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Episodic future thinking and anticipatory emotions: Effects on delay discounting and preventive behaviors during COVID-19

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Abstract

We examined the effects of anticipatory emotions induced by episodic future thinking on the basic decision-process of delay discounting and preventive behaviors during the most stringent COVID-19 "lockdown" period in China. We define anticipatory emotions as any discrete emotions induced from anticipating decision outcomes and felt during decision-making. In an online study conducted with healthy volunteers, anticipatory emotions were induced and appraised by asking participants to rate various emotions they feel when thinking they may be infected by COVID-19 ($N = 246$). The participants in the control group reported their present emotions during the COVID-19 pandemic ($N = 245$). Compared with the control group, the participants in the anticipatory emotion group had a higher future-oriented preference for monetary rewards, with a significantly lower delay discounting rate. These participants also had a higher intention to engage in proactive, preventive behaviors. The likelihood estimate of being infected by COVID-19 mediated these effects. Moreover, anticipatory disgust increased the preference for larger-and-later rewards.

[Corrections made on 3 June 2022, after first online publication: Affiliation details for Jianjun Zhou have been updated in this version.]

Anticipatory emotions induced by future thinking guide fast and rational decision-making in a health crisis.

KEYWORDS

anticipatory emotions, COVID-19, delay discounting, episodic future thinking, preventive health behavior, risk perception

INTRODUCTION

The outbreak of the COVID-19 pandemic spawned a significant challenge to public health. Alongside vaccination, behavioral preventive measures, such as wearing masks and diligent hand hygiene, play an essential role in curtailing transmissions and effectively slowing down the pandemic (Eikenberry et al., 2020; Ning et al., 2020; Tirupathi et al., 2020).

Among various manipulations to foster preventive behaviors, emotion induction has been regarded as a potentially effective tool since emotions directly regulate preventive behavior during the pandemic (Chou & Budenz, 2020). For instance, people living in the area with higher COVID-19 infection rates reported more heightened fear-related emotions (Du et al., 2020). Such emotional responses, in turn, reinforced preventive behaviors (Ning et al., 2020). Beyond correlational studies, experimentally induced emotions (e.g., empathy) also promoted social distancing (Pfattheicher et al., 2020).

The above evidence of emotion regulation during the pandemic has focused on reactive emotions, which are emotional experiences aroused by current events (Loewenstein et al., 2001). Little is known about how people regulate the degree of their preventive self-control based on anticipatory emotions. ***Anticipatory emotions*** are discrete emotions generated from anticipating future decision outcomes and felt during decision-making (Loewenstein et al., 2001). Unlike reactive emotions, anticipatory emotions are proactive rather than reactive, and they, therefore, provide a prompt and comprehensive assessment of social risks (Wang et al., 2021). Any unprecedented social or health risk, like the current COVID-19 pandemic, would impose difficulty for the public to cognitively assess the risk given little and often conflicting information. Passive reactions to the pandemic based on reactive emotions are also unlikely to provide timely and future-oriented coping strategies. Therefore, this research aimed to examine whether anticipatory emotions promote self-control and preventive behaviors.

In the remainder of the introduction, we provide a broader review of the literature on emotions in decision-making to understand better the interplay between anticipatory emotions and future-oriented decisions and preventive behaviors in everyday life. In this paper, the terms of "emotion" and "affect" refer to an anticipatory or current feeling state, including both discrete emotions (e.g., happiness, fear, sadness, and disgust) and conscious affective experiences (e.g., enthusiasm and distressed) (Barrett & Bliss-Moreau, 2009; Munezero et al., 2014). Based on this review, we make a synthetic effort to incorporate relevant theories of emotions in decision-making and put forward a hypothesis of anticipatory emotions as information for social risks (Wang et al., 2021). We then derive predictions from this hypothesis regarding how anticipatory emotions induced by episodic future thinking regulate delay discounting and health-related behaviors.

Emotions in decision-making

Emotions were traditionally viewed as interference to rational decision-making (Elster, 1999). Decision-making was typically viewed as a cognitive process of weighing values and probabilities of expected outcomes of various choice alternatives (e.g., von Neumann & Morgenstern, 1947). The subsequent development of prospect theory introduced the concept of decision reference points to modify the formulation of expected utilities (Kahneman & Tversky, 1979). Nevertheless, in the development of prospect theory, affective components, such as loss aversion and other emotional biases, entered the central arena of decision-making research (Kahneman & Tversky, 2013).

The last several decades have witnessed a boom of interest in the role of emotions in decision-making. Empirical evidence has shown that emotions help us make decisions by acting as tie-breakers in situations where cognitive processes become endless and lead to indecisiveness (Elster, 1999; Loewenstein & Lerner, 2003; Wang, 2004, 2006). Emotions often take precedence when there is a conflict between cognitive and emotional evaluations (Loewenstein et al., 2001).

When making choices under uncertainty, emotional heuristics rely on rapid and automatic emotional responses to judge the "goodness" or "badness" of stimuli and make quick and sometimes biased decisions (Finucane et al., 2000; Slovic et al., 2007). Emotions reflect the valence of a risky event, its outcome probabilities, and counterfactual comparisons (Mellers et al., 1997). Compared with cognitive heuristics, emotional heuristics equally or more effectively predicted public choices (Wang, 2008). Emotional cues may eliminate irrational reversals in risk preference and make decisions more consistent (Garelik & Wang, 2017).

Theories of emotions in decision-making

In this section, we selectively and briefly review several theories on the role of emotion in decision-making, which inspired the current work. The *somatic marker hypothesis* (Bechara et al., 1997; Damasio, 1994; Damasio et al., 1996) argues that emotion is *inevitable* in decision-making. Somatic markers are neurophysiological signals formed in the orbital-prefrontal lobe through learning and conditioning and guide decision-making under risk by generating emotional experiences. While the somatic marker hypothesis highlights the inevitability of emotions in decision-making, the *emotion as information theory* (Clore & Huntsinger, 2007; Schwarz, 1990) maintains that emotions guide decisions by providing functional information. The *emotion as social information hypothesis* (van Kleef, 2009) extends the information function of emotions to decision-making in social situations.

More relevant to the present study, the *risk as feelings hypothesis* (Loewenstein et al., 2001) emphasizes the role of anticipatory emotions in guiding decision-making since they are future-oriented and felt at the time of decision-making. The theory distinguishes between anticipatory emotions induced by imagining alternative future outcomes and *reactive emotions* provoked by a current event. Another important distinction is between anticipatory emotions and anticipated emotions. Anticipated emotions, such as regret and disappointment, are not felt at the time of decision-making and are often produced based on experience.

According to the *appraisal-tendency framework* (Lerner et al., 2007; Lerner & Keltner, 2000), different emotions possess specific cognitive and motivational properties. Emotions felt during social interactions signal specific social consequences and guide decision-making.

Anticipatory emotions as information for social risks: Hypothesis and predictions

In contrast to artificial intelligence, human intelligence is uniquely emotional and situated in a social context. As an essential part of emotional intelligence (Goleman, 1995), anticipatory emotions help people quickly analyze risks and make focused, forward-looking, and rational decisions.

We proposed a hypothesis of anticipatory emotions as information for social risks (Wang et al., 2021) by synthesizing the above theories. A general assumption of the previous theories discussed above is that emotions guide decisions without conscious awareness. Positive and negative emotions can help cope with uncertainty by substituting for values and probabilities of expected outcomes. Social and public risks (e.g., financial crisis, pollution, and racial conflicts) and health crises (e.g., pandemics and natural disasters) are characterized by high uncertainty and low predictability. Reactions to these public events spread quickly via social interactions and vary due to social conventions (Nelson & Katzenstein, 2014; Reynolds & Seeger, 2005). Behavioral responses in these social situations need to be quick and unambiguous. However, the probabilities of the consequences of these public risks are difficult to quantify. In these situations, anticipatory emotions can replace the weighted summation of expected utility calculations to provide clear directions. When uncertainty is high, people rely more on emotional processing in making decisions (Faraji-Rad & Pham, 2017).

From the perspective of risk as feelings (Loewenstein et al., 2001), emotions are more than just an essential input into decision-making under uncertainty; they mediate the connection between cognitive evaluations of risk and risk-related behavior. The current hypothesis further argues that given their forward-looking property, anticipatory emotions may provide rational guidance to decision-makers and strengthen self-control. We view anticipatory emotions as mental representations of risks in a public and social context. We predict that induction of anticipatory emotions (e.g., to anticipate possible outcomes or imagine a future event) can regulate self-control and preventive behaviors directly or indirectly by directing risk perception and assessment.

Lerner et al. (2013) argue that sadness creates a myopic focus (present-focus) on obtaining money now versus later. Results revealed that sadness significantly increased impatience and delay discounting of monetary rewards. In contrast, disgusted participants were not more impatient than neutral participants. Fear increases farsightedness when making intertemporal choices (Luo et al., 2014) more than other negative emotions. Fear of infection promotes precautionary health behaviors (Richard & Van Der Pligt, 1991).

We predict that exposure to a pandemic would activate disease-relevant emotions like disgust and fatigue. Disgust has long been regarded as the pathogen avoidance mechanism and helps people assess disease risks (Navarrete & Fessler, 2006; Sparks et al., 2018), and fatigue reduces motivation for preventive behaviors (Haktanir et al., 2021). A future-oriented cognitive appraisal of disease-relevant risks could induce higher intensity of anticipatory disgust and a lower level of fatigue to foster self-control and preventive behaviors. These emotions together would promote a forward-looking attitude and regulate preventive behaviors.

The current hypothesis distinguishes itself from the previous approaches in making the following two assumptions. First, a future-oriented cognitive appraisal is a crucial antecedent of anticipatory emotions. Anticipatory emotions are not simply reactive but proactive. Second, anticipatory emotions may promote rational decisions. This hypothesis aligns with the cognitive appraisal theory (Lazarus, 1991) in assuming that cognitive appraisals of risks prompt emotions.

For a similar token, conviction narrative theory (Tuckett & Nikolic, 2017) assumes that effective decision-making under high uncertainty depends on combining emotions with narratives that link approach-avoidance-related feelings with planned outcomes by a plot. Emotions generated from a simulation of the future consequences of decision actions boost the confidence of the decision-maker. Under radical uncertainty, as Keynes (1937) defined, emotions play an essential role in decision-making when an optimized information-processing approach fails to work. Tuckett and Nikolic (2017) emphasize the importance of narratives via causal modeling and mental simulations of future outcomes in emotion-based decision-making.

Thus, *cognitive antecedent* and *rational outcomes* are two unique theoretical assumptions of the current hypothesis. From this perspective, it is future thinking that activates anticipatory emotions. That is, the antecedent of anticipatory emotions has to be future-oriented. Anticipatory emotions induced by cognitive antecedent can be positive or negative and can increase or decrease risk-taking and self-control. For example, episodic future thinking may cause excitement or fear when facing a social risk, depending on perceived gains and losses. While the excitement may lead to risk-taking, fear may result in risk aversion.

The present study

The decision measures in the present study involve both risk preference related to health management (preventive behaviors) and ***intertemporal choice*** between a smaller-and-sooner (SS) reward and a larger-and-later (LL) reward.

The essential process underlying intertemporal choice is ***delay discounting***, where people discount the relative values of the rewards according to their expected delays until delivery (Frederick et al., 2002). In general, present goods are preferred over future goods because delayed benefits may never arrive and because earlier resource acquisition generally yields more time for accumulation of fitness (Wilson & Daly, 2004). However, steep and excessive discounting in intertemporal choices is evident in many problematic behaviors in healthy populations and populations with self-control deficiencies (Ainslie & George, 2001; Berns et al., 2007). From this perspective, delay discounting is also an index of self-control (Berns et al., 2007), with lower discounting rates indicating higher self-control and future orientation.

In the current study, we induced anticipatory emotions via ***episodic future thinking*** (i.e., imagining or mentally simulating experiences that might occur in one's future). Although the influence of episodic future thinking on preventive behaviors remains unexplored, a growing body of research has shown that episodic future thinking promotes self-control in intertemporal decision-making (Schacter et al., 2017; Stein et al., 2016). Among possible mechanisms underpinning this effect, emotion regulation in decision-making has been a leading candidate (e.g., Calluso et al., 2019). These studies revealed that positive and negative emotions induced during episodic future thinking enhance future-oriented choice preference. Consistent with these findings, another type of episodic future thinking, thinking of personal death, also reduces impatience and delay discounting of monetary rewards (Wang et al., 2019). These results and recent neurophysiological evidence (Peters & Büchel, 2010) support integrated cognitive-affective models of intertemporal decision (Calluso et al., 2019). We argued that the same cognitive-affective mechanism could also apply to preventive health behaviors, as wearing masks or diligent handwashing requires self-control and paying extra attention and time to these recommended but not compulsory actions.

In sum, based on the anticipatory emotion as information for social risks, we derived the following predictions. (1) Compared with automatic reactive emotions to COVID-19, episodic future thinking of COVID-19 infection would activate anticipatory emotions. (2) As a result, anticipatory emotions would increase the preference for LL rewards over SS rewards and thus reduce delay discounting. (3) By the same token, anticipatory emotions, especially emotions relevant to disease control (e.g., disgust and fatigue), would promote preventive health behaviors in the time of the COVID-19 pandemic. (4) Risk assessment on the likelihood of being infected by COVID-19 would work in tandem with anticipatory emotions to mediate the effect of episodic future thinking.

METHODS

Participants and procedure

The online study took place in March 2020 during the most stringent period of the first COVID-19 lockdown in China. We recruited participants via announcements posted in WeChat groups with a hyperlink to the online survey. WeChat is the most popular social media platform in China, with over 1.2 billion monthly active users worldwide in the first quarter of 2020.

All participants claimed no previous COVID-19 infection and had no direct contact with any COVID-19 patients. A total of 492 healthy volunteers (327 females and 165 males) from 167 cities across China participated in the study. One participant was excluded from the analysis since the information about the experimental condition was missing. Thus, the remaining sample size was 491. Each participant received an average of 5RMB in the form of digital red packets at the end of the survey.

We computed the a priori sample size calculation using a two-tailed Mann–Whitney test, $d = 0.3$, $\alpha = .05$, and power $= .8$; it yielded a sample size of 368. The actual sample size of 491 was sufficient for detecting group differences in the dependent measures of intertemporal choice and preventive behaviors.

Participants' age ranged from 18 to 66 years ($M = 23.9$ years, $SD = 7.75$). The participants were randomly assigned to either the anticipatory emotion group ($n = 246$) or the control group ($n = 245$). The anticipatory emotion group consisted of 152 females and 94 males with an average age of 25.4 ± 9.31 years. The control group consisted of 174 females and 71 males with an average age of 22.3 ± 5.07 years.

Experimental manipulation

Participants rated how they felt when thinking COVID-19 might infect them in the experimental group. In contrast, the participants in the control group rated their emotions when thinking COVID-19 pandemic in general, based on their present feelings during the COVID-19 pandemic. Determined by the induction method, the emotions in the experimental condition were anticipatory, while the same emotions measured in the control condition were reactive. Participants in both groups rated what they would feel with the positive and negative affect schedule (PANAS) (Watson et al., 1988). Thus, the emotions raised in the control group would differ from the experimental group in the aspect of the present versus future orientation.

All participants completed the following tasks: (1) the PANAS ratings and a few more emotion items that are more relevant to disease perception and prevention (e.g., disgust), (2) intertemporal choice questions for calculating delay discounting, (3) subjective likelihood estimations of COVID-19 infection and recovery, (4) the likelihoods of them taking preventive measures against COVID-19, and (5) demographic information.

Measures

PANAS and other affect ratings

The PANAS is a self-report measure of presently felt emotions. The PANAS consists of 10 positive and 10 negative affect words that describe feelings and emotions (Watson et al., 1988). Participants rate these emotional items based on their current feelings on a 5-point Likert scale from 1 (Not at all) to 5 (Extremely). Since its advent in 1988, the PANAS has been widely accepted as a sensitive measure to momentary changes in affect state for healthy and clinical individuals (Merz et al., 2013). A validation study (Huang et al., 2003) approved the effectiveness and validity of the PANAS with Chinese participants. The alpha coefficient in the present study was .80 for general positive affects and .91 for general negative affects.

We also included a few additional items relevant to disease prevention based on previous research, including disgust (Navarrete & Fessler, 2006), self-assurance (confident, bold, strong, proud, and daring) (Watson & Clark, 1999), feeling lucky and rejoicing, and fatigue-related items (sleepy, tired, sluggish, and drowsy). Participants rated these items on a 5-point Likert scale from 1 (Not at all) to 5 (Extremely),

Intertemporal choice and delay discounting

Using a well-established method, we calculated the delay discounting rate based on the choice preferences of each participant given to a set of seven intertemporal questions. Participants made seven independent choices between a SS and a LL monetary reward, such as "Would you prefer 498 RMB now or 1080 RMB in 37 days?"

This method developed by Kirby and Maraković (1996) was verified with both American participants (Wang et al., 2018; Wang & Dvorak, 2010; Wilson & Daly, 2004) and Chinese participants (Wang et al., 2019; Wang & Huangfu, 2017). These previous studies show that a set of seven questions were sensitive enough to capture differences in delay discounting among participants in different experimental conditions.

In the present study, the monetary rewards ranged from 126 to 8190 RMB (the equivalent of \$18 to \$1170 at the time of the study). The temporal delays ranged from 4 to 939 days. The seven questions differed in the delay discounting rate (k). For each intertemporal choice question, the following hyperbolic formula calculates the delay discounting rate (k):

$$k = (\text{larger amount} - \text{smaller amount}) / (\text{smaller amount} \times \text{longer delay}).$$

For example, according to the formula, if a participant is indifferent between 498 RMB now and 1080 RMB in 37 days (i.e., the two options are equally valuable to this person), the k value would be .0315858. A person with a higher k value would discount a future reward more steeply. In contrast, a person with a lower delay discounting rate would have a stronger future-oriented preference.

The k values of the seven choice questions ranged from .0004 to .5. A k of .0004 is an equivalent of indifference between 126 RMB now and 147 RMB in 417 days. A k of .5 is an equivalent of indifference between 2730 RMB now and 8190 RMB in 4 days.

To estimate the k value for each participant, we first arranged the seven decisions in ascending order of their k values. As the k value increases, the SS option in a choice question becomes less attractive, and the seven choices reveal where a participant switches from the SS to the LL option. After identifying the switching point from SS choice to LL choice, the value of delay discount (k) was computed as the geometric mean of the k-values bounding this choice switch. For example, if a participant selected a SS reward with a k value of .0004 in a previous trial and switched in the next trial to the LL option with a k of .0016, the k value of the participant would be .0008.

Likelihood estimations of covid-19 infection and recovery

Each participant estimated (a) the likelihood of being infected by COVID-19 in the present situation and (b) the likelihood of full recovery from COVID-19 if infected, in terms of probability (%) ranging from 0 to 100.

Preventive measures in response to COVID-19

We asked participants to estimate their preventive behaviors in response to COVID-19, including standard protection (wearing a mask) and other preventive behavior (wearing a mask in open spaces, wearing gloves, and washing hands):

> "During the current pandemic situation, would you wear a mask when you go out?"
>
> "Would you wear a mask in an open area with no people around?"
>
> "During the current pandemic situation, would you wear gloves when you go out?"
>
> "During the current pandemic, would you wash your hands after unpacking a food delivery?"

The options for answering the first three questions ranged on a 4-point scale from (1) Never, (2) Occasionally, (3) Most of the time, to (4) Always.

The options for answering the handwashing question ranged from (1) would not wash hands immediately, (2) would wash hands immediately most of the time, (3) would always wash hands immediately, and (4) would always wash hands immediately and use hand sanitizer. We conducted the McDonald's omega test to test the reliability between the above four measures (Dunn et al., 2014). The ω coefficient = .60, 95% CI [.53, .67]. According to a general rule (Ursachi, 2015), the reliability of our four measures reached an acceptable level. This reliability value between the four measures was relatively low due to their significant but relatively low intercorrelations (i.e., Pearson correlations ranged from .11 to .63).

RESULTS

An overview of the analyses

First, we conducted a validity check of the manipulation, a simple instruction to activate anticipatory emotions by episodic future thinking of being infected by COVID-19. Although anticipating COVID-19 infection may have various cognitive effects on risk perception, we first focused on comparing the control and experimental groups to verify expected differences in their emotional ratings.

Second, since the validity check only verified the differences in the intensity but not in temporal orientation between the anticipatory and reactive emotion groups, we further examined if the two groups also differ in their present versus future orientation, as measured by the delay discounting rate *k*. We also tested the behavioral effects on preventive health behaviors and risk perception.

Third, we conducted exploratory analyses to investigate if the changes in delay discounting and health behaviors were related to any specific emotions. Finally, we examined mediating effects of risk perception between anticipatory activation and preventive health behaviors.

Since most measures (e.g., emotional ratings and preventive behaviors) were based on Likert scales and thus were unlikely to satisfy the assumption of normality in the *t*-test, we thus used the Shapiro–Wilk test to examine the normality of the data distributions. Except for the general positive affect, all the other measures of emotions and preventive behaviors departed significantly from normality (all $ps < .014$). Therefore, we adopted a more robust Mann–Whitney *U*-test to cope with the nonnormal distributions of the data.

A validity check of the effects of anticipatory activation on affect ratings

Using the Mann–Whitney *U*-test (Table 1), we found that participants in the anticipatory emotion group reported higher scores on general negative affect ($z = -5.45$, $p < .001$) and lower scores on general positive affect ($z = -5.76$, $p < .001$), self-assurance ($z = -6.00$, $p < .001$), feeling lucky and rejoicing ($z = -5.26$, $p < .001$), and fatigue ($z = -2.72$, $p = .006$) than the control group. There was no significant difference in disgust ratings ($z = -.755$, $p = .45$).

TABLE 1 Affect ratings in the anticipatory and control groups

	Anticipatory		Control			
Affect ratings	***M***	***SD***	***M***	***SD***	***z***	***p***
General negative affect	2.60	0.85	2.19	0.71	−5.445	.000
General positive affect	2.62	0.63	2.95	0.57	−5.760	.000
Self-assurance	2.48	0.74	2.87	0.63	−6.003	.000
Feeling lucky and rejoicing	2.22	1.17	2.73	1.03	−5.261	.000
Fatigue	2.35	0.91	2.56	0.78	−2.742	.006
Disgust	1.88	1.09	1.71	0.82	−0.755	.450

Note. Anticipatory emotion group ($n = 246$); control group ($n = 245$). Given that the sample size was large, the Mann–Whitney *U* scores were approximated to *z*-scores with a normal distribution.

A post hoc analysis revealed that episodic future thinking had a much stronger effect on the rating of fear ($\eta_p{}^2 = .145$) than on the rating of sadness ($\eta_p{}^2 = .011$).

Behavioral effects of anticipatory emotions on delay discounting, preventive health behaviors, and risk perception

Table 2 shows the main behavioral effects of anticipatory emotion activation.

As predicted, participants in the anticipatory emotion group were more precautionary and preventive. The total score of the preventive behaviors, the sum of the four likelihood measures on a 4-point Likert-type scale, included wearing masks, wearing masks in open space, wearing gloves, and washing hands. The total score of the participants in the anticipatory emotion group was significantly higher than the control participants, $F(1, 489) = 7.02$, $p = .008$, $\eta_p{}^2 = .014$. More specifically, people in anticipatory emotion group were more likely to wear masks ($z = -2.26$, $p = .024$), to wear masks in open space ($z = -2.14$, $p = .032$), and to wear gloves ($z = -2.74$, $p = .006$). However, they did not differ significantly in the thoroughness of handwashing after returning home ($z = -1.52$, $p = .13$).

To compare the delay discounting rates between the control and anticipatory emotion groups, we performed a natural log transformation on the discounting parameters to normalize the variable distributions. As predicted, the anticipatory emotion group (M $= -5.14$, $SD = 2.16$) had a lower delay discounting rate than the control group ($M = -4.72$, $SD = 2.36$), $F(1, 488) = 4.31$, $p = .038$, $\eta_p{}^2 = .009$.

The anticipatory emotion group reported a higher perceived likelihood of being infected by COVID-19 ($z = -2.08$, $p = .038$). However, there was no difference in the perceived likelihood of being cured after infection ($z = -0.88$, $p = .38$).

TABLE 2 Main effects of anticipatory emotions on delay discounting, preventive health behaviors and risk perception

	Anticipatory		Control			
Dependent variables	***M***	***SD***	***M***	***SD***	***z***	***p***
Delay discounting in intertemporal choice						
Log *k* value	−5.12	2.16	−4.72	2.36	−1.98	.05
Preventive health behaviors						
Total score	13.13	1.98	12.58	2.05	−3.38	.001
Wearing masks	3.85	0.46	3.77	0.54	−2.26	.024
Wearing masks in open space	3.54	0.82	3.39	0.87	−2.14	.032
Wearing gloves	1.81	1.05	1.57	0.93	−2.74	.006
Washing hands	3.93	0.67	3.85	0.70	−1.52	.13
Risk perception						
Likelihood of being infected	11.68	17.30	7.87	11.60	−2.08	.038
Likelihood of being cured	77.19	22.33	79.68	19.28	−0.88	.38

Note. Anticipatory emotion group ($n = 246$); control group ($n = 245$). The total score of preventive health behavior was the sum of the likelihood measures of the four preventive behaviors.

It is important to note that the differences in delay discounting and preventive behaviors between the experimental and control group were NOT simply due to higher risk perception of COVID-19 infection in the anticipatory activation group. Our results showed no significant correlation between the likelihood estimate of COVID-19 infection and the delay discounting measure ($r = .061$) or the total score of preventive behaviors ($r = -.088$).

Given that some previous studies reported a higher discounting rate and lower acceptance of preventive behaviors in males than females (Kirby & Maraković, 1996; Ning et al., 2020), we tested Sex and Sex–Group interaction effects on delay discounting and the total score of preventive behaviors, using univariate ANOVA. The results show that both Sex ($F(1, 486) = 13.47$, $p < .001$, ${\eta_p}^2 = .03$) and Group ($F(1, 486) = 7.75$, $p = .006$, ${\eta_p}^2 = .02$) significantly affected delay discounting. However, the Sex–Group interaction effect was not significant ($F(1, 486) = 2.13$, $p = .15$, ${\eta_p}^2 = .00$).

Overall, males had a higher delay discounting rate than females. The log k values of males (-4.45 ± 2.32) were significantly higher than females ($-5.17 \pm .21$). The sex of the participants had no significant effect on the total score of preventive behaviors, $F(1, 486) = 2.74$, $p = .10$, ${\eta_p}^2 = .00$, while the Group effect remained significant, $F(1, 486) = 4.39$, $p = .037$, ${\eta_p}^2 = .01$.

There was an unexpected age difference between the two groups, with participants in the anticipatory emotion group ($M = 25.39$, $SD = 9.31$) older than those in the control group ($M = 22.28$, $SD = 5.07$), $t(379.69) = 4.60$, $p < .001$, Cohen's $d = 0.42$. However, age was not significantly associated with delay discounting rate (one participant was excluded due to missing k value), $r(488) = .05$, $p = .23$, or the total score of preventive behaviors, $r(489) = -.08$, $p = .06$.

Moderation effects of negative emotions, disgust, and fatigue

To further illustrate how negative emotions induced by episodic future thinking of COVID-19 infection regulated preventive behaviors, we regressed mask-wearing behavior on general negative affect (PANAS-NA). The significant interaction ($\beta = .15$, $t(487) = 2.15$, $p = .03$; experimental condition: $\beta = .02$; control: $\beta = -.14$) revealed that general negative affect improved the likelihood of wearing masks in the anticipatory activation condition. Figure 1 illustrates that negative affects (PANAS-NA) enhanced participants' preventive intention to wear masks only in the anticipatory emotion group. However, we found no significant associations between general negative emotions and the other preventive behaviors (all ps $< .61$) nor interactions (all ps $< .72$). The results suggested that wearing masks, one of the most common behavioral measures against COVID-19, may be uniquely sensitive to emotional regulation.

Besides the general positive and negative emotions, we also tested how disease-relevant specific emotions (i.e., disgust and fatigue) regulated delay discounting and preventive health behaviors under the control and experimental conditions. First, the delay discounting rate was regressed on disgust ratings. Disgust generally increased the delay discounting rate ($\beta = .16$, $t(484) = 2.10$, $p = .036$) and made people more present-oriented; however, this positive relationship between disgust and delay discounting was reversed in the anticipatory emotion condition, as revealed by a significant interaction ($\beta = -.17$, $t(484) = -2.23$, $p = .026$; experimental condition: $\beta = -.01$; control: $\beta = .16$). The implications of this finding are twofold: Disgust induced when anticipating COVID-19 infection had the opposite effects than disgust measured in the control condition. Second, the effects of anticipatory disgust were more rational and future-oriented. However, we found no evidence that anticipatory disgust prompted the willingness to take other preventive measures (all ps $> .07$).

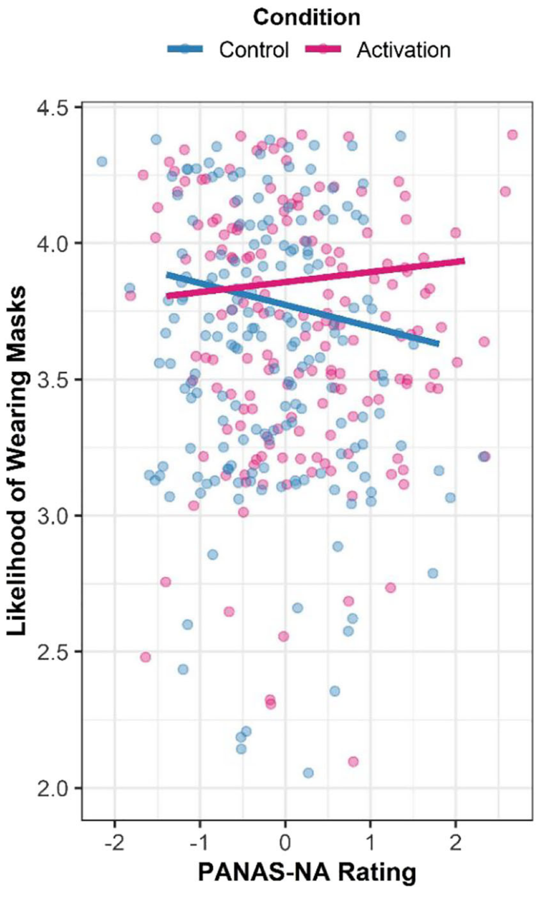

FIGURE 1 Moderation of negative emotions (positive and negative affect schedule [PANAS]-NA) on preventive health behavior (the likelihood of wearing masks) under two experimental conditions coded with a dummy variable (0 for the control and 1 for the anticipatory activation group). The PANAS-NA scores were zero-centered for the regression analysis

Next, we identified a significant interaction ($\beta = .18$, $t(487) = 2.55$, $p = .01$; experimental condition: $\beta = .18$; control: $\beta = -.08$) between the fatigue ratings and glove-wearing behavior. This differential regulation of the fatigue feeling was also found for the likelihood measure of wearing masks, $\beta = .14$, $t(487) = 1.99$, $p = .048$ (experimental condition: $\beta = .01$; control: $\beta = -.12$). Therefore, feeling fatigued increased the likelihood of wearing masks and gloves only in the anticipatory emotion condition. However, anticipatory fatigue had no significant effects on the likelihood measures of wearing masks in the open area and handwashing (all *p*s $> .51$).

Mediation effects of risk perception on preventive health behaviors

We further examined whether risk perception mediated preventive health behaviors, as measured by the likelihood estimate of being infected by COVID-19. We computed the total score of wearing masks and gloves to reflect a general tendency to wear sanitary products. We found

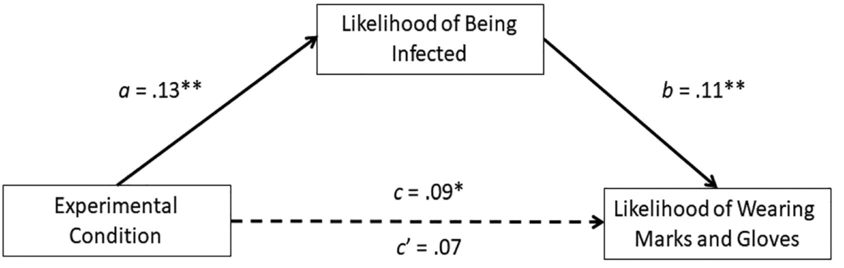

FIGURE 2 Mediation effects of COVID-19 risk perception between the emotion induction condition and preventive behaviors (averaged likelihood estimates of wearing masks and gloves)

that risk perception fully mediated the effect of the anticipatory activation on the likelihood of wearing masks and gloves (bootstrapped standardized indirect effect = .01, 95% CI [.002, .032]). Participants in the anticipatory condition had a higher likelihood estimate of being infected by COVID-19 (a: $\beta = .13$, $t(489) = 2.86$, $p = .004$), which in turn predicted the averaged likelihood of wearing masks and gloves (b: $\beta = .11$, $t(489) = 2.53$, $p = .001$). However, the anticipatory activation did not significantly change the estimate of the likelihood of full recovery from COVID-19 infection compared with the control group (see Figure 2).

Further analyses also verified the synergetic effect of risk evaluation and anticipatory emotions on preventive behaviors. The likelihood estimate of being infected by COVID-19 was significantly associated with anticipatory general negative emotions ($r(244) = .25$, $p < .001$), disgust ($r(244) = .17$, $p = .008$), and fatigue ($r(244) = .25$, $p = .002$) but not with reactive emotions (all ps > .29).

GENERAL DISCUSSION

We examined how anticipatory emotions and reactive emotions differentially regulate delay discounting and preventive health behaviors during the COVID-19 lockdown period in China. Our results show that episodic future thinking had its effects by activating anticipatory emotions and risk evaluations. There are three main findings: (1) inducing anticipatory emotions promote self-control in intertemporal decisions and preventive behaviors; (2) anticipatory emotions are qualitatively different from reactive ones, as exemplified by the moderation effects of emotion type on delay discounting and preventive health behaviors; and (3) the risk estimates of COVID-19 infection mediate the effect of episodic future thinking.

We first verified the intended impact of episodic future thinking on PANAS ratings (see Table 1) and the consequent behavioral effects. Compared with the participants who rated the same emotion items based on their current feelings, the participants anticipating COVID-19 infection had a higher rating of general negative affect and a lower rating of general positive affect. Anticipatory activation made participants more energetic, as shown in their significantly lower subjective fatigue ratings. Experiencing anticipatory emotions made participants more realistic, as seen in their significantly lower feeling of being lucky and rejoicing.

These results have significant policy implications. Recent studies during the pandemic found that the degree of self-control in health management decreases over time. For instance, self-projection of the degree of compliance with preventive measures during COVID-19 declined hyperbolically for prolonged containment over half a year (Nese et al., 2020). Other reasons for declining adherence to preventive measures include being emotionally drained (Haktanir et al., 2021). Activation of anticipatory emotions may have a refreshing effect to reinforce preventive behavior as time goes by.

Notably, the difference in intensity of emotions did not directly predict delay discounting and preventive measures of the participants in both groups (see Table 2, also Wang et al., 2019). This result suggests that it is not the intensity difference per se but the future orientations of anticipatory emotions that guide the self-control behaviors.

Second, as shown in Figure 1, the PANAS scores in the experimental group, but not in the control group, predicted the changes in preventive health behaviors. For example, the rating scores of disgust between the anticipatory condition and the control condition were not significant. However, anticipatory disgust reversed the effects of disgust measured in the control condition from present orientation to future orientation. The future-orientated time preference, in turn, promoted preventive health behaviors. A similar reversal was also evident for another disease-relevant emotion, fatigued. These results suggest that the forward-looking nature of anticipatory emotions made the participants more prudent and less impulsive.

Third, the participants in the anticipatory activation group estimated a higher likelihood of being infected by COVID-19, which mediated the effect of episodic future thinking. However, the effects of anticipatory emotions on decision-making were not simply a result of higher risk perception since the subjective estimate of COVID-19 infection did not predict the changes in the decision-making measures.

In a recent effort, the journal *Applied Psychology: Health and Well-Being* devoted 18 articles in a special issue to investigate people's health and well-being during the early stages of the COVID-19 pandemic, their coping strategies, and adherence to preventive measures. Of the many findings of these research endeavors, two specific results are most relevant to the present research. First and interestingly, among the most relevant risk factors, risk perception of COVID-19 infection had only a weak influence on adherence to preventive measures (Inauen & Zhou, 2020, p. 942). A second finding was that the increased prevalence rates of COVID-19 were associated with more Google searches for not only pandemic-related topics but also emotion-related terms, such as fear-related topics (Du et al., 2020). This second finding suggests that people make rational efforts to understand better their emotional reactions to public risks and health crises. The results of the present study provide insight into these seemingly unrelated findings. The effects of risk perception/assessment on health behaviors were not direct. Instead, episodic future thinking of COVID-19 infection induced both emotional reactions and assessment of risks: both together regulated decision-making.

This argument was also bolstered by significant correlations between anticipatory emotions and risk estimates. In addition, participants' estimated likelihood of full recovery after COVID-19 infection was not significantly different from the control group. This result suggests that activating anticipatory emotions made these participants more alert but not less confident. This combination of higher perceived risk with stable confidence would allow participants to behave more rationally and strategically.

Overall, the results from the present study suggest that anticipatory emotions during decision-making provide forward-looking guidance and enable quick and unambiguous reactions to a focused risk. Simple and focused instructions to activate anticipatory emotions appear to be an effective behavioral intervention to promote self-control and preventive health behaviors.

A recent study conducted in Italy during the lockdown period due to COVID-19 examined the relationship of personal discounting rate and compliance with containment without episodic future thinking induction (Calluso et al., 2019). The results showed an unexpected relationship where persons with a higher reward discount adhered to containment measures. These authors interpreted this result in terms of participants' overconfidence in a better future so that present orientation (higher discounting) would lead to a greater tendency to view preventive behaviors as immediate gains rather than losses. Interestingly, without being constrained by negative anticipatory emotions via future thinking, individuals may become unrealistically optimistic when dealing with health risks.

Based on our findings, an implication for behavioral interventions to improve health behaviors is to use anticipatory guidance to elicit proper emotions. Health experts also suggest that, in general, anticipating emotional reactions to the COVID-19 pandemic would reduce psychological stress instead of aggravating it. Stressful and negative experiences of patients, family members, and the public can be appropriately relieved by providing information about usual reactions to this kind of stress (Pfefferbaum & North, 2020).

During an infectious disease outbreak, people inevitably experience negative emotions (Cullen et al., 2020). However, negative emotions have different impacts on people's judgment and decision-making (Lerner et al., 2013). Our results suggest that forward-looking cognition help induce feelings that are more effective in promoting health behaviors than mere reactive emotions. However, these results do not indicate that only negative anticipatory emotions are effective. Previous studies also showed that people are more willing to engage in tasks with higher anticipated positive values (Taura et al., 2015). Therefore, future thinking may generate positive feelings such as happiness, rejoicing, and excitement, thus reducing procrastination and turning judgment and decisions into actions (Yang et al., 2021).

Among negative emotions, some are more anticipatory than others. Consistent with the postulation that fear is more future-oriented (Luo et al., 2014) and sadness is more present-oriented (Lerner et al., 2013), episodic future thinking of being infected by COVID-19 had a much more significant activation effect on fear than sadness.

Our study calls for research attention to the role of anticipatory emotions in decision-making. However, the current study is limited to the COVID-19 risk and is preliminary in revealing precise emotional mechanisms guiding decision-making. Future studies should explore multiple ways of generating and measuring anticipatory emotions.

Another caveat of the present study is that we only assumed that anticipatory emotions are specific to social and public risks. We studied the effects of emotions in such a public-risk situation of the COVID-19 pandemic. However, the study did not compare the effects of anticipatory emotions in social risk versus nonsocial risk situations. Thus, the results of our study do not exclude the possibility that nonsocial risks also similarly induce anticipatory emotions. Future studies need to investigate how risks induce emotions in social versus individual contexts.

A drawback in the current study relates to the acceptable but relatively lower reliability score between the preventive behavior measures. The low intercorrelations between preventive behaviors might be related to different motivations associated with different preventive behaviors. Indeed, adherence to COVID-19 preventive measures was high for some but not all measures (Tong et al., 2020).

In addition, we only measured the intention and self-reported likelihood of engaging in preventive behaviors. Thus, the study lacks the direct measures of the actual preventive behaviors of the participants. Limited by the online data collection, the actual preventive behaviors of different participants during the COVID-19 lockdown period would not be entirely comparable since the participants were not in the same environment with similar access to preventative supports and health resources.

The 492 participants in our sample were from 167 cities and thus had different exposure to COVID-19. As a result, their episodic future thinking and emotional reactions to the experimental manipulation would be quite different. In other words, different pandemic situations could change the vividness of their episodic thinking and awareness of the risk. Although random assignment reduces this potential confounding effect, it cannot guarantee to eliminate this effect.

CONCLUSIONS

The present study measured preventive health behaviors and delay discounting, an essential decision parameter underlying self-control and self-regulation. This research has advanced the current knowledge on how emotions guide decision-making in general and how anticipatory emotions promote future-oriented decision-making, as shown in a reduced delay discounting in monetary decisions and increased intention to engage in preventive health behaviors during the COVID-19 pandemic.

We view anticipatory emotions as an essential part of emotional intelligence (Goleman, 1995) and guidance for rational decision-making (Salovey & Grewal, 2005). We believe that the following four characteristics of anticipatory emotions are essential for making adaptive decisions in social situations with high uncertainty: fast, focused, forward-looking, and making possible consequences felt.

Our study demonstrates how basic knowledge of emotion science can lead to new testable hypotheses and potential interventions to promote healthy behaviors and future-oriented actions. In the current study, activating anticipatory emotional reactions to COVID-19 by episodic future thinking serves as psychological leverage to promote future-oriented choice preferences and preventive health behaviors.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the Chinese University of Hong Kong (Shenzhen) (protocol code EF20190228001, date of approval February 28, 2019). We obtained Informed consent from all participants.

AUTHOR CONTRIBUTIONS

Conceptualization: X.T. Wang and P. Wang; methodology: X.T. Wang. P. Wang, G. Li, and J. Zhou; data collection: P. Wang, G. Li, and S. Garelik; data analysis: X.T. Wang. P. Wang, and J. Lu; resources: X.T. Wang; writing – original draft preparation: X.T. Wang and J. Lu; writing – review & editing: X.T. Wang, J. Lu, P. Wang, and S. Garelik; supervision: X.T. Wang; funding acquisition: X.T. Wang and J. Zhou.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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