**Probability Discounting and Adherence to Preventive Behaviors During the COVID-19
Pandemic**

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Abstract

This brief communication reports preliminary findings of a study conducted to investigate the relationship between probability discounting and people's adherence to preventive behaviors recommended during the COVID-19 pandemic. A sample of 112 adults living in Brazil completed an online survey composed of a Probability Discounting Questionnaire (PDQ) and a 10-item assessment of how often they complied with the health authorities' recommendations (e.g., wash the hands frequently, practice social distancing, stay at home as much as possible, wear a mask when in public). Data analysis included the participants who showed higher ($n = 40$) and lower ($n = 40$) adherence to preventive behaviors. Results revealed that probability discounting measures are related to people's preventive actions. Participants in the higher adherence subgroup present significantly larger risk aversion indices (i.e., larger h values) than participants in the lower adherence subgroup. Also, participants who showed lower adherence to preventive behaviors were more likely to perform risky choices in the PDQ than participants who demonstrated higher compliance with health authorities' recommendations. These preliminary results suggest that probability discounting can play an essential role in people's self-protective decisions during a global health emergency, such as the COVID-19 pandemic.

Keywords: probability discounting, choice under uncertainty, risk, medical decision-making, compliance, COVID-19.

COVID-19 pandemic is one of the most significant challenges facing humanity in the past 100 years (Ferguson et al., 2020). Scientists from different fields are called upon to solve the problems caused by the uncontrolled spread of the new coronavirus in society (e.g., World Health Organization, 2020). The contributions of behavioral scientists are of enormous importance in this context, not only to minimize the pandemic's impacts on the mental health and psychological well-being of the population but also to reduce the rates of contagion and spread of the disease (O'Connor et al., 2020; Van Bavel, 2020). Until a new vaccine or drug proves effective in preventing and combating COVID-19, society places its best hopes on the mass adoption of preventive behaviors recommended by health authorities (Couto et al., 2020; Ferguson et al., 2020; Kissler et al., 2020). These recommendations include washing the hands frequently, practicing social distancing, staying at home as much as possible, and wearing a mask when in public (World Health Organization, n.d.). In a recent article, Camargo and Calixto (2020) suggested that behavioral processes related to self-control and social cooperation can modulate people's adherence to the health authorities' recommendations. One of these processes is probability discounting, and it will be the focus of this paper.

Probability discounting can be described as the devaluation of consequences as they become less likely (Green et al., 2014). In this sense, risk-averse people tend to discount positive outcomes more readily as they cease to be sure and become probabilistic. In the opposite direction, people who expose themselves to risky situations tend to devalue information about the probability of negative outcomes. During the COVID-19 pandemic, the probability discounting process may be modulating adherence to preventive behaviors since people who fail to protect themselves may do so, at least to some extent, because they underestimate the chances of getting infected (Camargo & Calixto, 2020). Even in the case of infection, people are uncertain about having more severe

symptoms, which can be mediated, for example, by the presence of some risk factor, such as being over 60 years old or having a chronic disease (Camargo & Calixto, 2020). Thus, the probability of adherence to the preventive behaviors would be discounted as the inferred likelihood of contagion and the development of more severe symptoms also decrease.

Previous research demonstrated the role of probability discounting in health-related outcomes, such as adherence to pharmacological treatments (e.g., Bruce et al., 2016; Jarmolowicz et al., 2019) and on the vaccination of children (e.g., Jarmolowicz et al., 2018). For example, Bruce et al. (2016) demonstrated that probability discounting is related to pharmacological treatment adherence in patients with multiple sclerosis (ME). According to the authors, when making a treatment decision (e.g., taking a medication), patients with ME balance the probability of side effects in the short-term against the likelihood of an improved health condition in the long-term. Complementarily, Jarmolowicz et al. (2018) demonstrated that probability discounting is involved in the adherence to children's vaccination campaigns. In situations like that, parents consider the chances of vaccine effectiveness, the risks of side effects, and the possible benefits for other, more or less socially distant people.

Probability discounting measures are typically obtained through a series of quick questions in which participants must choose between a smaller amount of money for sure or a larger but probabilistic amount (Green et al., 2014). There are variations in the procedures for assessing such measures depending on the research topic (e.g., Bruce et al., 2016; Jarmolowicz et al., 2018). In the present study, we used a standardized instrument, the Probability Discounting Questionnaire (PDQ; Madden et al., 2009), to investigate the relationship between probability discounting and people's adherence to the preventive behaviors against COVID-19. To date, there is no standardized instrument for assessing compliance with health authorities' recommendations, so

we created a 10-item questionnaire based on the advice for the public given by the World Health Organization (n.d.) to determine participants' level of adherence to preventive behaviors.

Method

Participants

A sample of 112 adults living in Brazil completed the research (65 females, 45 males, and two not reporting their gender; $M_{\text{age}} = 29$ years; 62 college students). Participants were invited through local media and social networks. Participation was entirely voluntary and took approximately 40 minutes. Data collection occurred between August 13 and 25, 2020, when the average number of new cases and deaths by COVID-19 reached Brazil's highest levels (G1, n.d.).

Procedure

Participants completed an online survey composed of 151 questions, including a 30-item Probability Discounting Questionnaire (Madden et al., 2009), three questions of sociodemographic data (gender, age, and level of education), and a 10-item assessment to determine the individual level of adherence to the preventive behaviors against COVID-19 (World Health Organization, n.d.). The remaining questions required additional data collection or analyses and will not be explored in this work.

Probability Discounting Questionnaire (PDQ)

PDQ evaluates the individuals' preferences for guaranteed *versus* risk rewards. In the present study, all the instructions were given in Brazilian Portuguese, and the monetary amounts were adapted to the participants' local currency (BRL). Participants were asked to consider a hypothetical scenario in which they won a voucher and had to choose between redeeming its monetary amount or using it to participate in a draw with an N -in-100 chance of winning a larger,

special voucher. For example, in the first item, participants could choose between redeem a 60 BRL voucher or use that voucher to participate in a draw with a 10-in-100 chance of winning a 240 BRL special voucher. The PDQ items were arranged in a standardized order across three 10-questions blocks. In block 1, the choice was between 60 BRL or [10 to 83]-in-100 chance of winning 240 BRL. In block 2, participants had to choose between 120 BRL or [18 to 91]-in-100 chance of winning 300 BRL. Finally, in block 3, the choice was between 120 BRL or [40 to 97]-in-100 chance of winning 240 BRL. This sequence of items and blocks allows researchers to identify the point in which participants change their preferences from certain to probabilistic rewards (i.e., their indifference point) while controlling for a possible magnitude effect.

10-item assessment of the level of adherence to preventive behaviors

Each of the items included a recommendation to prevent the contagion by the COVID-19 and spread of the new coronavirus (World Health Organization, n.d.), the statement “I’ve been following this recommendation...”, and five options of choice: *Always*, *Often*, *Partially/Sometimes*, *Rarely*, and *Never*. The topics of the items included (1) hand hygiene, (2) cough etiquette, (3) touch of nose and eyes, (4) physical distancing, (5) greeting etiquette, (6) hygiene of cellphones and toys, (7) sharing of personal objects, (8) room ventilation, (9) social distancing, and (10) the use of masks when in public. For example, the ninth item presented the following recommendation: “Regarding social distancing, it is recommended to stay at home and avoid crowded places, unless you need to go out to work, buy food and medicines, or need medical care.” The full list of recommendations is provided as supplemental material.

Data Analysis

Data analysis procedures were conducted using R language (Version 3.5.1; R Core Team, 2018) and the RStudio environment (RStudio Team, 2015). The first step of the analysis involved

calculating the h values, a type of metric for the individual degree of probability discounting. Risk-averse individuals tend to show larger h values than individuals more likely to involve themselves in risky situations. We used the syntax provided by Gray et al. (2016) to assess participants' h values on each block of the PDQ. Then we averaged the results of the three blocks to get the overall h value for each participant. The second step involved calculating an index of adherence to preventive behaviors based on the responses to the 10-item assessment. We scored the items-responses in a range from 0 (“*Never*”) to 4 (“*Always*”) and averaged the scores of the items. Finally, we transformed the average scores into an index ranging from 0 to 1. For subsequent analyses, we created two subgroups, including the 40 participants who showed the highest adherence indices (higher adherence subgroup) and the 40 participants who had the lowest adherence indices (lower adherence subgroup). A linear regression analysis was used to compare the average h values according to the level of adherence (higher vs. lower) to preventive behaviors. Additionally, we applied a multilevel logistic regression to evaluate how the likelihood of risky choices changes as the probability of winning a larger reward increases in the PDQ (see Young, 2018). Pairwise comparisons were conducted to evaluate the differences between the subgroups.

Results

The index of adherence to preventive behaviors ranged from 0.55 to 0.83 for the lower adherence subgroup and from 0.93 to 1.00 for the higher adherence subgroup ($M_{\text{index}} = 0.73$ and 0.96, respectively). The gender distribution was similar in both the subgroups (lower adherence = 22 females vs. 16 males; higher adherence = 23 females vs. 17 males; two participants in the lower adherence group did not report gender). The lower adherence subgroup included more younger participants than the higher adherence subgroup ($M_{\text{age}} = 26$ vs. 31 years, respectively) and had

more college students than the former ($n = 28$ vs. 18 , respectively). Due to length constraints, these demographic variables were not explored in subsequent analyses presented here.

Figure 1 shows the fitted average h values for each subgroup according to our linear regression analysis. Participants in the higher adherence subgroup (*black bar*) had significantly higher average h values ($M = 6.14$, $SE = 0.70$) than participants in the lower adherence subgroup (*white bar*; $M = 3.63$, $SE = 0.70$), demonstrating more risk aversion, $F(1, 78) = 6.46$, $\beta_{\text{Diff}} = -2.51$, $SE = 0.99$, $t(78) = -2.54$, $p = .013$.

Figure 1. Fitted average h values for participants that presented higher (*black bar*) or lower (*white bar*) adherence to preventive behaviors recommended during the COVID-19 pandemic. Error bars present the standard error for the model fit.

Figure 2 shows the fitted probability of risky choices in the PDQ (i.e., participate in a draw) according to our multilevel logistic regression analysis. For both subgroups, the probability of

risky choices decreases as the probability of winning a larger reward in the draw also decreases, $\chi^2(1) = 139.79, p < .001$. However, the decrease is steeper and occurs significantly earlier for the higher adherence subgroup than for the lower adherence subgroup, $\chi^2(1) = 5.73, \beta_{\text{Diff}} = 1.22, SE = 0.51, z(\text{Inf}) = 2.39, p = .017$. With a 50% probability of winning (i.e., our model intercept), participants in the higher adherence subgroup showed a 0.18 probability of choosing the risk option ($SE = 0.06$), while for participants in the lower adherence subgroup, such probability was 0.42 ($SE = 0.09$).

Figure 2. Fitted probability of risky choices (i.e., participate in a draw) at each probability of winning presented in the PDQ for participants in the subgroups that presented higher (*solid line*) or lower (*dashed line*) adherence to preventive behaviors recommended during the COVID-19 pandemic. Shaded areas denote the standard error for the model fit.

Discussion

The results of our analyses suggest that probability discounting can play an essential role in people's self-protective decisions during the COVID-19 pandemic. Participants who showed higher adherence to preventive behaviors were more risk-averse (i.e., larger h values) than participants who showed lower adherence. Also, participants in the lower adherence subgroup were more likely to make risky choices in the PDQ than participants who demonstrated higher adherence to the health authorities' recommendations.

These findings are in line with previous research that demonstrated the relationship between probability discounting and health-related decisions (i.e., Bruce et al., 2016; Jarmolowicz et al., 2018, 2019). Recent studies conducted during the COVID-19 pandemic also indicate the relationship between risk-related measures and compliance with health authorities' recommendations (e.g., Byrne et al., 2020; Nese et al., 2020). Byrne et al. (2020) conducted a similar study of the US population and found that an increased number of risky choices in a PDQ-like task can be a strong predictor of lower adherence to appropriate mask-wearing behavior and social distancing recommendations. Nese et al. (2020) surveyed the Italian population and found that information about the risks of contracting COVID-19 modulates the likelihood of compliance with containment measures overtime. When the risk is relatively low (e.g., 10%), the compliance level tends to decrease as the number of days of containment increases (a behavioral process known as delay discounting). The same occurs to a less extent when the risk is high (e.g., 90%).

To our knowledge, the present study is the first to investigate relationships between discounting measures and adherence to preventive behaviors in a Brazilian sample. We highlight the robustness of the results despite small variability in the observed adherence indices (i.e., both subgroups showed relatively high adherence indices: > 0.50), which indicates good sensitivity of

the probability discounting measures used in the study. Age and level of education seem to be related to the different adherence levels to preventive behaviors and, along with gender, deserve special attention in subsequent analyses. Furthermore, we have additional data under complementation and analysis, including questions regarding political affiliation, self-perception of risks, information access, and the impacts of COVID-19 on daily life. A better understanding of how the process of probability discounting is related to adherence to preventive behaviors against COVID-19 can be fundamental for proposing effective interventions to increase people's collaboration in overcoming the pandemic.

Declarations

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Compliance with Ethical Standards

On behalf of all authors, the corresponding author states that there is no conflict of interest. The research protocol was approved by the Institutional Review Board of the researchers' university (CAAE: 35825920.0.0000.5504) under the Declaration of Helsinki's ethical standards. Informed consent was obtained from all individual participants included in the study.

Availability of Data and Material

Online supplementary material is provided with this manuscript. This material contains a full list of recommendations presented in the 10-item assessment of the level of adherence to preventive behaviors against COVID-19. The original dataset of this study, including the R commands used in the analyses, are available at the OSF repository (<https://doi.org/10.17605/OSF.IO/SGBEJ>).

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Supplemental Material

Full list of recommendations presented in the 10-item assessment of the level of adherence to preventive behaviors:

1. Regarding personal hygiene, it is recommended to wash your hands frequently with soap and water or use 70% alcohol-based hand sanitizers.
2. When coughing or sneezing, it is recommended to cover your nose and mouth with the handkerchief or the arm, and not with the hands.
3. If your hands are not completely sanitized, it is recommended to avoid touching the eyes, nose, and mouth.
4. In public places, it is recommended to keep a minimum distance of about 2 meters from anyone.
5. When greeting people, it is recommended to avoid hugs, kisses, and handshakes, adopting friendly behavior without physical contact.
6. It is recommended to clean cell phones and smartphones frequently, as well as children's toys.
7. For personal use objects, it is recommended not to share cutlery, towels, plates, and glasses.
8. For home and/or work environments, it is recommended to maintain the place clean and with natural ventilation.
9. Regarding social distancing, it is recommended to stay at home and avoid crowded places, unless you need to go out to work, buy food and medicines, or need medical care.
10. When you need to leave home, it is recommended to use homemade or handmade masks made of fabric, completely covering the nose and mouth.