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Review

A mini-review on how the COVID-19 pandemic affected intertemporal choice

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Abstract

The coronavirus disease (COVID-19) has extremely harmful effects on individual lifestyles, and at present, people must make financial or survival decisions under the profound changes frequently. Although it has been reported that COVID-19 changed decision-making patterns, the underlying mechanisms remained unclear. This mini-review focuses on the impact of the COVID-19 pandemic on intertemporal choice, and potential psychological, biological, and social factors that mediate this relationship. A search of the Web of Science electronic database yielded 23 studies. The results showed that under the COVID-19 pandemic, people tended to choose immediate and smaller rewards, and became less patient. In particular, people with negative emotions, in a worse condition of physical health, or who did not comply with their government restriction rules tended to become more "short-sighted" in behavioral terms. Future studies should examine more longitudinal and cross-cultural research to give a broad view about the decision-making change under the COVID-19 pandemic.

Keywords: COVID-19; intertemporal choice; biological factors; psychological factors; social factors

Introduction

In the face of the ongoing public health emergency posed by the coronavirus disease (COVID-19) (Torales *et al.*, 2020; Velavan and Meyer, 2020), governments and individuals alike have had to make difficult decisions, such as whether to adopt stay-at-home restrictions to prevent future virus outbreaks, even though such methods reduce people's contact with each other (Pfefferbaum and North, 2020; Pokhrel and Chhetri, 2021).

Intertemporal choice, a concept from cognitive psychology, can be used to explain the decisions people make in situations such as that of the COVID-19 pandemic as 2020. Intertemporal choice involves evaluating the results of different decisions at several points in time, and the individual must weigh the cost and benefits of a later larger reward against sooner smaller rewards (Chabris *et al.*, 2010). When people prefer immediate rewards over larger rewards in the future, this is known as delay discounting (Keidel *et al.*, 2021).

The degree of delay discounting can vary between individuals and can be affected by experimental procedures or participants' emotions (Lempert and Phelps, 2016; Zhang and Ke, 2019). The COVID-19 pandemic has been linked to a decrease in public psychological well-being, as numerous emotional responses, such as stress or anxiety, have been observed (Coroiu *et al.*, 2020). This has resulted in people becoming less capable of making rational decisions in the pandemic crisis. Research has indicated that during the pandemic, there was an increase in health-related decisions that had negative consequences, such as a rise in substance use and engaging in risky sexual activities. However, some studies have also demonstrated that during this time, people have made fewer decisions with immediate rewards but long-term negative outcomes. The lockdown strategy is a major factor in the disagreement about people's involvement in "short-sighted" behavior; individuals with substance addiction were isolated from their related substance supply, thus decreasing their high-risk behavior, and some of them turned to other high-risk behaviors such as excessive social media use or other impulsive decisions (Dubey *et al.*, 2020). The lockdown strategy in the USA was successful in reducing after-school crime, however, serious battery, intimate partner violence, and homicide saw an increase (Boman and Gallupe, 2020). Nivette *et al.* (2021) found that the COVID-19 pandemic decreased some types of crime due to a decrease in opportunity, while the motivation of offenders remained unchanged (Boman and Mowen, 2021). Additionally, cultural factors can be considered to explain this discrepancy further. Studies have shown that in cultures that avoid uncertainty, individuals may display higher risk-taking tendencies to reduce the ambiguity caused by external factors (Pantano *et al.*, 2021). As the effect of uncertainty differs from culture to culture, the same level of increasing uncertainty can lead to different patterns of behavior.

Research has found that the COVID-19 pandemic caused an increase in impulsive behavior, such as interpersonal violence, impulsive buying, and addiction. Worry about violence has been higher than before due to the pandemic and its related lessening of efforts (Kravitz-Wirtz *et al.*, 2021). Panic buying has been a major influence on the US population's purchase behavior as a result of the risk of complete lockdown (Ahmed *et al.*, 2020). Tobacco, electronic cigarette, and alcohol addictions have all increased, as well as behavioral addictions such as internet addiction (Dubey *et al.*, 2020). Social media use has become more addictive, as individuals seek to cope with anxiety and uncontrollable feelings

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(Pollard *et al.*, 2020). Furthermore, recreational screen time has also increased among adolescents in three Australian states (Gardner *et al.*, 2022). This could be due to the compensatory effects of the internet, which was seen as an escape from reality and a means of coping with stress in the pandemic crisis (Haberlin and Atkin, 2022). Twenge and Campbell (2018) discovered a strong link between recreational screen time and low self-control, indicating that people tended to devote more time to leisure activities than what is considered "healthy": using the internet for educational or compulsive purposes (Babic *et al.*, 2017). In addition, a study conducted in five countries showed an upward trend in the consumption of electronic cigarettes during the lockdown period, with nicotine users reporting the excessive use of such products to relieve stress and anxiety related to the pandemic (Yach, 2020). These maladaptive behaviors imply that the COVID-19 pandemic caused distress in individuals, resulting in impulsive thinking and behavior.

We are interested in exploring how the COVID-19 pandemic affected decision-making patterns. We are looking for the factors that have caused this change, which may not only be a shift in the trend, but could also be an increase in the same trend that was present before the pandemic. For example, obesity has always been linked to higher delay discounting (Miranda-Olivos *et al.*, 2021). During lockdowns, people with obesity did less outdoor activity and had a more sedentary lifestyle, leading to an increase in weight for >50% of those affected (Sideli *et al.*, 2021). This increase in weight could lead to even higher delay discounting, meaning that the pandemic has not changed the association, but has instead intensified it. Therefore, we are focusing on the increased effects that have been caused by the pandemic.

This review seeks to analyze the effects of the COVID-19 pandemic on intertemporal choice, as well as the psychological factors that may be linked to such changes. The aim is to understand the effects and perceptions of COVID-19 on decision-making, and to pinpoint the factors that influence this variation.

Methods

A literature search was performed using the Web of Science electronic database. The retrieval method used was as follows: TS=("delay discounting" OR "intertemporal choice" OR "monetary choice") AND TI=(COVID-19 OR coronavirus), with the publication date ranging from 1 January 2020 to 31 August 2023. After initially finding 32 studies, nine were excluded as they were conference abstracts ($n = 1$), editorial material ($n = 1$), dissertations ($n = 1$), not empirical studies ($n = 1$), were focused on the discounting of compliance ($n = 3$) or test-reliability ($n = 1$), or used without an intertemporal choice task ($n = 1$). Ultimately, 23 studies were included (Table 1).

COVID-19 pandemic and intertemporal choice

During the COVID-19 pandemic, individuals' decision-making had been affected by psychological, biological, and social factors (Fig. 1). Studies have revealed that individuals experienced negative emotions such as uncertainty, fear, sadness, disgust, and anger when facing the COVID-19 situation (Wang *et al.*, 2022; Wu *et al.*, 2022). Those with higher levels of uncertainty chose immediate rewards (Wu *et al.*, 2022). From a psychological perspective, it has been found that social vulnerability is positively correlated with delay discounting (Felton *et al.*, 2022), and a weak but positive association between self-reported impulsivity and compliance behavior (Wismans *et al.*, 2021) has been identified. Moreover, they demonstrated that brain connectivity could predict their stress levels, which may lead to choices of smaller rewards sooner. Additionally, Calluso *et al.* (2021) found a negative correlation between compliance with containment measures and intertemporal discounting. As such, the following sections will further explore these factors in detail.

Psychological factors

There were three studies demonstrating that when individuals were exposed to uncertain conditions, they tended to opt for immediate rewards (Wu *et al.*, 2022; Li *et al.*, 2015). This was likely due to the psychological state of not knowing (Kuang, 2018), or uncertainty distress, that accounts for the attempt to understand unclear conditions (Freeston *et al.*, 2020). During the COVID-19 pandemic, people were still uncertain about the level of protection provided by vaccines, when restrictions would be lifted, and when employees could return to work (Koffman *et al.*, 2020; Szczygielski *et al.*, 2022). This resulted in that individual being more likely to choose smaller, immediate rewards over larger, delayed rewards.

Previous research has indicated a positive correlation between perceived stress and delay discounting in both adolescents and adults (Craft *et al.*, 2022). Moreover, the discounting rate has been identified as a significant predictor of perceived stress (Craft *et al.*, 2022). The COVID-19 pandemic has further highlighted this association, with studies suggesting an increase in stress levels leading to greater delay discounting (DeAngelis *et al.*, 2022; Agrawal *et al.*, 2023). Notably, children were found to display higher levels of delay discounting due to elevated stress during the pandemic (Crandall *et al.*, 2022).

In the face of the rapidly spreading COVID-19 pandemic, individuals have experienced heightened levels of fear, disgust, anger, and sadness. Fear and disgust are innate emotions that can be adaptive in terms of increasing individual survival, but can also be maladaptive when individuals overreact to the threat (Luo *et al.*, 2021; Miłkowska *et al.*, 2021). Milkowska *et al.* (2021) found that Polish women reported higher levels of disgust in response to sources of infection during the pandemic in 2020 compared to 2017. Similarly, Fitzpatrick *et al.* (2020) reported that participants rated an average 7 out of 10 in terms of fear related to the COVID-19 pandemic in the USA. Schimmenti *et al.* (2020) proposed an integrated model of fear experience during the pandemic, which included fear of the body, fear of significant others, fear of not knowing, and fear of inaction, According to Fiorenzato *et al.* (2022), a more pronounced rate of delay discounting was linked to a heightened fear of job loss. Studies have indicated that fear, disgust, anger, and sadness are also the most common emotional responses to traumatic events (Trnka and Lorencova, 2020). The outbreak of the COVID-19 pandemic, coupled with a lack of knowledge and misunderstanding of government actions, has caused public anger (Malakoutikhah *et al.*, 2021). Smith *et al.* (2021) found that 56% of participants in the UK expressed anger due to the pandemic. Another study showed that 40% of Brazilian respondents experienced sadness or depression during the pandemic (Barros *et al.*, 2020). This preference toward smaller, immediate rewards during experiences of negative emotions could be explained by emotion regulation strategies, which suggest that people use immediate rewards to compensate for negative emotions (Fichman *et al.*, 1999).

A potential direction of future study involves conducting longitudinal studies to better understand how emotions have changed over the course of the COVID-19 pandemic and how these emotions affect intertemporal choice. Additionally, studies could

Table 1: Studies included in this mini review.

References	Country	Study design	Sample	Measurement of ITC	Measurement of the impact of COVID-19	Mediators and/or moderators	Summary of findings
Agrawal *et al.* (2023)	USA	Cross-Sectional Experiments	12 906 adults	Money Earlier or Later Task	Stress and pandemic mitigation behaviors		The log-transformed discounting rate was found to have a small but significant positive correlation with perceptions of health and financial stress. Moreover, in financial decision-making, social distancing was observed to be significantly linked to discount rates.
Brown *et al.* (2023)	UK	Cross-sectional experiments	240 smokers	27-item Monetary Choice Questionnaire	COVID-19-related/traditional health warnings		Smokers who demonstrated decreased delay discounting exhibited higher levels of subjective arousal when presented with COVID-19-related health warnings.
Byrne *et al.* (2021)	USA	Cross-sectional online questionnaire	404 adults	Delay discounting task	Beliefs regarding mask-wearing effectiveness		Higher temporal discounting was associated with less suitable mask-wearing habits and social distancing.
Calluso *et al.* (2021)	Italy	Cross-sectional online questionnaire	353 adults	27-item Monetary Choice Questionnaire	Adherence to containment measures	Perception of contagion risk	The contagion risk index and individual discount rates had an inverse relationship, which was moderated by the individual's perception of contagion risk.
Cannito *et al.* (2021)	Italy	Cross-sectional experiments	100 adults	27-item Monetary Choice Questionnaire	Time estimation		Evaluating surgical masks led to a stronger preference for immediate commodities over money.
Craft *et al.* (2022)	USA	Cross-sectional online questionnaire	267 adults	Delay discounting task	Perceived stress		The discount rate was found to have a significant influence on the level of stress perceived in relation to COVID-19.
Crandall *et al.* (2022)	USA	Longitudinal online questionnaire	A stratified cohort of families (N = 76 dyads)	Delay discounting task	Pandemic food insecurity		During the pandemic, children were observed to demonstrate a greater tendency to discount delayed rewards in response to an increase in psychological stress.

Table 1: Continued

References	Country	Study design	Sample	Measurement of ITC	Measurement of the impact of COVID-19	Mediators and/or moderators	Summary of findings
DeAngelis *et al.* (2022)	96 countries	Cross-sectional online questionnaire	3686 adults	Monetary 5-trial delay discounting task	Stress, stockpiling, physical distancing		Stress had a positive impact on delay discounting, which was positively associated with stockpiling and negatively associated with physical distance.
Felton *et al.* (2022)	USA	Cross-sectional online questionnaire	72 adults	27-item Monetary Choice Questionnaire	Coronavirus impact scale	Exposure to COVID-19	Social vulnerability and delay discounting were positively correlated.
Fiorenzato and Cona (2022)	Italy	Cross-sectional online questionnaire	586 adults	Monetary 5-trial delay discounting task	COVID-19 pandemic-related information	Depression, anxiety, intolerance of uncertainty	An increased rate of delay discounting was mainly linked to the interaction between older age and higher levels of financial insecurity, such as fear of job loss.
Halilova *et al.* (2022)	13 countries	Cross-sectional online questionnaire	4452 adults	Intertemporal choice procedure	COVID-19 vaccination status		Unvaccinated individuals showed a greater tendency to discount delayed rewards.
Hall *et al.* (2022)	Canada	Cross-sectional online questionnaire	1958 adults	5-trial delay discounting task	SARS-CoV-2 infection status		Young and middle-aged adults with a positive SARS-CoV-2 infection history and moderate to severe COVID-19 symptoms were more likely to exhibit amplified delay discounting than those without.
Hall *et al.* (2023)	USA	Cross-sectional/longitudinal experi-ments/online questionnaire	2122 adults	Delay discounting task	COVID-19 history, neurocognitive function, psychiatric symptoms	Age, sex	The rate of delay discounting was higher among those with a history of a symptomatic COVID-19 infection, with age and sex acting as moderators.
Hudson *et al.* (2023)	Canada	Cross-sectional online questionnaire	2002 adults	5-item delay discounting task	Future orientation, executive function, mitigation behaviors, vaccination status		Lower levels of delay discounting were linked to more frequent mask-wearing and full vaccination status.
Krawiec *et al.* (2022)	Poland	Cross-sectional online questionnaire	515 university students	Monetary 5-trial delay discounting task	Attitudes toward disinfection, distancing, and masks		No link was established between public health policy and delay discounting.
Lloyd *et al.* (2021)	UK	Cross-sectional online questionnaire	442 adults	27-item Monetary Choice Questionnaire	COVID-19 risk behaviors		A steeper inclination to delay discounting was associated with poorer observance of social distancing measures.

Table 1: Continued

References	Country	Study design	Sample	Measurement of ITC	Measurement of the impact of COVID-19	Mediators and/or moderators	Summary of findings
SHEN *et al.* (2023)	18 countries	Cross-sectional online questionnaire	26 355 adults	Delay discounting tasks	Self-rated survival achievement	Culture	The degree of change in intertemporal choice for different currencies and the degree of change in intertemporal choice at different stages of Chinese and Singaporeans could be used to jointly predict their self-rated survival achievement.
Sonmez (2021)	Turkey	Cross-sectional online questionnaire	167 adults	Hypothetical choices	COVID-19 related/classical mortality salience manipulation		Contemplating mortality led to a greater inclination to discount future rewards.
Strickland *et al.* (2022)	USA	Longitudinal online questionnaire	333 adults	Monetary Choice Questionnaire	Vaccination intent, vaccination status, probability discounting, health variables		A greater inclination to discount future rewards and costs was associated with a lower likelihood of receiving vaccinations.
Wang *et al.* (2022)	China	Cross-sectional online questionnaire	491 adults	27-item Monetary Choice Questionnaire	Emotion when thinking they may be infected by COVID-19	Likelihood estimates of being infected	The group that experienced anticipatory emotions exhibited a lower rate of delay discounting.
Wismans *et al.* (2021)	Belgium, France, Ireland, Italy, the Netherlands, Sweden, Portugal	Cross-sectional online questionnaire	6759 students	Trial adjusting delay discounting task	Compliance behavior and impulsivity		Self-reported impulsivity had a negative correlation with compliance behavior, whereas discounting rate had a weak but positive relationship with compliance behavior.
Wu (2022)	China	Cross-sectional online questionnaire	363 college students	Choice titration procedure with 19 choice trials	Recall the uncertainty feeling related to COVID-19	Future orientation	The future orientation of an individual was a mediator between the feelings of uncertainty and the tendency to discount delayed rewards.
Xiao *et al.* (2022)	China	Longitudinal online questionnaire	683 college students	27-item Monetary Choice Questionnaire	Brain functional connectivity unique to stress changes under COVID-19		Males exhibited a greater discount than females, and the functional connectome was able to forecast this difference.

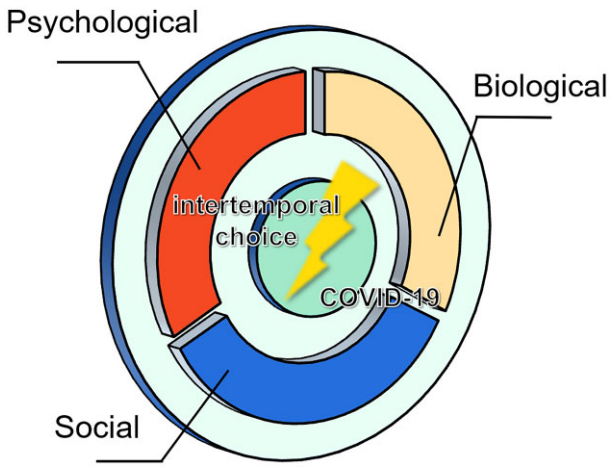

Figure 1: A brief outline of the key elements that have an influence on intertemporal decisions during the COVID-19 pandemic. Social, biological, and psychological factors are all included.

investigate the underlying mechanisms that cause shifts in intertemporal decision. It has been suggested that people are inherently more sensitive to losses than gains to protect themselves and avoid harm (Kahneman and Tversky, 1979). Therefore, future studies could explore whether individuals experiencing negative emotions during the pandemic are particularly sensitive to losses.

Biological factors

Two studies have measured biological and physical changes related to the COVID-19 pandemic, and the results have demonstrated that those with worse health conditions exhibited more impulsive behaviors (Xiao *et al.*, 2022). Findings suggest that unvaccinated individuals display higher rates of delay discounting than vaccinated individuals (Halilova *et al.*, 2022). Furthermore, a negative correlation has been observed between delay discounting and the likelihood of vaccination (Strickland *et al.*, 2022). Age and sex are identified as moderators of the relationship between symptomatically experienced COVID-19 infection and delay discounting rate, with older adult females displaying the lowest discounting rate (Hall *et al.*, 2023). Additionally, Hall *et al.* (2022) found that infection history of COVID-19 and symptom severity are positively associated with the delay discounting rate among young and middle-aged adults. Finally, Brown *et al.* (2023) observed that graphic health warnings on cigarette packets, particularly those related to COVID-19, elicited greater subjective arousal ratings in smokers with lower delay discounting, whereas those with higher delay discounting showed no significant effect.

A study of 2000 school children aged 2 to 19 years in the USA showed that BMI increased during the COVID-19 pandemic compared to previous years (Knapp *et al.*, 2022), thus making obesity a highlighted concern of the COVID-19 pandemic (Soeroto *et al.*, 2020). Xiao *et al.* (2022) measured individual differences in the brain functional connectivity network prior to the pandemic, and the results showed that consensus functional connectivity network strength declined in relation to the increase in delay discounting during the pandemic. As the frontal parietal network is unique to stress, it was found to be an essential factor influencing the stress brought by the pandemic. Therefore, those with limited strength in their frontal parietal network were more likely to feel stress during the pandemic and assumed self-control to defend against the stress, which elicited them to make more immediate choices (Xiao *et al.*, 2022).

Further studies are necessary to investigate the biological factors associated with intertemporal choice. For example, cortisol is often referred to as the primary stress hormone, which is an evolutionarily response to "fight or flight." During the COVID-19 pandemic, people were likely to experience heightened levels of stress, which may have led to an increase in cortisol levels. Future studies should measure cortisol levels while using methods to elicit individuals' emotions about the COVID-19 pandemic to gain a better understanding of the physical changes people experienced as well as the associated brain structural and functional changes during crisis events, and whether these changes affected their decision-making abilities.

Social factors

Containment measures such as wearing masks, implementing lockdowns, and encouraging compliance have been shown to influence intertemporal choice during the COVID-19 pandemic. The World Health Organization (WHO) has proposed two strategies to combat the virus: reducing its circulation and treating it as soon as possible to reduce deaths. To this end, many countries put restrictions in place, such as lockdowns, to contain the virus and, as a result, alter people's lifestyles (Coroiu *et al.*, 2020). Studies have suggested that inadequate mask-wearing behavior and social distancing are associated with a greater degree of temporal discounting (Byrne *et al.*, 2021; DeAngelis *et al.*, 2022). Experiments have demonstrated that when evaluating surgical masks, people showed a stronger preference for immediate commodities compared to value for money (Cannito *et al.*, 2021). Additionally, research has indicated that in financial decision-making, the degree of social distancing, but not mask use, was statistically significantly correlated with discount rates (Agrawal *et al.*, 2023). Studies have indicated that individuals who adhered to containment regulations more strictly were more likely to prefer immediate rewards in the intertemporal choice task (Calluso *et al.*, 2021; Lloyd *et al.*, 2021). This could be attributed to the desire for freedom that could only be enjoyed in the present (Calluso *et al.*, 2021). However, other research has not found a connection between public health policy and delay discounting (Krawiec *et al.*, 2022). To further explore the underlying mechanism, Studies reported a negative relationship between compliance with containment measures and intertemporal discounting (Coroiu *et al.*, 2020; Calluso *et al.*, 2021). Additionally, studies have revealed that delay discounting is inversely associated with mask-wearing behavior and complete vaccination status (Hudson *et al.*, 2023). Furthermore, increased death-related thoughts have been linked to a tendency to choose present-oriented rewards (Sonmez, 2021). It is possible to conduct further research into cross-culture differences in response to the COVID-19 pandemic. Such research could compare the various policies adopted by different countries and the attitudes of individuals toward those policies. Simultaneously, it could provide insight into how decision-making has changed in different countries due to the pandemic. Furthermore, it could take into account the impact of national economic conditions and individual socioeconomic status on intertemporal choices. Finally, such research could help governments to implement more effective interventions, encouraging people to think long-term and learn from the pandemic.

Conclusion

This study investigated that intertemporal choice patterns changed during the COVID-19 pandemic, as well as its underlying mechanism. The results showed that under the COVID-19 pandemic, people tended to choose immediate and smaller rewards, and became less patient. Our findings explored that negative emotions, being in worse physical and biological healthy condition, and incompliance with the social restriction rules made people become behaviorally "short-sighted." This review focused on the influence of the COVID-19 pandemic on intertemporal decision-making, yet gave little attention to other pandemics. To gain a better understanding of the effects and mechanisms of pandemics, and to find out the related factors that could lead to better management and coping strategies, future studies should compare COVID-19 to other past pandemics. Furthermore, longitudinal, and cross-cultural research should also be included to provide a comprehensive view of the changes in decision-making during the pandemic .).

Author contributions

Xinwen Zhang (Investigation, Methodology, Resources, Validation, Visualization, Writing – review & editing), Ziyun Wu (Conceptualization, Formal analysis, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing), and Qinghua He (Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Writing – review & editing)

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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