COVID-19-related financial scarcity is associated with greater delay discounting but not probability discounting

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Abstract

Prior laboratory studies suggest that scarcity increases delay discounting (devaluation of delayed outcomes) and disturbs other decision-making processes. Recent evidence on the effect of COVID-19 on delay discounting is mixed. In addition, no study has examined the effect of COVID-19-related scarcity on probability discounting (devaluation of probabilistic outcomes). The present study examined cross-sectional associations between COVID-19-related scarcity, delay discounting, and probability discounting. During April 2020, 1012 participants with low income were recruited on Amazon Mechanical Turk (MTurk) and completed measures of delay and probability discounting of money and food (grocery gift card), COVID-19-related financial impacts, stress, and food security. Regression analyses indicate that compared to those with no COVID-19 related financial impacts, those with severe COVID-19 related financial impacts had greater delay discounting of money and greater delay discounting of food. In addition, greater food insecurity in the past month was associated with greater delay discounting of food but not money. COVID-19 related financial impact was not associated with probability discounting of money or probability discounting of food. Combined with laboratory experiments, the present study provides additional support for the idea that scarcity or income shock may increase delay discounting, particularly during the onset of COVID-19.

Keywords: delay discounting, probability discounting, scarcity, income shock, stress, food security

Globally, there have been over 600 million confirmed cases of COVID-19 and more than 6.5 million deaths as of September 21, 2022 [1]. The United States alone has suffered nearly 95 million cases of this disease and over 1 million deaths [1]. Although its direct impact on public health is staggering, the emergence of COVID-19 also devastated the global and local economies due to business closures, lost wages, and mounting health care costs. For example, in the early months of the pandemic, the unemployment rate in the United States reached 14.7% [2] and an estimated 40% of small businesses were temporarily closed [3]. At the start of the COVID-19 pandemic, many characteristics of the disease, the length and extent of lockdowns, and other public health guidelines were unknown. These unknowns associated with the pandemic were associated with increased psychological distress [4] and created a sense of unpredictability and uncertainty about both near- and long-term financial and health outcomes.

Uncertainty during the COVID-19 pandemic may have impacted decision-making processes involving delay and risk, including delay discounting and probability discounting. Delay and probability discounting refer to the tendency for outcomes to be devalued as their delay to receipt increases and likelihood of receipt decreases, respectively [5]. Higher delay discounting (reflecting greater preference for smaller, sooner over larger more delayed rewards) has been associated with several maladaptive health behaviors including unhealthy food choice [6], lower vegetable consumption in breast cancer survivors [7] and lower exercise frequency [8]. In addition, people with a higher body mass index [9] or people with addictive disorders [10] tend to have higher delay discounting compared to controls. The relationship between probability discounting and health behaviors is less clear, although probability discounting is consistently related to problem gambling [11]. Because of its associations with several maladaptive health behaviors, delay discounting has been explored as a therapeutic target in the treatment and

prevention of lifestyle-related diseases [e.g., 12]. Understanding the factors that are related to greater delay discounting, including resource scarcity experienced following COVID-19, may help guide future interventions, as resource scarcity is one of the most direct and addressable policy instruments for improving decision making and health on a large scale.

Laboratory experiments provide support for the idea that scarcity increases delay discounting. For instance, using an experimental economy, Haushofer et al. [13] gave participants either a high or low endowment (i.e., 1000 or 100 points exchangeable for money) and a negative, positive, or no income shock (i.e., a loss, gain, or no change in total points). Participants who experienced a negative income shock had higher delay discounting compared to participants without a negative income shock and a low endowment. Crucially, this design controls for the effect of income as both groups had similar income after the income shock. These results suggest that abrupt income loss contributes to more delay discounting. In another laboratory paradigm, participants who read a narrative involving scarcity (e.g., job loss) before completing a delay discounting task tend to have a higher degree of delay discounting compared to participants who read a neutral narrative [14-18]. Related, experimentally manipulating personal relative financial deprivation, or feelings of having fewer monetary resources compared to others, has also been shown to result in greater delay discounting [e.g., 19]. Despite consistent findings across methodologies, both experiential [13] and narrative [e.g., 18] income shock experiments raise concerns over external validity and generalizability to real-world decision-making. That is, experiencing income loss in a point-based economy and simply imagining a job loss might have different effects on delay discounting than real scarcity, as would be suggested by construal level theory [20] and projection bias [21]. One way to increase confidence in these

laboratory findings would be to examine delay discounting in individuals who have experienced real disruption to employment or income.

Several studies have examined the effect of COVID-19-related financial changes on psychological constructs and delay discounting. For instance, in a sample of 1,145 adults in the United States, Blain et al. [22] found that both negative affect and income shock during March and June 2020 were related to greater delay discounting, but negative affect did not mediate the relationship between income shock and delay discounting. In contrast, Crandall et al. [23] found that for 76 mother-child dyads, wage losses or expected wage losses during the pandemic were not related to delay discounting, but children with greater stress during the pandemic had higher delay discounting than children with lower stress. In a diverse sample of 72 adults living in a low resource, urban area, Felton et al. [24] found that for those with low social vulnerability, but not high social vulnerability, larger COVID-19 impact was associated with greater delay discounting.

In the present study, we examined potential associations between COVID-19-related income shock and both delay and probability discounting. We asked participants to complete decision-making tasks and report COVID-19-related financial changes in April 2020, immediately after lockdowns began in the United States. We recruited participants with low income, given their vulnerability to the effects of income shock. We hypothesized that individuals who experienced greater negative financial impact or food insecurity during this time period would have higher levels of delay discounting of money and a grocery gift card compared to those without negative financial impact or food insecurity. To date, probability discounting has not been examined, in spite of the elevated uncertainty and negative financial impact

incurred during the COVID-19 pandemic. Thus, we sought to explore the relationship between probability discounting and COVID-19 related financial changes.

Method

Participants

Participants were recruited on Amazon Mechanical Turk (MTurk), a crowdsourcing platform in which users can complete human intelligence tasks (HITs) in exchange for monetary compensation. Eligible participants had no previous diagnosis of COVID-19 and reported household income within 200% of the federal poverty line [25]. To increase data quality, workers from MTurk must (1) have had previous HITs approved by requesters at least 90% of the time; (2) live in and complete the survey from the United States; and (3) pass a "No CAPTCHA reCAPTCHA" response item [26], which estimates whether screen activity is produced by a human or a computer program (detection of the latter prevented survey continuation). In addition, participants were allowed to screen only once; individuals that attempted to screen twice were prevented from completing the survey by collecting and cross-checking MTurk ID. Participants were compensated $4 for survey completion.

A total of 1159 participants completed the study, and 1012 were included in all primary analyses. Participants were excluded (n = 143) for incorrectly answering delay and probability discounting quality checks [e.g., indicated they would prefer $50 now to $100 now; for discussion see 27] or attention checks (e.g., "Most of the options below are colors. Please select the option that is not a color.") or reporting different household income amounts across different sections of the survey. A comparison of demographic and descriptive statistics for those included and excluded can be found in Supp. Table 1 and sensitivity analyses with all participants (n = 1159) can be found in Supp. Tables 2-4.

Measures

Participants completed the 5-trial, adjusting delay task [28] to assess delay discounting and the 5-trial, adjusting probability task [29] to assess probability discounting. Two iterations of each task type were presented in order to assess valuation of both a hypothetical $100 and a $100 grocery gift card. Participants also completed demographic measures, the Perceived Stress Scale [30], food security (4 items modified from the U.S. Household Food Security Survey Module; see Supp. Method), savings, if they received public assistance benefits, and COVID-19 impact. Severity of financial consequences due to COVID-19 was assessed by asking participants 1a) "*Have you experienced negative financial consequences due to COVID-19?",* and if yes, 1b) *"How severe have these negative financial consequences been?".* A composite ordinal variable (1a and 1b; None, Mild, Moderate, Severe) for financial impact was used for analyses. For food security, an ordinal variable was calculated with 4 denoting high food insecurity and 9 indicating high food security.

Results

Participants

Participant characteristics and descriptive statistics are described in Table 1 for the entire sample and by severity of financial consequences due to COVID-19. Those with relatively more severe financial consequences appear to have greater stress, lower food security, and less often had at least one month's wages in savings. In addition, a greater proportion of participants in higher severity groups reported being a racial or ethnic minority or receiving public assistance benefits.

Univariate linear regression was used to examine the relationship between severity of financial consequences and delay and probability discounting of money and a food gift card (4

univariate models total; see Figure 1 for mean delay and probability discounting). For delay discounting of money and food, reporting moderate or severe financial consequences was associated with greater delay discounting (for money, Moderate vs None standardized $\beta = 0.32$, CI = .17-.46, $p < .001$; Severe vs None, standardized $\beta = 0.63$, CI = .46-.81, $p < .001$; similar for food gift card). Severity of financial consequences was not significantly associated with probability discounting for money or food (standardized βs between 0.01-0.13, ps between 0.15-0.9).

Additional linear regression models were used to consider other factors potentially related to delay discounting, including food security and stress, possible protective factors (savings, public assistance benefit program participation), and demographics. For delay discounting of money, severity of financial consequences remained significant (Severe vs None; standardized $\beta = .34$, CI = .15-.54, $p < .001$), but the comparison for Moderate vs None was no longer significant. Less education was associated with greater delay discounting (standardized $\beta = .34$, CI = .15-.54, $p < .001$). In addition, having a month of savings was associated with lower delay discounting (standardized $\beta = -0.28$, CI = -0.41, -0.15, $p < .001$). Reporting a racial or ethnic minority status was associated with greater delay discounting (standardized $\beta = 0.23$, CI = 0.10-0.35, $p < .001$). In this model, income, stress, and food security were not significantly associated with delay discounting (βs between -0.09-0.1, ps > .11). For delay discounting of a food gift card, similar results were found. However, in contrast to delay discounting of money, food security in the past month was a significant predictor of delay discounting of a food gift card (standardized $\beta = -0.12$, CI = -0.23 to -0.01, $p = .04$). Full regression tables can be found in Supp. Tables 5-8.

Delay and probability discounting

Delay discounting for food and money (r = .87) and probability discounting for food and money (r = .84) were highly correlated. Delay discounting and probability discounting for food and money were weakly but positively correlated (rs between .2 and .23). Delay discounting of money was only slightly lower than delay discounting for a grocery gift card, as indicated by a significant t-test ($t(1011) = 2.0615$, $p = 0.04$, Cohen's $d = 0.03$).

Discussion

As predicted, delay discounting was higher for those that experienced severe COVID-19 related financial consequences compared to those without financial changes. Probability discounting was similar for all participants regardless of COVID-19-related financial changes. Greater food insecurity predicted delay discounting of a grocery gift card but not delay discounting of money. This is in line with prior studies suggesting that scarcity, and other experimental manipulations, [31] may exert greater effects on delay discounting of domain relevant outcomes. Combined with laboratory evidence and natural experiments [13-17, 22], the present study provides additional support for the idea that feelings of scarcity, or not having enough, increases delay discounting.

While the present study and Blain et al. [22] found higher delay discounting in those that experienced more severe financial consequences due to COVID-19, our results are not in line with some other recent studies that have examined the impact of COVID-19 on delay discounting. First, Crandall et al. [23] found no relationship between wage loss or expected wage loss and delay discounting. Some have suggested that measuring perceived financial changes may hold benefits over measuring actual, objective financial changes, as individual reference points for loss may be different [22, 32, 33]. Crandall et al. [24] asked if participants had experienced wage increases or wage losses, a more objective than subjective measure. These

different question formats may help to explain the different results. Our results are also not necessarily in line with Felton et al. [24], who found that for those with high social vulnerability, delay discounting was similar regardless of extent of COVID-19 impact. However, Felton et al. [25] used a multifaceted, broader measure of COVID-19 impact, whereas the present study primarily examined financial consequences, and not the effect of other COVID-19 impacts on delay discounting.

It is important to note a few limitations of the present study. As the study was observational, no causal assumptions should be made specifically about the effect of COVID-19 on delay discounting; it could be the case that those with higher delay discounting were more susceptible to COVID-19 related financial changes. Another potential limitation of the present study is data quality due to using a sample from Amazon MTurk. To address this limitation, we included multiple attention and quality checks, a CAPTCHA item, prevented individuals from screening multiple times, and cross-checked responses on different components of the survey. Finally, we specifically recruited participants with a low household income. Although Blain et al. [23] found similar results in a sample with somewhat higher annual household income (M = $52,500) the results may not generalize to samples with substantially higher income.

Nevertheless, we found that greater severity of financial consequences due to COVID-19 predicted higher delay discounting, after controlling for several factors. Future research could examine the effects of domain relevant scarcity on delay discounting of different outcomes, the difference between feelings of scarcity and objective losses, factors that may mediate the relationship between scarcity and increased delay discounting, and if scarcity-related changes in delay discounting also impacts health behaviors.

References

1. WHO. (2022). Who Coronavirus (Covid-19) Dashboard. Retrieved September 22 2022, from https://covid19.who.int/
2. U.S. Bureau of Labor Statistics.). Unemployment Rate [Unrate]. Retrieved June, 30, 2022, from https://fred.stlouisfed.org/series/UNRATE
3. Bartik, A. W., Bertrand, M., Cullen, Z., Glaeser, E. L., Luca, M., & Stanton, C. (2020). The Impact of Covid-19 on Small Business Outcomes and Expectations. *Proceedings of the National Academy of Sciences, 117*(30), 17656-17666. doi: doi:10.1073/pnas.2006991117
4. Talevi, D., Socci, V., Carai, M., Carnaghi, G., Faleri, S., Trebbi, E., . . . Pacitti, F. (2020). Mental Health Outcomes of the Covid-19 Pandemic. *Riv Psichiatr, 55*(3), 137-144. doi: 10.1708/3382.33569
5. Rachlin, H., Raineri, A., & Cross, D. (1991). Subjective Probability and Delay. *J Exp Anal Behav, 55*(2), 233-244. doi: 10.1901/jeab.1991.55-233
6. Appelhans, B. M., Tangney, C. C., French, S. A., Crane, M. M., & Wang, Y. (2019). Delay Discounting and Household Food Purchasing Decisions: The Shopper Study. *Health Psychology, 38*(4), 334.
7. Sukumar, J. S., Vaughn, J. E., Tegge, A., Sardesai, S., Lustberg, M., & Stein, J. (2022). Delay Discounting as a Potential Therapeutic Target for Weight Loss in Breast Cancer Survivors. *Cancers, 14*(5), 1134.
8. Daugherty, J. R., & Brase, G. L. (2010). Taking Time to Be Healthy: Predicting Health Behaviors with Delay Discounting and Time Perspective. *Personality and Individual differences, 48*(2), 202-207.
9. Jarmolowicz, D. P., Cherry, J. B. C., Reed, D. D., Bruce, J. M., Crespi, J. M., Lusk, J. L., & Bruce, A. S. (2014). Robust Relation between Temporal Discounting Rates and Body Mass. *Appetite, 78*, 63-67.
10. MacKillop, J., Amlung, M. T., Few, L. R., Ray, L. A., Sweet, L. H., & Munafò, M. R. (2011). Delayed Reward Discounting and Addictive Behavior: A Meta-Analysis. *Psychopharmacology, 216*(3), 305-321.
11. Kyonka, E. G., & Schutte, N. S. (2018). Probability Discounting and Gambling: A Meta-Analysis. *Addiction, 113*(12), 2173-2181.
12. Athamneh, L. N., Brown, J., Stein, J. S., Gatchalian, K. M., LaConte, S. M., & Bickel, W. K. (2021). Future Thinking to Decrease Real-World Drinking in Alcohol Use Disorder: Repairing Reinforcer Pathology in a Randomized Proof-of-Concept Trial. *Experimental and Clinical Psychopharmacology*.
13. Haushofer, J., Schunk, D., & Fehr, E. (2013). Negative Income Shocks Increase Discount Rates.
14. Craft, W. H., Tegge, A. N., & Bickel, W. K. (2021). Narrative Theory Iv: Within-Subject Effects of Active and Control Scarcity Narratives on Delay Discounting in Alcohol Use Disorder. *Experimental and clinical psychopharmacology*.
15. Mellis, A. M., Snider, S. E., & Bickel, W. K. (2018). Narrative Theory: Ii. Self-Generated and Experimenter-Provided Negative Income Shock Narratives Increase Delay Discounting. *Experimental and clinical psychopharmacology, 26*(2), 113.
16. Stein, J. S., Craft, W. H., Paluch, R. A., Gatchalian, K. M., Greenawald, M. H., Quattrin, T., . . . Bickel, W. K. (2021). Bleak Present, Bright Future: Ii. Combined Effects of Episodic

Future Thinking and Scarcity on Delay Discounting in Adults at Risk for Type 2 Diabetes. *Journal of Behavioral Medicine, 44*(2), 222-230.
17. Sze, Y. Y., Stein, J. S., Bickel, W. K., Paluch, R. A., & Epstein, L. H. (2017). Bleak Present, Bright Future: Online Episodic Future Thinking, Scarcity, Delay Discounting, and Food Demand. *Clinical Psychological Science, 5*(4), 683-697.
18. Bickel, W. K., Wilson, A. G., Chen, C., Koffarnus, M. N., & Franck, C. T. (2016). Stuck in Time: Negative Income Shock Constricts the Temporal Window of Valuation Spanning the Future and the Past. *PloS one, 11*(9), e0163051.
19. Moeini-Jazani, M., Albalooshi, S., & Seljeseth, I. M. (2019). Self-Affirmation Reduces Delay Discounting of the Financially Deprived. *Frontiers in psychology, 10*, 1729.
20. Trope, Y., & Liberman, N. (2010). Construal-Level Theory of Psychological Distance. *Psychological review, 117*(2), 440.
21. Loewenstein, G., O'Donoghue, T., & Rabin, M. (2003). Projection Bias in Predicting Future Utility. *the Quarterly Journal of economics, 118*(4), 1209-1248.
22. Blain, B., Globig, L. K., & Sharot, T. (2021). Income Shock Increases Delay Discounting Independently of Emotion.
23. Crandall, A. K., Madhudi, N., Osborne, B., Carter, A., Williams, A. K., & Temple, J. L. (2022). The Effect of Food Insecurity and Stress on Delay Discounting across Families: A Covid-19 Natural Experiment.
24. Felton, J. W., Rabinowitz, J. A., Strickland, J. C., Maher, B. S., Summers, M., Key, K., . . . Yi, R. (2022). Social Vulnerability, Covid-19 Impact, and Decision making among Adults in a Low-Resource Community. *Behavioural Processes, 200*, 104668. doi: https://doi.org/10.1016/j.beproc.2022.104668
25. United States Department of Human and Health Services. (2020, January 17, 2020). 2020 Poverty Guidelines. from https://www.federalregister.gov/documents/2020/01/17/2020-00858/annual-update-of-the-hhs-poverty-guidelines
26. Shet, V. (2014). Are You a Robot? Introducing "No Captcha Recaptcha". 2022, from https://developers.google.com/search/blog/2014/12/are-you-robot-introducing-no-captcha
27. Craft, W. H., Tegge, A. N., Freitas-Lemos, R., Tomlinson, D. C., & Bickel, W. K. (2022). Are Poor Quality Data Just Random Responses?: A Crowdsourced Study of Delay Discounting in Alcohol Use Disorder. *Experimental and Clinical Psychopharmacology*.
28. 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*(3), 222.
29. Cox, D. J., & Dallery, J. (2016). Effects of Delay and Probability Combinations on Discounting in Humans. *Behavioural processes, 131*, 15-23.
30. Cohen, S., Kamarck, T., & Mermelstein, R. (1994). Perceived Stress Scale. *Measuring stress: A guide for health and social scientists, 10*(2), 1-2.
31. Skrynka, J., & Vincent, B. T. (2019). Hunger Increases Delay Discounting of Food and Non-Food Rewards. *Psychonomic bulletin & review, 26*(5), 1729-1737.
32. Mullainathan, S., & Shafir, E. (2013). *Scarcity: Why Having Too Little Means So Much*: Macmillan.
33. Carvalho, L. S., Meier, S., & Wang, S. W. (2016). Poverty and Economic Decision-Making: Evidence from Changes in Financial Resources at Payday. *The American economic review, 106*(2), 260-284. doi: 10.1257/aer.20140481

Figure 1. *Mean (±SEM) delay and probability discounting for $100 and a $100 food gift card.*

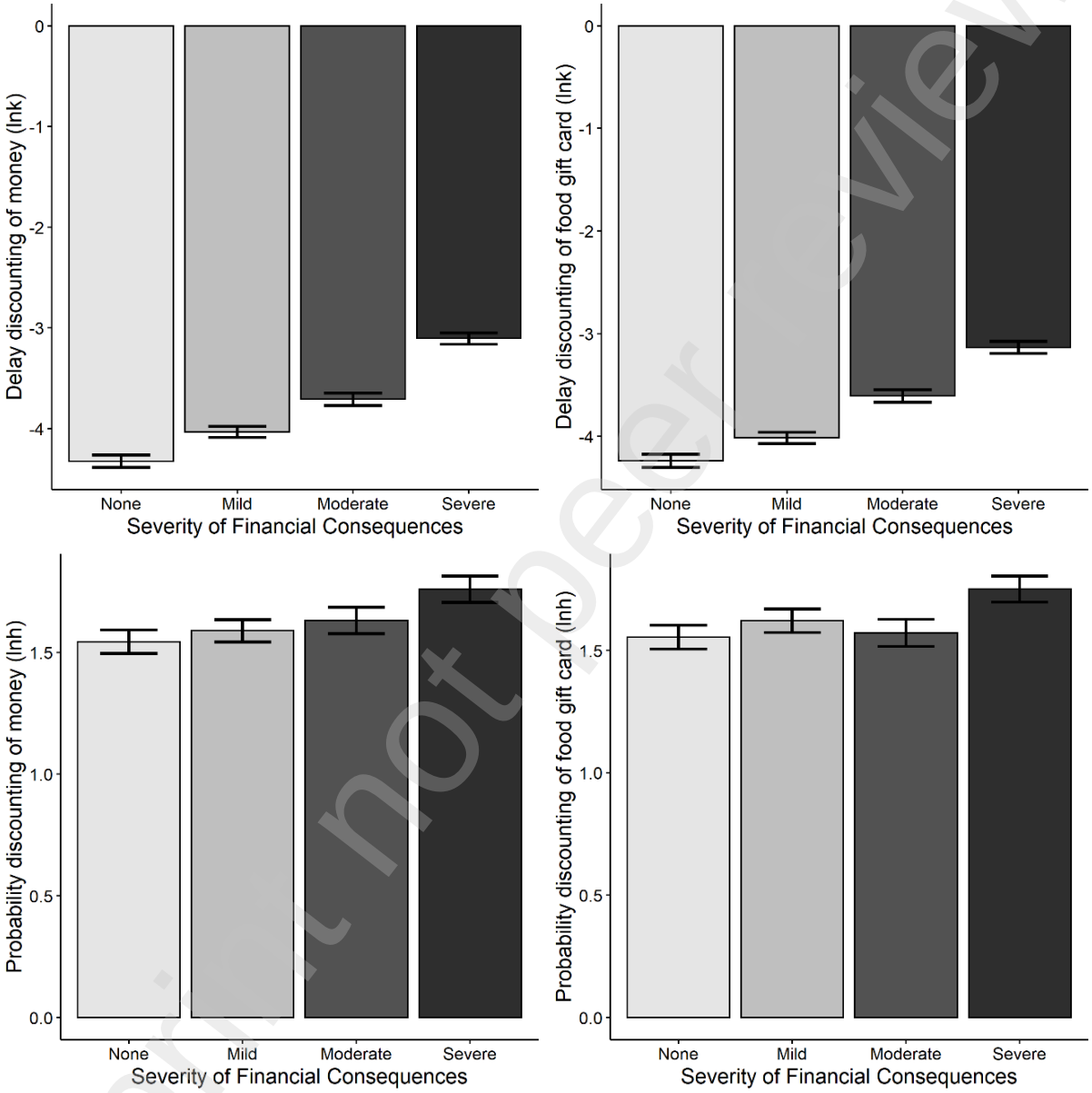

Table 1. Demographics and descriptive statistics for the overall sample, and by severity of financial consequences due to COVID-19.

	Overall	By Severity of Financial Consequences			
Variable	N = 1,012	None, N = 365	Mild, N = 147	Moderate, N = 323	Severe, N = 177
Age	34 (13)	36 (13)	32 (12)	33 (12)	34 (11)
Education					
High school or less	175 (17%)	61 (17%)	21 (14%)	56 (17%)	37 (21%)
Some college or two-year degree	489 (48%)	164 (45%)	76 (52%)	161 (50%)	88 (50%)
Four-year degree or more	348 (34%)	140 (38%)	50 (34%)	106 (33%)	52 (29%)
Gender					
Another Gender	21 (2.1%)	3 (0.8%)	6 (4.1%)	9 (2.8%)	3 (1.7%)
Female	663 (66%)	223 (61%)	104 (71%)	214 (66%)	122 (69%)
Male	328 (32%)	139 (38%)	37 (25%)	100 (31%)	52 (29%)
Household income (thousands)	25 (15, 35)	25 (17, 40)	25 (15, 36)	25 (15, 35)	24 (15, 30)
Delay discounting for money	-3.87 (1.93)	-4.32 (1.95)	-4.03 (1.74)	-3.71 (1.94)	-3.11 (1.75)
Delay discounting for food gift card	-3.81 (1.95)	-4.24 (2.00)	-4.01 (1.76)	-3.61 (1.89)	-3.13 (1.87)
Probability discounting for money	1.62 (1.63)	1.54 (1.54)	1.59 (1.46)	1.63 (1.73)	1.76 (1.75)
Probability discounting for food gift card	1.60 (1.66)	1.55 (1.57)	1.62 (1.54)	1.57 (1.78)	1.75 (1.70)
Perceived Stress Scale	20 (8)	17 (8)	19 (7)	21 (7)	24 (8)
Savings of at least one month of pay?	423 (42%)	198 (54%)	74 (50%)	110 (34%)	41 (23%)
Receives public assistance benefits	437 (43%)	126 (35%)	57 (39%)	157 (49%)	97 (55%)
Minority Status (Hispanic/Latino, Non-white)	402 (40%)	129 (35%)	53 (36%)	142 (44%)	78 (44%)
Food security for February	8 (2)	8 (1)	8 (1)	7 (2)	7 (2)
Food security for the last month	7 (2)	8 (1)	7 (2)	7 (2)	6 (2)
Perceived food security for next month	7 (2)	8 (1)	7 (2)	6 (2)	6 (2)

Figure captions

Figure 1. Mean delay and probability discounting by severity of financial consequences due to COVID-19. Error bars represent standard errors.

Table 1. N(%) for categorical variables and M(SD) for continuous variables