty group. The task of manipulating uncertainty proposed by Hogg, Sherman, Dierseluis, Maitner, and Moffitt (2007) was used in this study. In this task, participants were asked to write no fewer than 200 words to ensure that they could recall the uncertainty event in as much detail as possible. Participants in the *high-uncertainty (low-uncertainty)* condition read the following instructions:

“Please spend five minutes or more thinking about the aspects of your life that make you feel *uncertain or confused (certain)* about your lives and future. Then, please describe three events that made you feel *uncertain (certain)* in as much detail as possible, in at least 200 words. After you finish writing, please immerse yourself in these events as much as possible.”

Next, participants answered the question, “Please review the events you just described, and to what extent does this event make you feel uncertain?” The items were answered on a 9-point scale (1 = *not at all*, 9 = *very much*). The purpose of this question was to test whether uncertainty can be successfully manipulated. In addition, two independent raters were invited to score whether the writing fit the theme on a 7-point scale (1 = *not at all*, 7 = *very much*). The criteria for the rating included whether the written content met the requirements of the theme and whether a solution to the uncertainty was presented. A third rater was invited to participate in the scoring when there was a large disparity between the two independent raters. When two raters scored less than three, the data were removed. The inter-rater reliability was 0.92.

Temporal discounting was measured using the choice titration procedure proposed by Chen and He (2011), which included 19 choice options. Participants were presented with two monetary options: one was smaller-sooner and the other larger-later. Wang's (2009) research showed that when the delayed reward was ¥1000, college students tended to choose it, regardless of how long they were required to wait. Therefore, the delayed reward was set to ¥500 in this study, and the delay time was six months. Participants were asked questions such as, “Would you prefer ¥25 today or ¥500 in six months?” The choice “getting ¥25 today” gradually increased to “getting ¥475 today,” and the participants were required to respond to all 19 items. The average of the amount at which the participants first chose the smaller-sooner option and the previous amount for that option was the utility equivalent value of ¥500 obtained six months later. If participants chose the larger-later option for all intertemporal choices, the utility was ¥475. If they all chose the smaller-sooner option, the utility was ¥25. Subsequently, the time discount rate (K) was derived from the discounted utility model (Samuelson, 1937) and log-transformed such that K was normally distributed.

2.2. Results and discussion

Participants rated the manipulation check item significantly higher

in the high-uncertainty group ($n = 42$, $M = 6.98$, $SD = 1.32$) than in the low-uncertainty group ($n = 34$, $M = 2.26$, $SD = 0.96$), with $t(74) = 17.43$, $p < 0.001$, 95% CI [4.17, 5.25], $d = 4.09$, indicating successful manipulation of uncertainty. In addition, there was no significant difference in the time discount rate between males ($n = 13$, $M = -1.19$, $SD = 0.79$) and females ($n = 63$, $M = -0.84$, $SD = 0.88$), with $t(78) = -1.35$, $p = 0.18$. Therefore, gender differences were not discussed in subsequent analyses.

As expected, the time discount rate of the high-uncertainty group ($n = 42$, $M = 6.60$, $SD = 0.84$) was significantly higher than that of the low-uncertainty group ($n = 34$, $M = 1.19$, $SD = 0.82$), $t(74) = 2.75$, $p = 0.007$, 95% CI [0.15, 0.91], $d = 6.52$. The results supported Hypothesis 1: People who are more uncertain prefer small and immediate gains.

3. Study 1b

Study 1a measured behavioral intention for intertemporal choice under controlled laboratory conditions, which lacks ecological validity. Therefore, Study 1b was designed to re-examine the relationship between uncertainty and intertemporal choice (Hypothesis 1), while meeting the requirements of ecological validity. Specifically, we tested whether the uncertainty induced by COVID-19 would influence real intertemporal choice. After recalling certainty (or uncertainty related to COVID-19) they experienced since January 23, 2020, participants completed an intertemporal choice task, which was measured by the time they received the honorarium for their participation (i.e., smaller-sooner gains refer to choosing ¥7 honorarium immediately, and larger-later refers to ¥8 honorarium a week after participating in the experiment).

3.1. Method

3.1.1. Participants

We recruited 105 college students from a university in Wuhan, China, none of whom had previously participated in this experiment. Fourteen participants were excluded, of which three did something unrelated and distracted the experiment (e.g., receiving and sending messages), four did not describe the physiological response or described it in less than 60 words, and seven wrote inconsistently with the theme (judged by two independent raters). Ultimately, the sample consisted of 91 participants (70 females, 21 males) aged between 17 and 27 years ($M_{age} = 20.03$, $SD_{age} = 1.77$). A sensitivity analysis (chi-squared goodness of fit test: contingency tables; $\alpha = 0.05$, one degree of freedom) was conducted. With a sample size of 91, the analysis yielded a medium detectable effect size of $w = 0.3$ at 82% power.

3.1.2. Procedure

After reporting demographic information (gender, age, and grade) and signing the informed consent form, participants were randomly divided into two groups: a high-uncertainty group and a low-uncertainty group. The participants completed all the following tasks, either on computers or on paper. First, they completed the writing tasks, which activated feelings of high or low uncertainty. Second, they reported their state emotional experiences to test whether uncertainty manipulation was successful. Then, participants were informed that the experiment was completed and were offered two options to receive payment for participation (receiving ¥7 honorarium immediately or receiving ¥8 honorarium a week later). In fact, this was an intertemporal choice task that participants completed while unaware.

3.1.3. Measures

3.1.3.1. Uncertainty. In Study 1b, we adapted the task of Van den Bos (2001) in a realistic context to manipulate uncertainty. Moreover, the participants were asked to write no less than 60 words to ensure that

they could recall their emotions and physiology in as much detail as possible. Participants in the *low-uncertainty (high-uncertainty)* group read the following instructions:

“Please recall the *certainty (uncertainty related to COVID-19)* that you have experienced since January 23, 2020, and then: (1) Please briefly describe the emotions that the thought of being *certain (uncertain)* arouses in you, in at least 60 words and (2) Please write down, as specifically as you can, what you think will physically happen to you as you feel *certain (uncertain)*, in at least 60 words.”

3.1.3.2. Manipulation checks. Since directly asking participants about the degree of uncertainty was suggested in Study 1a, the Positive Affect and Negative Affect Scale (PANAS) revised by Qiu, Zheng, and Wang (2008) was used in Study 1b to confirm whether the uncertainty manipulation was successful. Importantly, we added “at this moment” to each item to measure the state emotion, and all items were answered on a 5-point scale ($1 = \text{not at all}$, $5 = \text{very much}$). This yielded reliable positive and negative subsets ($\alpha = 0.97$ and $\alpha = 0.94$, respectively). Two independent raters were invited to score whether the writing fit the theme on a 7-point scale ($1 = \text{not at all}$, $7 = \text{very much}$). The criteria for rating included whether the written content met the requirements of the theme, whether a solution to uncertainty was presented, and whether it contained a mutual transformation of positive and negative emotions. A third rater was invited to participate in the scoring when there was a large disparity between the two independent raters. When two raters scored less than three, the data were considered invalid and removed. The inter-rater reliability was 0.93.

3.1.3.3. Intertemporal choice. After participants completed the writing task and the PANAS scale, they were told that the experiment was complete. We informed the participants that “we would obtain project funding for this research the following week. If you are willing to wait, we will pay you an ¥8 honorarium next week; if you do not want to wait, we will pay you a ¥7 honorarium immediately. No matter what you choose, we will transfer the rewards to your personal account via online payment.” Referring to the research of Xia (2014), in this experiment, the time interval was set to one week, and the amount difference was ¥1. If participants chose to receive ¥7 immediately, they chose smaller and immediate gains in intertemporal choice. Otherwise, they chose larger-later gains in the intertemporal choice.

3.2. Results and discussion

The *t*-test showed that the positive emotion in the high-uncertainty group ($n = 50$, $M = 15.06$, $SD = 5.00$) was significantly less than that in the low-uncertainty group ($n = 41$, $M = 35.73$, $SD = 6.20$), with $t(89) = 17.62$, $p < 0.001$, 95% CI [18.34, 23.00], $d = 3.67$; the negative emotion in the high-uncertainty group ($n = 50$, $M = 29.90$, $SD = 6.50$) was significantly higher than that in the low-uncertainty group ($n = 41$, $M = 12.56$, $SD = 3.38$), with $t(89) = -16.37$, $p < 0.001$, 95% CI [-19.45, -15.23], $d = 3.35$. The results indicate that the manipulation of uncertainty salience was successful.

The results showed no significant difference between the number of males ($n = 21$) and females ($n = 70$) who chose to receive ¥7 immediately, with $\chi^2 = 1.93$, $p = 0.21$. Therefore, gender differences were not discussed in subsequent analyses. A chi-square test showed that the number of participants in the high-uncertainty group who chose to receive ¥7 immediately was significantly greater than that in the low-uncertainty group ($\chi^2 = 17.94$, $p < 0.001$) (see Table 1).

By asking participants to draw on their own real-life experiences with uncertainty related to COVID-19, we found that participants recalling uncertain events chose to receive ¥7 for participation immediately compared to those recalling certain events. The results again supported Hypothesis 1 and indicated that uncertainty leads people to

Table 1

Number of people who chose a different method of payment in different groups.

Group	Receiving ¥7 immediately	Receiving ¥8 in one week	χ^2
Low uncertainty	13	28	17.94***
High uncertainty	38	12	

Note. *** $p < 0.001$.

be more short-sighted, focusing on immediate benefits and ignoring long-term gains.

4. Study 2

Study 2 examined future orientation as a mechanism for the uncertainty effect on intertemporal choice (Hypothesis 2). However, the measurement of the intertemporal choice task in Study 1a might show an anchoring effect (Huang, 2020). In addition, the realistic intertemporal choice task in Study 1b could not be performed in a laboratory setting. To avoid these problems, the intertemporal choice task of McClure, Laibson, Loewenstein, and Cohen (2004) was used in Study 2. Specifically, participants were asked to complete 32 tasks, each containing both smaller-sooner gain and larger-later gain options. Intertemporal choice was defined as the total number of times a participant chose the smaller-sooner gain option.

4.1. Method

4.1.1. Participants

We recruited 87 college students from a university in Wuhan, China, none of whom had previously participated in this experiment. Twelve participants were excluded, of which two expressed no physiological reaction, two participants completed the experimental task within 10 min,¹ and eight wrote inconsistently with the theme (judged by two independent raters). The final sample consisted of 75 participants, of whom 68 were female and seven were male, with ages ranging from 17 to 23 years and a mean age of 19.29 years ($SD_{age} = 0.90$). A sensitivity analysis (difference between two independent means; $\alpha = 0.05$) was conducted, and we did not purposefully increase the number of participants as a result of improving power. With a sample size of 75, the analysis yielded a medium-to-large detectable effect size of Cohen's d of 0.65 at 87% power, for mean level differences between conditions.

4.1.2. Procedure

Participants completed an online questionnaire for uncertainty tolerance and post-traumatic stress disorder (PTSD) one week in advance. They arrived at the laboratory for the formal experiments. After completing questions about their personal information (gender, age, and grade) and signing the informed consent form, participants were randomly divided into two groups: a high-uncertainty group and a low-uncertainty group. Subsequently, both groups completed the manipulation check task used in Study 1b and the measure of state future orientation. Finally, all participants moved to an intertemporal choice task, which has been shown to be effective and valid in measuring the preference for smaller-sooner or larger-later gains (Ma et al., 2012; McClure et al., 2004).

¹ The experiment took approximately 20 min to complete, yet some participants spent 10 min between classes to attend the experiment, which can trigger time pressure (Weenig & Maarleveld, 2002). And time pressure has impact on intertemporal choice (e.g., Lindner & Rose, 2017). To avoid the distraction of nuisance variables in this study, participants completed the experimental task within 10 min were excluded.

4.1.3. Measures

4.1.3.1. Uncertainty. We manipulated uncertainty using the same method described in Study 1b.

4.1.3.2. Manipulation checks. The manipulation check was the same as in Study 1b. This again yielded reliable scales for positive affect ($\alpha = 0.97$) and negative affect ($\alpha = 0.95$). Two independent raters were invited to score whether the writing fit the theme on a 7-point scale ($1 = \text{not at all}$, $7 = \text{very much}$). The rating criteria and procedures were the same as those used in Study 1b. The inter-rater reliability was 0.94.

4.1.3.3. Intolerance of uncertainty. Li et al. (2015) found a strong association between the personality trait of intolerance of uncertainty and intertemporal choices. Therefore, to exclude the influence of this variable on this study, it was treated as a covariate in subsequent data analyses. We used the short version of the Intolerance of Uncertainty Scale-12 (IUS-12), revised by Wu, Wang, and Qi, (2016) in the context of Chinese culture, which contains 12 items answered on a 5-point scale ($1 = \text{not at all}$, $5 = \text{very much}$). Cronbach's α for the scale was 0.83.

4.1.3.4. Post-traumatic stress disorder. During the COVID-19 pandemic, people are more likely to suffer from PTSD (Wei, Meng, & Ni, 2020), which is strongly associated with uncertainty. Therefore, to exclude the PTSD-induced outcome variance, it was treated as a covariate. We used the PTSD Check-Civilian version revised by Yang, Yang, Liu, and Yang (2007) in the context of Chinese culture, which contains 17 items and is answered on a 5-point scale ($1 = \text{not at all}$, $5 = \text{very much}$). Cronbach's α for the scale was 0.88.

4.1.3.5. Future orientation. We selected three items from the Future Negative Scale (Zaleski, Sobol-Kwapinska, Przepiorka, & Meisner, 2017) that best fit the theme of this study and added "at this moment" to each item to measure the state future orientation, such as: "At this moment, I am afraid that in the future, my life will change for the worse." "At this moment, I am terrified by the thought that I might face a life crisis or difficulties." and "At this moment, I am disturbed by the thought that in the future, I won't be able to realize my goals." All items were answered on a 7-point scale ($1 = \text{not at all}$, $7 = \text{very much}$); a higher total score implied that participants' views of the future were more negative. Cronbach's α for the scale was 0.90.

4.1.3.6. Intertemporal choice. We used a task to measure intertemporal choice similar to the study by McClure et al. (2004). Two choices were presented on either side of a computer screen, with the smaller-sooner gains (¥R) always presented on the left and the larger-later gains (¥R') presented on the right. The delay times for larger gains were set as one month and 1.5 months, and there were no differences in the time discount rate between the two delay times (He, Huang, Yin, & Luo, 2010). Smaller-sooner gains were described as those amounts that can be received today, unlike in Study 1b, which defined them as those payoffs that were immediately received. The percent difference in monetary amounts between the two gains $[(¥R' - ¥R) / ¥R]$ was selected from the set (1%, 3%, 5%, 10%, 15%, 25%, 35%, 50%). Two yellow triangles appear underneath these two choices. Once participants pressed one of the two buttons corresponding to the location of the options on the keyboard (smaller-sooner gains: F; larger-later gains: J), the associated yellow triangles turned red for one second. All participants needed to select within five seconds, and they had to make a total of 32 choices. Before the intertemporal choice task, there were four practice tasks for participants to understand keystroke rules. The following instructional statement was presented on the screen: "Please imagine that you have found an online part-time job through an agency and will receive a commission of ¥200. However, the agency must take a fee. In fact, you will receive less than ¥200. The agency now offers

two options for receiving payments to raise money in a short period. Please choose the option that suits you." Intertemporal choice was defined as the total number of times a participant chose the smaller-sooner gain option.

4.2. Results and discussion

As expected, positive emotions in the high-uncertainty group ($n = 35$, $M = 13.51$, $SD = 4.50$) were significantly less than in the low-uncertainty group ($n = 40$, $M = 36.50$, $SD = 6.56$), with $t(73) = -17.43$, $p < 0.001$, 95% CI $[-25.61, -20.36]$, $d = 4.09$, and negative emotions in the high-uncertainty group ($n = 35$, $M = 32.03$, $SD = 6.10$) were significantly higher than those in the low-uncertainty group ($n = 40$, $M = 12.93$, $SD = 3.68$), with $t(73) = 16.64$, $p < 0.001$, 95% CI $[16.73, 21.48]$, $d = 3.79$. The results indicate that the manipulation of uncertainty salience was successful. The results also showed no significant difference in future orientation between males ($n = 7$, $M = 11.43$, $SD = 5.44$) and females ($n = 68$, $M = 12.56$, $SD = 5.65$), with $t(73) = -0.51$, $p = 0.61$, and no significant difference in intertemporal choice between males ($n = 7$, $M = 17.71$, $SD = 4.96$) and females ($n = 68$, $M = 17.06$, $SD = 6.81$), with $t(73) = 0.25$, $p = 0.81$. Therefore, gender differences were not discussed in subsequent analyses.

Moreover, we found that participants in the high-uncertainty group ($n = 35$, $M = 19.71$, $SD = 6.28$) chose the smaller-sooner gain option more than those in the low-uncertainty group ($n = 40$, $M = 14.85$, $SD = 6.08$), with $t(73) = 3.39$, $p = 0.0011$, 95% CI $[2.00, 7.23]$, $d = 0.79$ (see Fig. 1), which again supports Hypothesis 1. A t -test also indicated a causal link between uncertainty and future orientation. There was a significant difference in future orientation between the high-uncertainty group ($n = 35$, $M = 17.17$, $SD = 2.83$) and the low-uncertainty group ($n = 40$, $M = 8.33$, $SD = 3.88$), with $t(73) = 11.14$, $p < 0.001$, 95% CI $[7.26, 10.43]$, $d = 2.58$ (see Fig. 2), revealing that individuals with higher uncertainty viewed the future more negatively.

The descriptive statistics and bivariate correlation coefficients are presented in Table 2. As predicted, individuals viewed the future more negatively, choosing smaller-sooner gain options more times. In addition, participants who could not tolerate uncertainty and had greater negative emotions chose the smaller-sooner gain option more often. However, fewer positive emotions were associated with choosing smaller-sooner gain options. Participants with greater negative emotions viewed the future more negatively, whereas participants with

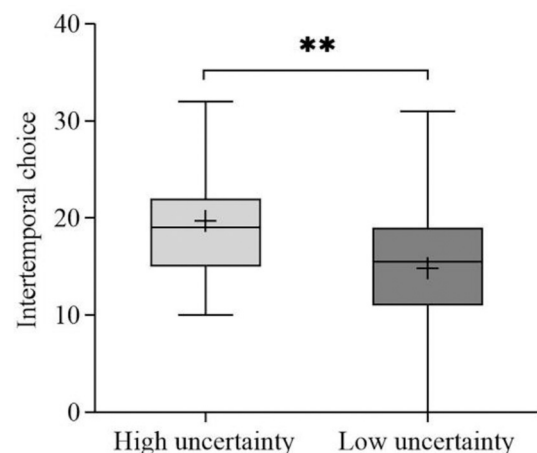


Fig. 1. Intertemporal choice of participants in the high-uncertainty and low-uncertainty groups in Study 2. Participants who felt high uncertainty (vs. low uncertainty) chose the smaller-sooner gain option more times. The intertemporal choice is the total number of times that participants choose the smaller-sooner gain option. Box boundaries represent lower and upper quartiles, interior lines within boxes represent median, whiskers for data range (minimum to max), and + represent mean value. $** p < 0.01$.

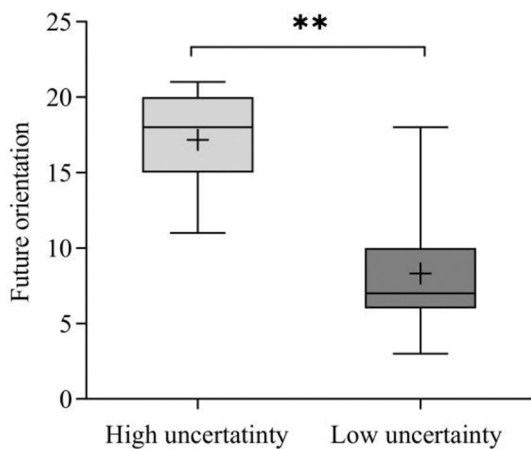


Fig. 2. Future orientation of participants in the high-uncertainty and low-uncertainty groups in Study 2. Participants who felt high uncertainty (vs. low uncertainty) viewed the future more negatively. Box boundaries represent lower and upper quartiles, interior lines within boxes represent median, whiskers for data range (minimum to max), and + represent mean value. ** $p < 0.01$.

greater positive emotions viewed the future more positively. A follow-up analysis treated negative emotions, positive emotions, and intolerance of uncertainty as covariates.

We then coded the high-uncertainty group as “1” and the low-uncertainty group as “0.” We conducted the procedure proposed by Wen and Ye (2014) to test whether future orientation mediated the effects of uncertainty on intertemporal choice, while the variables of negative emotion, positive emotion, and intolerance of uncertainty were treated as covariates. In Model 1, we entered uncertainty as the predictor variable and intertemporal choice as the outcome variable (Table 3). The results showed that Model 1 held ($F = 5.93, p = 0.0012, R^2 = 0.20$), and uncertainty positively predicted intertemporal choice (Path c) ($\beta = 0.50, t = 2.08, p = 0.041, 95\% \text{ CI} = 0.28 \text{ to } 12.98$). Then, uncertainty was entered as the predictor variable and future orientation as the outcome variable in Model 2. The results showed that Model 2 held ($F = 68.03, p < 0.001, R^2 = 0.65$), and uncertainty positively predicted future orientation (Path a) ($\beta = 0.47, t = 2.68, p = 0.004, 95\% \text{ CI} = 1.79 \text{ to } 8.79$). Finally, both uncertainty and future orientation were

Table 2
Means, standard deviations, and correlations for Study 2 variables ($n = 75$).

	M	SD	1	2	3	4	5
1. Intolerance of uncertainty	39.32	7.36	–				
2. Post-traumatic stress disorder	29.56	9.80	0.48***	–			
3. Negative emotion	21.84	10.79	–0.09	–0.06	–		
4. Positive emotion	25.77	12.86	0.01	0.03	–0.86***	–	
5. Future orientation	12.45	5.60	0.13	0.06	0.73***	–0.78***	–
6. Intertemporal choice	17.12	6.63	0.24*	0.06	0.30**	–0.31**	0.43***

Note. M and SD represent the mean and standard deviation, respectively. Higher future orientation scores indicated more negative future views. Intertemporal choice was measured by the total number of times smaller-sooner gains were chosen. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3
The mediating role of future orientation between uncertainty and intertemporal choice.

	Predictor variable	Future orientation				Intertemporal choice			
		β	t	R^2	F	β	t	R^2	F
Model 1	Uncertainty					0.50	2.08*	0.20	5.93**
Model 2	Uncertainty	0.47	2.68**	0.65	68.03***				
	Future orientation					0.44	2.53*		
Model 3	Uncertainty					0.19	1.31	0.22	6.74**

Note. Negative emotion, positive emotion, and the personality trait of intolerance of uncertainty were treated as covariates. Dummy-coded for the high-uncertainty group = 1, low-uncertainty group = 0. Intertemporal choice was measured by the total number of times smaller-sooner gains were chosen. Higher future orientation scores indicated more negative future views. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

entered to predict intertemporal decisions in Model 3. The results showed that Model 3 held ($F = 6.74, p = 0.005, R^2 = 0.22$), and intertemporal choice was predicted by future orientation (Path b) ($\beta = 0.44, t = 2.53, p = 0.014, 95\% \text{ CI} = 0.11 \text{ to } 0.92$). However, when paths a and b were controlled, the previously significant relationship between uncertainty and intertemporal choice was no longer significant (Path c') ($\beta = 0.19, t = 1.31, p = 0.194, 95\% \text{ CI} = -2.10 \text{ to } 10.87$). A bootstrap analysis (bootstrap samples = 5000) showed that the 95% CI for the size of the indirect effect excluded zero [0.04, 0.86], suggesting that future orientation mediated the relationship between uncertainty and intertemporal choice (see Fig. 3).

Study 2 again supported Hypothesis 1: People who felt more uncertain preferred smaller gains that could be received today to those that were larger but available in a month or a month and a half. Most importantly, we found the following mechanism: Future orientation. Uncertainty boosted a preference for smaller-sooner gains because people viewed the future more negatively, supporting Hypothesis 2.

5. Study 3

Although the results of Study 2 support the mediation effect of future orientation between uncertainty and intertemporal choice, they fail to provide causal evidence of the mediation relationship. For further exploration, we sought to directly examine the causal effect of future orientation on intertemporal choice, which can exclude the possible existence of other causal chains (i.e., intertemporal choice may mediate the relationship between uncertainty and future orientation) and improve the reliability of the mediating effect results. In Study 3, we followed the suggestions of Pirlott and Mackinnon (2016) to prime high levels of uncertainty in all participants and then randomly assign them to a future orientation group or a control group.

5.1. Method

5.1.1. Participants and design

We recruited 80 college students from a university in Wuhan, China, none of whom had previously participated in this experiment. Eleven participants were excluded, of which one completed the experimental task within 10 min, four wrote inconsistently with the theme of uncertainty (judged by two independent raters), and six wrote inconsistently with the theme of future orientation.

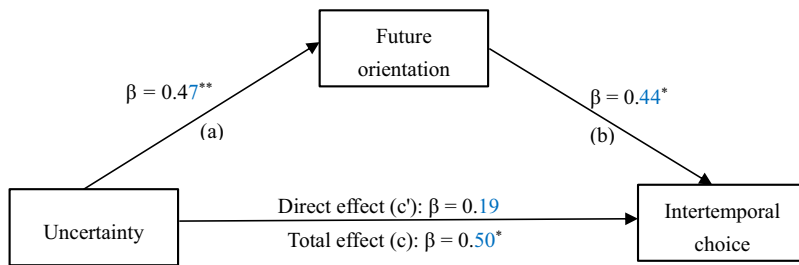


Fig. 3. Mediation effect of future orientation on the relationship between uncertainty (dummy-coded for high-uncertainty group = 1, low-uncertainty group = 0) and intertemporal choice (total number of times smaller-sooner gains were chosen), while entering negative emotion, positive emotion, and the personality trait of intolerance of uncertainty as covariates. Relative to low uncertainty, high uncertainty induces a more negative view of future, which in turn increases the number of times smaller-sooner gains are chosen. * $p < 0.05$, ** $p < 0.01$.

To ensure that the potential results were not driven by any particular aspect of the control writing task, this study included a second control group in which participants did not complete any task regarding future orientation, which is consistent with the tasks of the high-uncertainty group ($n = 35$) in Study 2. They used the same methods to manipulate uncertainty and measure state future orientation and intertemporal choice. Therefore, we used data associated with the high-uncertainty group in Study 2 as the second control group. Ultimately, there were three conditions in Study 3: the future orientation group ($n = 35$), the control group ($n = 34$) and the second control group ($n = 35$). The final sample consisted of 104 participants, of which 90 were female and 14 were male, with ages ranging from 17 to 25 years ($M_{age} = 19.41, SD_{age} = 1.17$). The results of a sensitivity analysis ($\alpha = 0.05$) showed that the sample size of 104 participants could detect a medium-to-large effect size ($f = 0.32$), with an assumed power of 83%, in a one-way ANOVA.

5.1.2. Procedure and measures

Participants completed the online questionnaires on uncertainty tolerance (Cronbach's $\alpha = 0.82$) and PTSD (Cronbach's $\alpha = 0.92$) one week in advance, as described in Study 2. Participants arrived at the laboratory for the formal experiment. After reporting demographic information (gender, age, and grade) and signing the informed consent form, all participants were induced to feel highly uncertain. The manipulation of uncertainty was the same as in Study 1b and the manipulation check of uncertainty was the same as in Study 2 (negative affect subscale: Cronbach's $\alpha = 0.87$; positive affect subscale: Cronbach's $\alpha = 0.89$). Two independent raters were invited to score whether the writing fit the theme of uncertainty on a 7-point scale ($1 = not at all, 7 = very much$). The rating criteria and procedures were the same as those used in Study 1b. The inter-rater reliability was 0.84.

Participants were then randomly assigned to a future orientation group or a control group. The participants in the future orientation group were required to complete a writing task similar to the study conducted by Yang (2017): "People are always thinking and planning about their future life, please imagine and describe your life in 30 years." Participants in the control group were asked to describe the facilities, layout, etc. in the environment. The manipulation check of future orientation used the state future orientation measurement, as in Study 2 (Cronbach's $\alpha = 0.84$). Two other raters were invited to score whether the participants' writing fit the theme in the future orientation and control groups on a 7-point scale ($1 = not at all, 7 = very much$). The criteria for rating included whether the writing content was relevant to future planning and whether the plans and thoughts about the future were detailed. A third rater was invited to participate in the scoring when there was a large disparity between the two independent raters. When two raters scored less than three, the data were removed. The inter-rater reliability was 0.83. Finally, participants were required to complete the intertemporal choice task described in Study 2.

5.2. Results and discussion

Significant differences in future orientation among the groups were found through ANOVA analyses, with $F(2,101) = 38.17, p < 0.001, \eta^2 =$

0.43. A post hoc test showed that participants in the future orientation group ($n = 34, M = 9.29, SD = 4.32$) viewed the future less negatively than participants in the control group ($n = 35, M = 13.46, SD = 3.94, p < 0.001$) and second control group ($n = 35, M = 17.17, SD = 2.83, p < 0.001$), while participants in the control group viewed the future less negatively than participants in the second control group ($p < 0.001$), suggesting successful manipulation.

First, we examined the differences in PTSD and the personality trait of intolerance of uncertainty among the groups. ANOVA showed that there was no difference in PTSD among the future orientation group ($n = 34, M = 31.38, SD = 10.84$), control group ($n = 35, M = 31.91, SD = 11.68$), and second control group ($n = 35, M = 29.23, SD = 8.06$), with $F(2,103) = 0.67, p = 0.52$. ANOVA also showed that there was no difference in the personality trait of intolerance of uncertainty among the future orientation group ($n = 34, M = 41.47, SD = 6.53$), control group ($n = 35, M = 38.17, SD = 7.38$), and second control group ($n = 35, M = 39.11, SD = 7.05$), with $F(2, 103) = 2.04, p = 0.14$. The results also showed no significant difference in the total number of times smaller-sooner gain options were chosen between males ($n = 14, M = 20.79, SD = 5.56$) and females ($n = 90, M = 17.88, SD = 6.76$), with $t(102) = 1.53, p = 0.13$. Therefore, we did not treat these variables as covariates in subsequent analyses.

As expected (see Fig. 4), significant differences in intertemporal choice among the groups were found through ANOVA, $F(2, 103) = 3.34, p = 0.04, \eta^2 = 0.06$. A post hoc test showed that the number of times that participants chose smaller-sooner gain options in the future orientation group ($n = 34, M = 15.91, SD = 6.58$) was greater than that in the control group ($n = 35, M = 19.11, SD = 6.68, p = 0.04$) and the second control group ($n = 35, M = 19.71, SD = 6.28, p = 0.02$), but there were no differences between the control group and the second control group ($p = 0.70$).

These results supported Hypothesis 2. By directly manipulating future orientation, Study 3 provides further evidence for the mediating

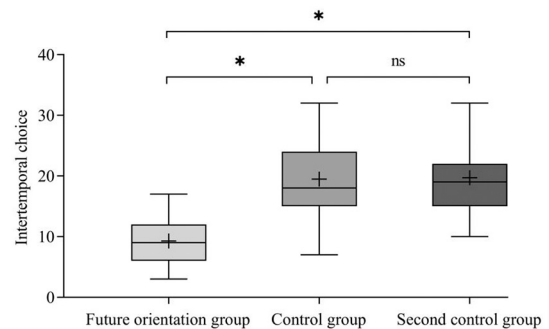


Fig. 4. The intertemporal choice is the total number of times that participants choose the smaller-sooner gain option. Participants in the future orientation group (vs. control group vs. second control group) chose the smaller-sooner gain option fewer times in total after being asked to think and plan the future. Box boundaries represent lower and upper quartiles, interior lines within boxes represent median, whiskers for data range (minimum to max), and + represent mean value. ** $p < 0.01$.

role of future orientation between uncertainty and intertemporal choice. We also found that participants in the control group viewed the future more positively than those in the second control group, which is consistent with several previous studies. A meta-analysis by Webb, Miles, and Sheeran (2012) highlighted that attentional distraction is an effective emotion regulation strategy that can help individuals shift away from emotional stimuli (Min, Tao, & Jiang, 2015). Therefore, compared with the second control group, the control group was less affected by uncertainty and viewed the future more positively after the writing task. However, the emotion-regulation strategy of attention distraction did not reduce the effects of negative emotions. Although the participants were distracted by the writing task, conscious distraction encouraged them to suppress negative emotions. Instead, it increased the activity of peripheral physiological activities and disrupted cognitive function. Thus, there were no differences in the intertemporal choice between the control group and the second control group.

6. General discussion

This study clarifies how uncertainty induced by COVID-19 impacts intertemporal choice, intending to understand why people have made short-sighted decisions during the COVID-19 pandemic. For example, they buy more cigarettes (China Xiangyan, 2020) at the expense of their health. We investigated the relationship between uncertainty and intertemporal choice, and the mediating role of future orientation using a series of experiments. We found evidence that supports our hypotheses.

After recalling a sense of uncertainty, participants preferred smaller-sooner gains to larger-later gains (Study 1a) or chose immediate but smaller rewards (Study 1b), which revealed that uncertainty can cause individuals to become more impatient. Furthermore, we identified the mediating role of future orientation between subjective uncertainty and intertemporal choice (Study 2). Moreover, priming a high level of future orientation attenuated the negative effect of subjective uncertainty on intertemporal decision-making (Study 3). These results indicate that future orientation is the underlying mechanism of short-sighted behavior in people with a sense of uncertainty.

This study makes some theoretical and methodical contributions to the literature. Theoretically, compared with previous studies that confounded risky decisions and intertemporal choices, we examined the effect of uncertainty on intertemporal choice from the perspective of individual experience and identified the mediating role of future orientation. After initiating subjective high uncertainty, increasing future orientation can reduce the preference for small and immediate gains. This implies that future orientation may be a way to cope with the negative effects of uncertainty. Future orientation has a protective function. If the attention of individuals in a stressful event is shifted to the future, they feel positive emotions such as hope (Hassija, Luterek, Naragon-Gainey, Moore, & Simpson, 2012) and confidence (Sword, Sword, Brunskill, & Zimbardo, 2013). Simultaneously, a focus on the future can help people reshape their cognition and create a connection between past events and future goals (Boucher & Scoboria, 2015), thus embracing a better future. Methodologically, this study reveals the causal relationship between future orientation and intertemporal choice by manipulating future orientation. Moreover, to compensate for this study's shortcomings under laboratory conditions, such as ecological validity, we explored the influence of subject uncertainty on intertemporal choice in real situations. Thus, they are more generalizable. Overall, the multimethod test enhances the robustness of the mediation model as well as the reliability of these conclusions.

There are several themes that future research can explore. First, this longitudinal study would be of great value because long-term investigations of chronically uncertain individuals can help us to better understand how future orientation develops as a significant adaptive mechanism. Moreover, longitudinal studies across cultures may shed additional light. Currently, many countries are suffering severely from

COVID-19, such as India. Longitudinal surveys of individuals in these countries can help us to understand the sources of subjective uncertainty more comprehensively, perhaps as they relate to the self, government, and society. Simultaneously, such a study would describe the change in subjective uncertainty more accurately. Second, it may provide an effective intervention to promote sensible decision-making. When people experience higher levels of uncertainty, they are more inclined to satisfy their immediate needs and become short-sighted. Educational interventions can guide people to think and imagine the future and develop realistic goals or plans to rebuild hope and confidence to cope with the hazards of uncertainty. Third, Kahneman and Tversky (1979) proposed that the aggravation of one experience of losing a sum of money appears to be greater than the pleasure of gaining the same amount. Humans are inherently more sensitive to loss, which is a mechanism to ensure survival and reproduction and to avoid harm. Future research could explore whether people with a sense of uncertainty are more sensitive to losses. Other study limitations can be addressed by future research. The research used three methods to measure intertemporal choice, which improved the robustness of the results but may also overlook the replicability of the findings. In addition, there was a gender imbalance in this study. Although the gender imbalance in this study did not have an impact on these findings, the representativeness of the sample remains insufficient. Future studies should balance gender when sampling and further improve the generalizability of the research conclusions.

7. Conclusions

This study explored the effect of uncertainty induced by the COVID-19 pandemic on intertemporal choice and its underlying mechanisms. The results showed that those with high uncertainty tended to choose smaller and sooner gains and that future orientation played a mediating role in this relationship. Our findings indicated that the uncertainty induced by the COVID-19 pandemic made people develop a present orientation, which in turn led them to be more satisfied with immediate gains and become short-sighted.

Disclosure statement

No potential conflict of interest was reported by the authors.

Data availability statement

The data supporting the findings of this study are available upon request from the corresponding author. The data are not publicly available because they contain information that can compromise research participants' privacy/consent.

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