

SHORT COMMUNICATION

Stress and COVID-19 related behaviours: The mediating role of delay discounting

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Abstract

We examined stress as a predictor of behaviours related to Coronavirus Disease-2019 (COVID-19) through its effects on delay discounting. Adults ($N = 3686$) completed an online survey with a behavioural measure of delay discounting and questions regarding stress, physical distancing, and stockpiling of food and supplies. Stress was weakly, but positively, correlated with delay discounting ($p < 0.01$). Delay discounting was positively correlated with stockpiling ($p < 0.01$); and discounting was negatively correlated with physical distancing ($p < 0.01$). Mediation models indicated that discounting was a significant mediator of the relationship between stress and physical distancing (-0.003) and stockpiling (0.003); bootstrap 95% CIs ($-0.006, -0.001$) and ($0.001, 0.005$), respectively. After accounting for its indirect effects through discounting, stress continued to have a direct effect on these outcomes. This study indicates that delay discounting partially mediates the link between stress and behaviours related to COVID-19. Results suggest that interventions reducing stress and/or delay discounting may be profitable for increasing infection prevention and reducing stockpiling.

KEYWORDS

COVID-19, delay discounting, physical distancing, stress

1 | STRESS AND COVID-19 RELATED BEHAVIORS: THE MEDIATING ROLE OF DELAY DISCOUNTING

Coronavirus Disease-2019 (COVID-19) is the most severe global health emergency declared by the World Health Organization (WHO; Adhanom Ghebreyesus, 2020). As of 25 October 2020, COVID-19 has been confirmed in 43,341,451 people, and it has caused 1,157,509 deaths worldwide (World Health Organization, 2020). At present, there are no treatments nor vaccines specifically approved for COVID-19; therefore, prevention is essential for mitigating spread of the virus and reducing the impact of the disease on individuals and societies. As with many health outcomes, prevention of COVID-19 relies heavily on behaviours and practices of individuals. Thus, it is critical to understand predictors of individuals' behaviours to guide the development

of targeted interventions that aim to protect and enhance public wellbeing. Given that the pandemic has been a significant source of stress for individuals across the globe (Brown et al., 2020; Henry J. Kaiser Family Foundation, 2020; Wang et al., 2020), this investigation focuses on stress as a predictor of decision making tendencies and, ultimately, consequential behaviours during the COVID-19 pandemic.

Extant research indicates that stress influences decision making (Herbert, 2020; Wemm & Wulfert, 2017; Zaleskiewicz & Traczyk, 2020). For instance, stress is associated with amplified tendencies for selecting immediate gratification with smaller benefits rather than waiting for larger benefits in the future (Diller et al., 2011), a tendency referred to as delay discounting. Studies have also established a link between stress and risk for maladaptive behaviours, such as substance use and food addiction (McMullin

et al., 2020; Sinha, 2008). Furthermore, some researchers have found that delay discounting mediates the relationship between stress and substance use (Fields et al., 2009; Nikolova et al., 2016).

Beyond its association with substance use, delay discounting is related to a wide range of other maladaptive behaviours (Bickel et al., 2019), such as unhealthy food consumption (Barlow et al., 2016; Garza et al., 2016), pathological gambling (Dixon et al., 2003), and reduced propensities to obtain influenza vaccinations (Chapman & Coups, 1999) and cancer screenings (Bradford, 2010). In the context of COVID-19, stress and delay discounting may play roles in explaining other behaviours of public importance, such as adherence to physical distancing guidelines and acquisitiveness (i.e., stockpiling food or other household supplies). Physically distancing oneself from others and minimizing in-person interactions, is a critical way to mitigate viral spread during pandemics (Glass et al., 2006; Maharaj & Kleczkowski, 2012). Despite its importance, physical distancing requires individuals to forgo immediate social enjoyment for longer-term personal and societal benefits. Thus, individuals who tend to engage in delay discounting may be more inclined to choose the immediate enjoyment of social gatherings rather than adhering to physical distancing guidelines.

Furthermore, the impacts of individual decision making on public wellbeing during a pandemic extend beyond mitigation of viral spread. For instance, during early months of the COVID-19 pandemic, the implications of individuals' decision making were made salient as shortages of toilet paper became an issue worldwide, in part, due to a subset of consumers making large purchases and hoarding these supplies (Horowitz-Ghazi, 2020; National Public Radio, 2020). Such stockpiling behaviours appear to reflect a focus on immediate gratification rather than on larger, longer-term implications of one's decisions for other members of the community. Thus, individuals who tend to engage in delay discounting may be more inclined to stockpile resources.

The purpose of this study was to formally examine whether delay discounting would predict these consequential, pandemic-related behaviours and to specifically test whether these behaviours would be predicted by a mediation model in which stress predicts delay discounting. We predicted that perceived stress during the pandemic would be positively related to delay discounting during the pandemic and that greater delay discounting would be related to behaviours that reflect a focus on immediate gratification, including less physical distancing and more stockpiling of food and basic supplies during the COVID-19 pandemic.

2 | METHODS

An English-language, cross-sectional survey was created in Qualtrics (Qualtrics, 2020) and translated into seven other languages by native speakers of Arabic, Chinese, French, German, Italian, Russian and Spanish. Survey links were distributed internationally via paid advertisements on Facebook and via email in social and professional networks between 31 March and 15 May 2020. Individuals aged 18+

years were eligible to participate after indicating their age in years and providing electronic consent. The survey took approximately 15 min to complete and no incentive was provided for participation. All study protocols were approved by the Institutional Review Board at the University of Minnesota.

2.1 | Measures

2.1.1 | Respondent characteristics

Respondents self-reported their age, country of residence, sex at birth (*male, female other*), and highest level of education completed (0 = *no formal education* to 4 = *post-secondary/tertiary school*).

2.1.2 | Delay discounting

A monetary 5-trial delay discounting task (Koffarnus & Bickel, 2014) was used to assess discounting rates. The currency was set to \$ for the English, Arabic and Russian surveys; it was set to € for the French, German, Italian, and Spanish surveys; and it was set to ¥ for the Chinese survey. The maximum (larger, later amount) was set to 7000 for ¥ and to 1000 for \$ and € for approximate equivalence in worth across currencies.

2.1.3 | Stress

Respondents reported the extent to which they have felt 'stressed' and the extent to which they felt 'overwhelmed' in the time since COVID-19 began spreading. Response options ranged from 0 (*Not at all*) to 5 (*A lot*). Similar to previous research (DeAngelis & al'Absi, 2020), responses to these items were averaged to create an index of stress, $r = 0.76$.

2.1.4 | COVID-19 behaviours (stockpiling, physical distancing)

Respondents indicated the extent to which they have been practicing physical distancing (i.e., limiting their physical interactions with others and maintaining at least 6 feet/1.8 m between themselves and other individuals to prevent spreading COVID-19) and the extent to which they have stocked-up on a larger supply of basic household supplies or food than they usually do because of COVID-19. Response options for these items included *Not at all* (0), *Somewhat*, *Moderately*, and *A lot* (3).

2.2 | Study sample and analytic approach

Only respondents who completed the delay discounting task were included in this study ($N = 3686$). Prior to analyses, delay discounting

rates were natural log transformed to achieve normality (Koffarnus & Bickel, 2014) and a dichotomous variable for male (1) versus female (0) sex was created.

Previous research has documented that stress (Cohen & Janicki-Deverts, 2012) and delay discounting (Green et al., 1994; Jaroni et al., 2004; Kirby & Maraković, 1996) are associated with age, education, and sex. Therefore, we included these variables in our analyses. Pearson correlations were used to examine the relationships between stress, delay discounting, and COVID-19-related behaviours as well as age, education, and sex. Finally, separate mediation models were run for each dependent variable, with stress as an exogenous variable, discounting as a mediator, and with sex, age, and education as covariates. All analyses were run in SPSS v24, using model 4 of Hayes' PROCESS macro (version 3.4; Hayes, 2017), which runs OLS regression for continuous dependent variables and logistic regression for dichotomous outcomes. We requested 5000 bootstrap samples for regression coefficients and for percentile bootstrap confidence intervals for model inferences.

3 | RESULTS

The sample included respondents from 96 different countries, with nearly half of the respondents (48%, $n = 1776$) reporting residence in the United States of America. Respondents ranged from 18 to 87 years old ($M = 38.6$, $Mdn = 36.0$, $SD = 14.3$); and they were relatively well-educated, with most reporting completion of more than 12 years of school (i.e., post-secondary/tertiary school; $n = 3217$). A little over 70% of the sample identified as female ($n = 2607$; male $n = 1056$).

Correlations among all study variables and basic descriptive statistics are presented in Table 1. Consistent with previous research (Green et al., 1994; Jaroni et al., 2004; Kirby & Maraković, 1996), discounting was negatively related to both age and education; males tended to have higher discounting than females. As predicted, stress was positively related to discounting, albeit weakly. Discounting was

also negatively correlated with physical distancing and discounting was positively correlated with stockpiling.

Mediation model coefficients and model summaries are presented in Table 2 and indices of mediation are presented in Figure 1. Results from the mediation models for both outcomes indicated significant positive effects of stress on delay discounting and significant relationships between discounting and the outcomes. Moreover, there was evidence of significant mediation for both physical distancing and stockpiling (Figure 1). Notably, for both outcomes, a direct effect of stress on the behavioural outcomes remained significant, even after accounting for its indirect effects through delay discounting.

4 | DISCUSSION

Consistent with our predictions, the findings of this study indicate that stress was positively, though weakly, related to delay discounting; and delay discounting was correlated with less physical distancing and more stockpiling of food and basic supplies during the COVID-19 pandemic. Moreover, we found that delay discounting mediated the effects of stress on these behaviours. Even after accounting for indirect effects of stress, however, we found that stress had a direct effect on physical distancing and stockpiling behaviours.

This study adds timely data to existing literature on the role of stress in decision making and consequential behaviours. Similar to previous research that documented associations between stress and delay discounting (Diller et al., 2011) and maladaptive behaviours, such as substance use and food addiction (McMullin et al., 2020; Sinha, 2008), we found that stress was positively related to delay discounting and stockpiling, and stress was negatively related to physical distancing during the COVID-19 pandemic. These findings highlight stress reduction as a potential avenue for managing behaviours that have the potential to impact both individual and public health and well-being.

TABLE 1 Descriptives and zero-order Pearson correlations (N)

	Stress	Delay Discounting†	Male Sex	Age	Education	Stockpiling	Physical Distancing
Mean (SD) or %	2.8 (1.5)	-5.1 (2.6)	28.8%	38.6 (14.3)	3.9 (0.4)	1.1 (0.8)	2.6 (0.7)
Stress	1 (3672)	-	-	-	-	-	-
Delay discounting†	0.05** (3672)	1 (3686)	-	-	-	-	-
Male sex	-0.20** (3654)	0.12** (3663)	1(3663)	-	-	-	-
Age	-0.22** (3672)	-0.07** (3686)	0.09** (3663)	1(3686)	-	-	-
Education	-0.05** (3637)	-0.08** (3645)	-0.05** (3631)	0.09** (3645)	1(3645)	-	-
Stockpiling	0.18** (3671)	0.10** (3677)	0.04* (3659)	0.01 (3677)	-0.02 (3641)	1(3677)	-
Physical distancing	0.05** (3672)	-0.16** (3678)	-0.15** (3660)	0.15** (3678)	0.09** (3642)	0.02 (3677)	1(3678)

Note: Male sex (1 = male, 0 = female). SD, standard deviation.

†Natural log transformed.

** $p < 0.01$; * $p < 0.05$.

TABLE 2 Coefficients and model summaries for mediation models in which stress predicts the dependent variables through its effects on delay discounting

DV	Model step 1: Predicting discounting						Model step 2: Predicting dependent variables							
	Model summary	Predictor	Coefficient	BootMean	BootSE	BootLLCI	BootULCI	Model summary	Predictor	Coefficient	BootMean	BootSE	BootLLCI	BootULCI
Stockpiling	R = 0.167 R ² = 0.028 F(4, 3618) = 25.886 p < 0.001	Constant	-3.646	-3.650	0.504	-4.647	-2.668	R = 0.219 R ² = 0.048 F(5, 3617) = 36.519 p < 0.001	Constant	0.766	0.764	0.145	0.470	1.046
		Stress	0.108	0.107	0.033	0.041	0.175		Stress	0.116	0.116	0.010	0.096	0.135
		Sex	0.759	0.760	0.109	0.546	0.976		Discounting	0.028	0.028	0.005	0.017	0.038
		Age	-0.012	-0.012	0.003	-0.018	-0.006		Sex	0.114	0.115	0.032	0.051	0.176
		Education	-0.393	-0.392	0.124	-0.631	-0.146		Age	0.003	0.003	0.001	0.001	0.005
							Education	-0.012	-0.012	0.035	-0.078	0.059		
Physical distancing	R = 0.167 R ² = 0.028 F(4, 3619) = 25.915 p < 0.001	Constant	-3.646	-3.641	0.505	-4.635	-2.671	R = 0.270 R ² = 0.073 F(5, 3618) = 56.826 p < 0.001	Constant	1.825	1.824	0.126	1.571	2.071
		Stress	0.108	0.108	0.033	0.043	0.173		Stress	0.029	0.029	0.008	0.012	0.044
		Sex	0.759	0.758	0.108	0.545	0.970		Discounting	-0.032	-0.032	0.005	-0.041	-0.023
		Age	-0.012	-0.012	0.003	-0.018	-0.006		Sex	-0.200	-0.201	0.026	-0.253	-0.149
		Education	-0.393	-0.395	0.123	-0.632	-0.153		Age	0.007	0.007	0.001	0.006	0.009
							Education	0.088	0.088	0.031	0.028	0.149		

Note: Sex was coded 1 = male and 0 = female.

Abbreviations: BootMean, mean of bootstrap estimates; BootSE, standard deviation of bootstrap estimates; BootLLCI, lower level of bootstrap 95% confidence interval; BootULCI, upper level of bootstrap 95% confidence interval; DV, dependent variable.

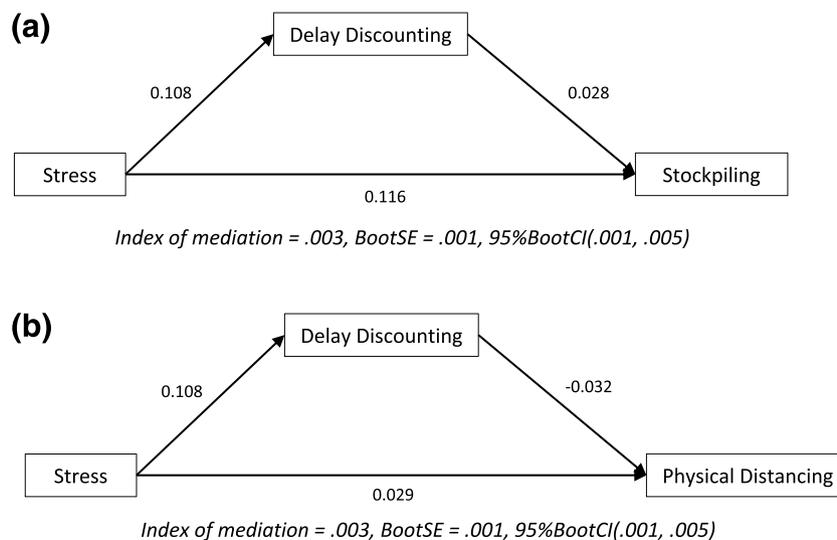


FIGURE 1 Figures 1a and 1b depict the mediation models that were tested using Model 4 of Hayes' PROCESS macro (version 3.4). Coefficients (adjusted for covariates) are presented for the primary relationships of interest (also presented in Table 2). The indices of mediation reflect that the indirect effect of stress through its effects on discounting was statistically significant for stockpiling (0.003, Bootstrapped 95% Confidence Interval: 0.001, 0.005) and for physical distancing (-0.003, Bootstrapped 95% Confidence Interval: -0.006, -0.001)

Previous research indicated that steeply discounting the future is correlated with a wide range of maladaptive behaviours that pose significant public health concerns, such as unhealthy food consumption (Barlow et al., 2016; Garza et al., 2016) and reduced propensities to obtain influenza vaccinations (Chapman & Coups, 1999). Similarly, results from this study indicate that delay discounting is associated with less physical distancing, which undermines one of our primary ways to mitigate viral spread during the COVID-19 pandemic (Glass et al., 2006; Maharaj & Kleczkowski, 2012). This study also found that delay discounting is related to more extensive stockpiling of food and other supplies, which can have negative consequences for supply chain management (Zheng, Shou, & Yang, 2020), infrastructure (Fenston, 2020), and community members who are unable to purchase needed supplies (40% of respondents in this study reported being unable to purchase food or basic household supplies due to store or retailer shortages during COVID-19). These findings suggest that delay discounting may be another promising target for interventions that aim to increase preventive health behaviours or decrease behaviours that may have adverse or deleterious consequences.

As with all research, this study is not without limitations. The cross-sectional nature of the current design does not rule-out the possibility of alternative causal orders among the variables in our models. In addition, although our measures of stockpiling and physical distancing have high face validity, these items were written for the purpose of this study and were not extracted from validated measures. Finally, while we found significant mediation, there remains a sizable amount of variance in the dependent measures that our models were unable to account for - future research should

examine additional predictors of discounting, behaviours related to COVID-19.

Given that physical distancing is the primary means of mitigating viral spread during a pandemic and given the deleterious consequences of stockpiling behaviours, understanding predictors of these behaviours is critical for protecting and enhancing public health and well-being. Therefore, this study examined stress and delay discounting as predictors of these behaviours during the COVID-19 pandemic, with delay discounting as a mediator of stress effects. Our findings suggest that stress and delay discounting might be useful for identifying groups prone to engaging in behaviours that may undermine one's own or others' quality of life (stockpiling scarce resources, failure to practice physical distancing during pandemics). Moreover, our results suggest that stress and delay discounting present potential opportunities for targeted interventions and communication campaigns that may ultimately reduce such maladaptive behaviours.

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CONFLICT OF INTEREST

The authors have declared that they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data may be made available by the corresponding author upon reasonable request.

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REFERENCES

- Adhanom Ghebreyesus, T. (2020). *WHO Director-General's opening remarks at the media briefing on COVID-19 - 27 July 2020*. World Health Organization. <https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---27-july-2020>
- Barlow, P., Reeves, A., McKee, M., Galea, G., & Stuckler, D. (2016). Unhealthy diets, obesity and time discounting: A systematic literature review and network analysis. *Obesity Reviews*, 17, 810–819. <https://doi.org/10.1111/obr.12431>.
- Bickel, W. K., Athamneh, L. N., Basso, J. C., Mellis, A. M., DeHart, W. B., Craft, W. H., & Pope, D. (2019). Excessive discounting of delayed reinforcers as a trans-disease process: Update on the state of the science. *Current Opinion in Psychology*, 30, 59–64. <https://doi.org/10.1016/j.copsyc.2019.01.005>.
- Bradford, W. D. (2010). The association between individual time preferences and health maintenance habits. *Medical Decision Making*, 30, 99–112. <https://doi.org/10.1177/0272989X09342276>.
- Brown, S. M., Doom, J. R., Lechuga-Peña, S., Watamura, S. E., & Koppels, T. (2020). Stress and parenting during the global COVID-19 pandemic. *Child Abuse & Neglect*, 110, 104699. <https://doi.org/10.1016/j.chiabu.2020.104699>.
- Chapman, G. B., & Coups, E. J. (1999). Time preferences and preventive health behavior. *Medical Decision Making*, 19, 307–314. <https://doi.org/10.1177/0272989X9901900309>.
- Cohen, S., & Janicki-Deverts, D. (2012). Who's stressed? distributions of psychological stress in the United States in probability samples from 1983, 2006, and 2009. *Journal of Applied Social Psychology*, 42, 1320–1334. <https://doi.org/10.1111/j.1559-1816.2012.00900.x>.
- DeAngelis, B. N., & al'Absi, M. (2020). Regular cannabis use is associated with blunted affective, but not cardiovascular, stress responses. *Addictive Behaviors*, 107, 106411. <https://doi.org/10.1016/j.addbeh.2020.106411>.
- Diller, J. W., Patros, C. H. G., & Prentice, P. R. (2011). Temporal discounting and heart rate reactivity to stress. *Behavioural Processes*, 87, 306–309. <https://doi.org/10.1016/j.beproc.2011.05.001>.
- Dixon, M. R., Marley, J., & Jacobs, E. A. (2003). Delay discounting by pathological gamblers. *Journal of Applied Behavior Analysis*, 36, 449–458. <https://doi.org/10.1901/jaba.2003.36-449>.
- Fenston, J. (2020). *People are using more wipes because of coronavirus, clogging sewers*. American University Radio WAMU 88.5. <https://wamu.org/>, <https://wamu.org/story/20/03/27/people-are-using-more-wipes-because-of-coronavirus-clogging-sewers/>
- Fields, S., Leraas, K., Collins, C., & Reynolds, B. (2009). Delay discounting as a mediator of the relationship between perceived stress and cigarette smoking status in adolescents. *Behavioural Pharmacology*, 20, 455–460. <https://doi.org/10.1097/FBP.0b013e328330d0c0>.
- Garza, K. B., Ding, M., Owensby, J. K., & Zizza, C. A. (2016). Impulsivity and fast-food consumption: A cross-sectional study among working adults. *Journal of the Academy of Nutrition and Dietetics*, 116, 61–68. <https://doi.org/10.1016/j.jand.2015.05.003>.
- Glass, R., Glass, L., Beyeler, W., & Min, H. (2006). Targeted social distancing designs for pandemic influenza. *Emerging Infectious Diseases*, 12, 1671–1681. <https://doi.org/10.3201/eid1211.060255>.
- Green, L., Fry, A. F., & Myerson, J. (1994). Discounting of delayed rewards: A life-span comparison. *Psychological Science*, 5, 33–36. <https://doi.org/10.1111/j.1467-9280.1994.tb00610.x>.
- Hayes, A. F. (2017). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York, NY: Guilford Publications.
- Henry J. Kaiser Family Foundation. (2020). KFF Health Tracking Poll July 2020. KFF.
- Herbert, J. (2020). Hormones, stress and financial decision making. In T. Zaleskiewicz, & J. Traczyk (Eds.), *Psychological perspectives on financial decision making* (pp. 39–68). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-45500-2_3.
- Horowitz-Ghazi, A. (2020). *Why are stores are running low on toilet paper? It's not just hoarding*. NPR.Org. <https://www.npr.org/2020/04/03/826945396/why-are-stores-are-running-low-on-toilet-paper-its-not-just-hoarding>
- Jaroni, J. L., Wright, S. M., Lerman, C., & Epstein, L. H. (2004). Relationship between education and delay discounting in smokers. *Addictive Behaviors*, 29, 1171–1175. <https://doi.org/10.1016/j.addbeh.2004.03.014>.
- Kirby, K. N., & Maraković, N. N. (1996). Delay-discounting probabilistic rewards: Rates decrease as amounts increase. *Psychonomic Bulletin & Review*, 3, 100–104. <https://doi.org/10.3758/BF03210748>.
- Koffarnus, M. N., & Bickel, W. K. (2014). A 5-trial adjusting delay discounting task: Accurate discount rates in less than one minute. *Experimental and Clinical Psychopharmacology*, 22, 222–228. <https://doi.org/10.1037/a0035973>.
- Maharaj, S., & Kleczkowski, A. (2012). Controlling epidemic spread by social distancing: Do it well or not at all. *BMC Public Health*, 12, 679. <https://doi.org/10.1186/1471-2458-12-679>.
- McMullin, S. D., Shields, G. S., Slavich, G. M., & Buchanan, T. W. (2020). Cumulative lifetime stress exposure predicts greater impulsivity and addictive behaviors. *Journal of Health Psychology*, 1359105320937055. <https://doi.org/10.1177/1359105320937055>.
- National Public Radio. (2020). *Why is there A worldwide run on toilet tissue amid the Coronavirus?* NPR.Org. <https://www.npr.org/2020/03/07/813191533/why-is-there-a-worldwide-run-on-toilet-tissue-amid-the-coronavirus>
- Nikolova, Y. S., Knodt, A. R., Radtke, S. R., & Hariri, A. R. (2016). Divergent responses of the amygdala and ventral striatum predict stress-related problem drinking in young adults: Possible differential markers of affective and impulsive pathways of risk for alcohol use disorder. *Molecular Psychiatry*, 21, 348–356. <https://doi.org/10.1038/mp.2015.85>.
- Qualtrics (2020). [Survey Platform]. Provo: Qualtrics. <https://www.qualtrics.com>.
- Sinha, R. (2008). Chronic stress, drug use, and vulnerability to addiction. *Annals of the New York Academy of Sciences*, 1141, 105–130. <https://doi.org/10.1196/annals.1441.030>.
- Wang, C., Pan, R., Wan, X., Tan, Y., Xu, L., Ho, C. S., & Ho, R. C. (2020). Immediate psychological responses and associated factors during the initial stage of the 2019 Coronavirus Disease (COVID-19) epidemic among the general population in China. *International Journal of Environmental Research and Public Health*, 17, 1729. <https://doi.org/10.3390/ijerph17051729>.

- Wemm, S. E., & Wulfert, E. (2017). Effects of acute stress on decision making. *Applied Psychophysiology and Biofeedback*, 42, 1–12. <https://doi.org/10.1007/s10484-016-9347-8>.
- World Health Organization. (2020). COVID-19 weekly epidemiological update. <https://www.who.int/publications/m/item/weekly-epidemiological-update---27-october-2020>.
- Zaleskiewicz, T., & Traczyk, J. (2020). Emotions and financial decision making. In T. Zaleskiewicz, & J. Traczyk (Eds.), *Psychological perspectives on financial decision making* (pp. 107–133). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-45500-2_6.
- Zheng, R., Shou, B., & Yang, J. (2021). Supply disruption management under consumer panic buying and social learning effects. *Omega*, 101, 102238. <https://doi.org/10.1016/j.omega.2020.102238>.

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