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TEMPORAL DISCOUNTING OF GAINS AND LOSSES IN MONETARY AND HEALTH DOMAINS

DESCUENTO TEMPORAL EN GANANCIAS Y PÉRDIDAS EN DOMINIOS MONETARIOS Y DE SALUD

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Abstract

Delay discounting is the decrease in the subjective (present) value of a reward as a function of the delay until its receipt. The delay discounting rates of money and health were evaluated. We used a fixed sequence delay discount task, with four questionnaires of hypothetical situations: monetary gains and losses, and health gains and losses (disease), with five delays (1 month, 6 months, 1 year, 5 years and 10 years), and 20 binary options, in ascending and descending order. Relative subjective value decreased as a function of prospective time and the hyperbolic curve provided a good fit to the group data. A smaller area under

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the curve (AUC) was observed in monetary domains compared to the health domain with both signs and the AUC values were positively correlated in all conditions. These results suggest that there was a sign effect both in the monetary and in health domain, as well as domain independence. The reported data contribute to the growing literature by showing the domain and sign effect on monetary and health domain through a within-subject design and a fixed sequence task.

Key words: delay discounting, monetary, health domain, AUC, framing

Resumen

El descuento temporal es la disminución en el valor subjetivo (presente) de una recompensa como función de la demora hasta su recepción. Se evaluaron las tasas de descuento temporal del dinero y la salud. Con una tarea de descuento temporal de secuencia fija, con cuatro cuestionarios de situaciones hipotéticas: ganancias y pérdidas monetarias, ganancias y pérdidas de salud (enfermedad), con cinco demoras (1 mes, 6 meses, 1 año, 5 años y 10 años), y 20 opciones binarias, en orden ascendente y descendente. El valor subjetivo relativo disminuyó en función del tiempo de espera y la curva hiperbólica se ajustaba bien a los datos del grupo. Se observó una menor área bajo la curva (AUC) en los dominios monetarios en comparación con el dominio de la salud con ambos signos y los valores de AUC se correlacionaron positivamente en todas las condiciones. Estos resultados sugieren que hubo un efecto de signo tanto en el dominio monetario como en el de salud, así como independencia de dominio. Los datos contribuyen a la creciente literatura al mostrar el efecto de dominio y signo en los dominios monetario y de salud a través de un diseño intra-sujeto y con una tarea de secuencia fija.

Palabras clave: descuento temporal, dominio monetario, dominio de salud, AUC, encuadre

Delay discounting refers to the phenomenon by which a reward loses its value when it is delayed (Critchfield & Kollins, 2001). The value of a reward, however, is not discounted at a constant rate; in fact, the rate of discounting is greater at shorter delays than at longer ones (e.g., Baumann & Odum, 2012; Green & Myerson, 1996; Green et al., 2010; Jones & Rachlin, 2006; McKerchar et al., 2010). This pattern may be well characterized by a hyperbolic function (Mazur, 1987):

$$V = \frac{A}{1 + kD} \tag{1}$$

In this model, V represents the subjective value of the reward that increases directly with its magnitude (A) and decreases as a function of a delay (D), *k* is a free parameter that describes how steeply the value is discounted by the delay, with higher *k* values indicating steeper discounting. The degree to which a delay decreases the value of a reward, indicated by *k*, has been considered as an individual indicator of impulsivity (preference for immediate rewards) that may underlie decision-making processes in various contexts (Charlton & Fantino, 2008; Odum, 2011a).

Another model that has been used to describe the relationship between value and delay has been the hyperbola-like model (Green et al., 1994; McKerchar, et al., 2009). This function includes the free parameter s that represents the nonlinear scaling of amount and time (McKerchar, et al., 2009):

$$V = \frac{A}{(1 + k\ D)^{S}} \tag{2}$$

Another theory of delay discounting assumed that the subjective value of the reward could decrease exponentially as a function of delay, based on the assumption that preferences should remain consistent across delays (Tesch & Sanfey, 2008; McKerchar, et al., 2009). The function describing this type of discounting has the following form:

$$V = Ae^{-kD}$$

Where V is the value of the reward, A is the Amount of the reward, e is a constant, k is a free parameter describing the discount rate (how fast the value of the reward declines with increasing delay or probability), and D is the delay until the reward is received (Green & Myerson, 2004; McKerchar & Renda, 2012). Economists generally tend to favor the exponential equation as a delay discounting function, assuming that all reinforcers are discounted by the same percentage as a function of the time elapsed, regardless of their size or the delay (Mazur, 2006).

The study of delay discounting has been useful to understand the underlying processes involved in decision-making and the variables that affect choice. Discount rates in human participants have been shown to vary systematically as a function of numerous variables. For example, the magnitude of the reward has been extensively shown to be negatively related to discount rates (e.g., Benzion et al., 1989; Grace & McLean, 2005; Green et al., 1997; Myerson & Green, 1995; Thaler, 1981).

The type of commodity (sometimes referred to as the domain) also influences discount rates. For instance, primary reinforcers (alcohol, food) have steeper discount curves than secondary reinforcers such as money (Odum & Rainaud, 2003). The durability of the rewards seems to be inversely related to the discount rate (Odum & Rainaud, 2003; Odum et al., 2006; Ostaszewski et al., 1998). Directly consumable rewards present a greater degree of discounting than those that cannot be exchanged or manipulated (Charlton & Fantino, 2008; Estle et al., 2006). Finally, commodities that are typically consumed immediately upon acquisition may be discounted at a higher rate than those that can be saved for a period before consumption or that require a greater amount of time for consumption (Rainieri & Rachlin, 1993).

Framing outcomes as gains or losses may also affect the degree of discounting. This asymmetry between gains and losses had been called the "sign effect" and it has been replicated in many studies (Hardisty & Weber, 2009; Johnson et al., 2007; Odum et al., 2002). The sign effect suggests that a lower discount rate will be applied to the decision if it is framed as a choice between losses. This is potentially applicable to the modification of health decisions because preventive behaviors may be promoted by framing decisions as losses.

Delay discounting is a growing area of research with implications for many socially important problems including obesity, drug abuse, and gambling. Research in this field has increased significantly because the tendency to make unhealthy choices might be related to an individual's delay discount rate (Odum, 2011b). High discount rates for money (and in some instances food or drug rewards) have been associated with several unhealthy behaviors and markers of health status, establishing discounting as a promising predictive measure of healthy behavior (Odum et al., 2002; Cisneros & Silva, 2017).

Discounting tasks with monetary rewards require participants to decide between hypothetical small immediate amounts of money and larger amounts with longer delays (e.g., $ 10 today vs $ 100 in 6 months). Health rewards are usually described as an improvement in health from a baseline of illness (for example, Ganiats et al., 2000), and participants choose between small and immediate improvements in health over larger and more delayed improvements.

Studies of delay discounting have focused on evaluating whether some important properties of monetary discounting are conserved in the health domain or whether, on the contrary, the properties of monetary discounting are independent of health discounting (Chapman, 1996; Chapman & Elstein, 1995; Chapman et al., 1999). However, there is reason to believe that health is not discounted like money, because, unlike money, health cannot be invested or saved for future consumption.

Given that health outcomes might not be discounted the same way or at a comparable rate as monetary outcomes, and health decisions might depend on the way these outcomes are valued, evaluating the discount for health commodities may help guide public policies that rely on the aggregate decisions of individuals. In addition, comparing the discount of health and monetary outcomes should help determine whether the shape of discount functions is similar, and this is important considering that most studies on discount and health use monetary discount tasks (Chapman, 1996; Chapman & Elstein, 1995; Madden et al., 1997).

Few studies have evaluated directly whether people discounted at the same rate the outcomes in these two domains, money and health. Chapman and Elstein (1995), using a fill-in-blank procedure, found that decision-makers show different discount rates for health-related decisions and money-related decisions. Specifically, participants showed a greater discount with monetary outcomes. Chapman (1996) report that this difference is related to parameters such as framing and magnitude. However, this difference disappears when a monetary cost is given to the disease, for example, the person is told that a drug should be taken and is available for $ 1000 a year (Chapman, 2002).

Because discounting has been related to public health issues, many studies have evaluated the discount rates of substance users (e.g., Odum et al., 2002). However, the common use of specific populations of consumers may confound the evaluation of the domain and sign effects due to the history of substance use. Assessing these effects in non-clinical populations may provide information on the generality of the domain and sign effect in other samples and their choices concerning health outcomes may be important for their self-care and may have preventive implications in the applied field.

The present research aims to contribute to the body of research on the variables that affect discount rates and was designed to assess the role of the domain (money and health) and framing (gains and losses) in the discount rate of a sample of healthy participants using an adjusting procedure in a within-subject design. The present study will allow evaluating in a non-clinical population a) the discount rate of monetary and health commodities, b) the sign effect in both domains and c) the consistency of the delay discounting in four conditions.

Method

Participants

Fifty-one university employees, 33 women and 18 men, with a mean age of 38.1± 4.2 years, equitably distributed among administrative, operative, and academic areas, participated voluntarily. An invitation to participate in the study was sent by email to 498 university employees in the 30-45 age range. A within-subject design was used. Participants with chronic diseases or those who did not complete the four questionnaires were excluded. Participants signed a letter of informed consent, and the ethics committee approved all procedures.

Procedure

Materials and Setting

Participants were individually tested in a cubicle equipped with a chair and desk. After consenting to participate, each participant received four paper questionnaires in which they had to choose between two alternatives, each with 20 binary options per delay. The questionnaires evaluated the delay discounting in four conditions (monetary gains, monetary losses, health gains, health losses). The order of presentation of these conditions were counterbalanced for all participants. They were asked to read the instructions and ask the experimenter if they had any questions. The interval between each questionnaire was between two and five minutes and they were all completed in the same session.

Questionnaire 1: Monetary gains. Participants were asked to choose between an immediate and a delayed hypothetical amount of money. On a piece of paper, immediately available hypothetical monetary rewards, ranging from $1 to $100 (with intermediate values of $2.5, $5, $7.5, $10, $15, $30, $35, $40, $50, $55, $60, $65, $ 70, $75, $80, $85, $90, $95, $97.5, $99), were presented in separate rows along with the delayed amount (always $100). Thus, in the first row, participants had to choose between gaining $1 now and gaining $100 in a month; in the second row, the choice was between $2.5 now and $100 in a month, and so on until the largest immediate value. This procedure was repeated in ascending and descending order for each one of five delays (1 month, 6 months, 1 year, 5 years, and 10 years).

Questionnaire 2: Monetary losses. The questionnaire was similar to monetary gains with the difference that participants were asked to choose between an immediate and a delayed hypothetical loss of money. Thus, in the first row, participants had to choose between losing $1 now and losing $100 in a month; in the second row, the choice was between losing $2.5 now and losing $100 in a month, and so on until the largest immediate value. This procedure was also repeated in ascending and descending order for each one of five delays (1 month, 6 months, 1 year, 5 years, and 10 years).

Questionnaire 3: Health Gains. Before answering the questionnaire, participants were asked to imagine the following scenario:

> "To answer this questionnaire, you must imagine the following hypothetical situation:
>
> For the past two years, your state of health fits the following description:
>
> You must be very careful with the food you eat, so you must pay close attention to your diet. You need to visit the bathroom frequently to urinate. You often feel tired and sometimes groggy. Sometimes you have trouble sleeping and sometimes you have nightmares during sleep. Your mouth feels dry at times, and food does not seem to taste as good as it used to. You do not have as much desire for sex as you used to, and you do not find sex as enjoyable as before. You often feel angry or irritated, and it is difficult to concentrate. Imagine that this state of health will continue unchanged for some time."

This hypothetical situation was based on Chapman and Elstein's study (1995). Participants were asked to choose between an immediate and a delayed period of health. On a piece of paper, immediately available health periods ranging from .5 months to 48 months (with intermediate values of 1, 3, 9, 12, 16, 18, 21, 24, 26, 28, 30, 32, 34, 36, 38, 42, 45 and 47 months), were presented in separate rows with the delayed amount (always 48 months). Thus, in the first row, participants had to choose between 0.5 months of health now and 48 months of health after some delay; in the second row, the choice was between 1 month of health now and 48 months of health, and so on until the largest immediate value. This procedure was repeated in ascending and descending order for each one of five delays (1 month, 6 months, 1 year, 5 years, and 10 years).

Questionnaire 4: Health Losses. The questionnaire was similar to health gains with the difference that participants were asked to choose between an immediate and a delayed illness. Before answering the questionnaire, participants were asked to imagine the following scenario, also adapted from Chapman and Elstein's study (1995):

> "To answer the questionnaire, you must imagine the following hypothetical situation:
>
> For the last two years, your health has been perfect. You were diagnosed with a disease and you will have to wait a certain time for the appearance of the following symptoms:
>
> You must be very careful with the food you eat, so you must pay close attention to your diet. You need to visit the bathroom frequently to urinate. You often feel tired and sometimes groggy. Sometimes you have trouble sleeping and sometimes you have nightmares during sleep. Your mouth feels dry at times, and food does not seem to taste as much as it used to. You do not have as much desire for sex as you used to, and you do not find sex as enjoyable as before. You often feel angry or irritated, and it is difficult to concentrate."

Data analysis

Points of subjective equivalence between immediate and delayed reward values (indifference point) were obtained by averaging the immediate value participants chose after switching from the delayed amount and the immediate value just before switching for a questionnaire for each delay. Considering that each questionnaire was presented in ascending and descending order, the indifference point corresponds to the average of the result of the two presentations. Because the indifference point was expressed as a proportion of the delayed amount, their values ranged between 0 to 1.

Nonlinear curve-fitting analyses were performed using Solver for Microsoft Excel, version 2013. The regression tool was used to find the minimum sum of the squares of the errors between data points and a nonlinear function using a standard iterative technique for solving least squares problems. The hyperbolic (Eq. 1), hyperbola-like (Eq. 2) and the exponential equation (Eq. 3), were fitted to the median of the indifference points in each delay condition for each questionnaire.

From the indifference points, we computed the area under the curve (AUC) for each subject and condition. This measure, proposed by Myerson et al. (2001), provides an estimate of the degree of discounting. It has the advantage of not committing to any theoretical model because it is based on the observed values rather than predicted values for a particular model. The AUC values varied between .01 and 1. Values closer to 0 indicate a lower area under the curve and correspond to lower indifference points. Higher values of AUC indicate higher indifference points and, therefore, higher subjective values associated with the reward.

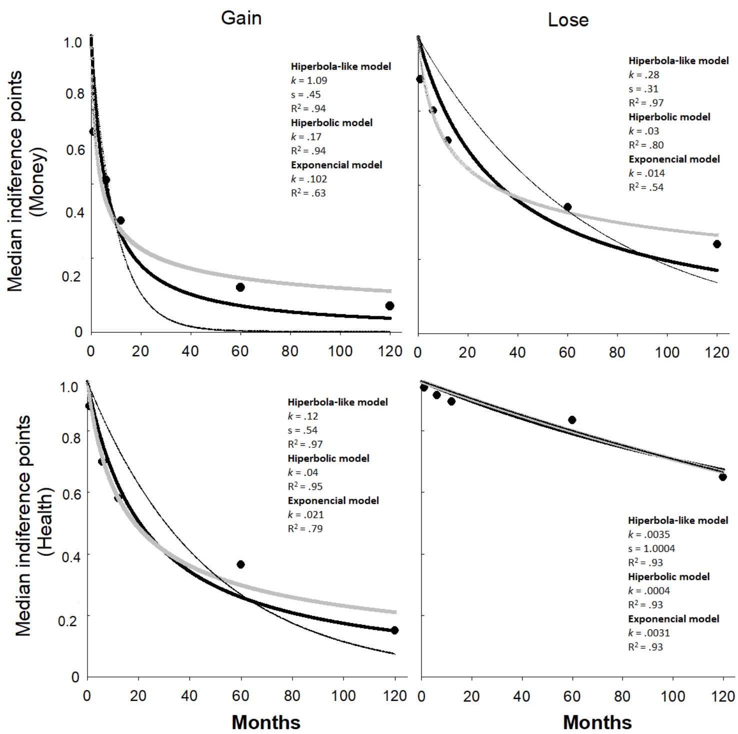
Results

Figure 1 shows median indifference points at each delay for money (top row) and health domain (bottom row); gains are presented in the left column and losses in the right column. The lines represent the best fitted hyperbolic (Eq. 1) and hyperbola-like model. The relative subjective value decreased as a function of time and the hyperbolic and hyperbola-like model showed a good fit to the group data. We used the Akaike Information Criterion (AIC) to assess model fit, because R^2 may not be a good measure of goodness of fit for nonlinear models with different number of parameters. The hyperbola-like model provided a better fit for 58% of the datasets in the monetary gains condition, for 54% of the datasets in the monetary losses condition, for 39% of the datasets in the health gains condition, and for 46% of the datasets in the health losses condition. The hyperbolic model provided a fit for 23% in gains and 28%

losses monetary condition, for health 33% in the gains condition, and for 17% losses condition. The exponential model provided a fit for 17% in gains and 18% losses monetary condition, for health 27% in the gains condition, and for 36% losses condition. The lower percentage of cases described better by Eq. 2 in the health losses condition might be related to the number of nonconvergent datasets in this condition (12 cases vs. 2 cases in the others), mostly due to no discounting.

There was a higher discount rate with gains, as indicated by the value of k, both for the monetary domain (money gain k =1.09: vs money loss: k =.28) and the health domain (health gain k =.12: vs health loss: k =.0035). Regarding the domain, the data show a higher discount rate in the monetary domain both in the gains condition (money: k =1.09 vs health: k=.12) and in the losses condition (money: k =.28 vs health: k =0.0035). The sensitivity parameter s was similar among conditions, except for health losses (close to unity).

Figure 1. Delay discounting functions

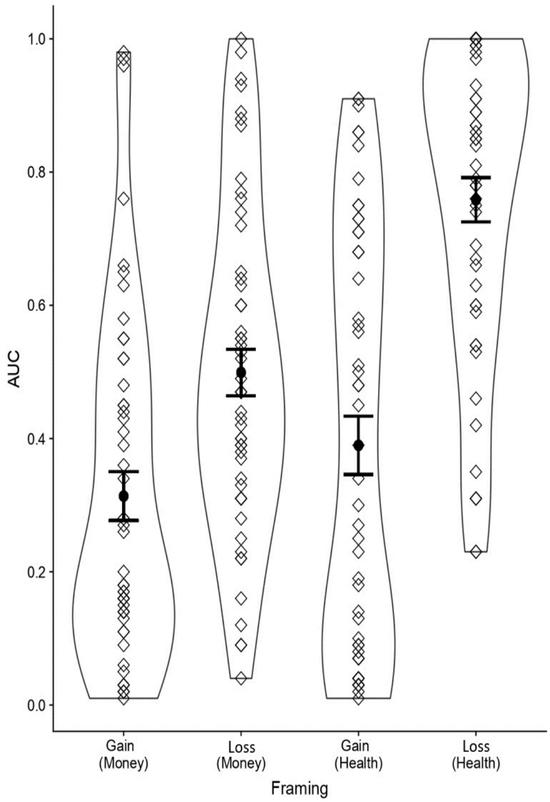


Note. Points represent median indifference points. Gray solid lines show the best-fitting discounting functions generated by the hyperbola-like model. Thicker black solid lines show the best-fitting discounting functions generated by the hyperbolic model. Thinner black solid lines show the best-fitting discounting functions generated by the exponential model. The adjusted parameters for each model were added.

Figure 2 shows individual AUC values for each task. The Shapiro-Will test showed that the AUC data was not normally distributed (all $p<0.01$). Durbin test for repeated measures with two within-subject factors domain (monetary or health) and sign (gain or loss) shows a significant effect of domain ($\chi^2_1=13.06$, $p < 0.001$, *Kendall´s W*=.18.047), and sign ($\chi^2_1 = 32.26$, $p < 0.001$, *Kendall´s W*=-18.57). Post hoc pairwise comparisons show lower AUC values are observed in monetary domains compared to the health domain in both gains (gain money: *mean* =.31 vs gain health: *mean* =.38, p_{holm}=0.06) and losses (loss money: *mean* =.49 vs loss health: *mean* =.75, p_{holm}= 0.02).

Additionally, lower AUC values were found with gains both for money (money gain: *mean* =.*31* vs money loss: *mean* =.49, p_{holm}< 0.01) and health (health gain: *mean* =.38 vs health loss: *mean* =.75, p_{holm}< 0.01). Statistical power was calculated in a post hoc analysis using the G*Power software, the statistical power of the analysis was high (1-β> .9).

Figure 2. Violin plots of the area under the curve (AUC) of each task



Note. The black dots indicate the average AUC for each task and the lines represent the standard error, the white diamonds represent individual data, the lines indicate the density of data distribution.

To determine the consistency of the subjective value in the questionnaires, Table 1 shows the correlation between the AUC obtained for each participant. The AUC values were positively correlated in all conditions and all correlations were statistically significant, except one: money loss – health gain, varying between r_s =.22 and r_s =.60.

Table 1. Spearman rank-order correlations between AUC in each condition

		Money		Health	
		Gain	**Loss**	**Gain**	**Loss**
Money	Gain	1.0	.604**	.317*	.345*
	Loss		1.0	.227	.591**
Health	Gain			1.0	.301*
	Loss				1.0

**p < 0.001 level (2-tailed).
*p< 0.01 (2-tailed).

Discussion

The present research evaluated the effect of framing (gains and losses, on monetary and health domains) in a sample of healthy participants. The current results suggest three major points for consideration 1) the significant differences in the degree of discount between the monetary and health domain, 2) the asymmetry between gains and losses and, 3) the relative consistency observed between conditions as evidenced by the correlations.

The highest discount rate was observed in the monetary domain compared to the health domain for both the gain and loss conditions. These results are contrary to those previously reported by Chapman (1996), in which health discount rates appeared to be higher than money discount rates, especially for the small magnitudes and short delays. However, there are several important differences concerning the study by Chapman (1996): the present investigation used a smaller amount of money ($100 vs $200), whereas the magnitude used in the health domain was greater (48 months vs 24 months). In addition, the format we used involved choosing between binary alternatives, unlike the fill-in-the-blank format. We did not equate the magnitudes of money with health and determined an initial equivalence. Thus, the lower discount rates of health outcomes may be due to the number of months of health or illness used in the task being highly valued by the participants. This hypothesis may be tested by initially titrating the amount of money that would be equivalent to days of health or illness at the individual level.

In addition to magnitudes, according to Charlton and Fantino (2008), the relevant aspects that affect discount rates are the type of reinforcer (primary or secondary), durability, satiability, the possibility of direct consumption, and the possibility of exchanging. One of the main differences between the commodities we evaluated is the possibility of exchanging (health is a valuable reward that cannot be exchanged), and durability (health cannot be saved for later consumption). Therefore, observing lower discount rates with health may be related to one or both aspects of the reward.

Regarding the asymmetry between gains and losses (sign effect), the data in this study are consistent with previous studies in which other commodities were used. A lower discount rate was found when outcomes were framed as losses regardless of domain. This finding is supported by the differences in the free parameter *k* and by the differences found in the AUC values and it may be related to loss aversion (Tanaka et al., 2014). Another hypothesis that may account for the lower degree of discount of losses is that a loss usually entails a previous gain, which usually involves some kind of effort to be obtained (as most parents usually say: "money does not grow on trees!"), as opposed to traditional delay discounting tasks with monetary gains in which the reward is obtained without any effort. Results reported by Zentall and Singer (2007) suggest that a hard-earned reward might be more valuable and, if losses do indeed imply a previous gain that one had to work to obtain, then money lost is valued more highly than money gained (also see Rasmussen & Newland, 2008). However, this may not apply to loss of health, because health is the default state for most people and no effort is normally required to maintain it.

The correlation between AUC values under different domains reflects the tendency to respond in similar ways under different circumstances, and previous studies have found different degrees of correlation that have been interpreted as indicators of consistency in responding. Some studies have reported good reliability through repeated application of the questionnaires between one week and one year. For example, Simpson and Vuchinich (2000) found evidence for strong test-retest reliability (r =.91) with a test-retest interval of 1 week using a choice task with the economic domain (Kirby, 2009), and a high correlation after one year (r =.71). Another way to evaluate consistency has been through the correlation of AUC in different domains: for example, Odum (2011b) reported moderate correlations of the discount of monetary outcome with the discount of heroin (*r* =.56), food (*r* =.39), cigarette (*r* =.54) and alcohol (*r* =.59).

We found a low degree of consistency between monetary and health gains (r =.31), while Chapman and Elstein (1995) reported an even lower and non-significant correlation (r =.18). The results of the present investigation contribute to the study of the consistency of the discount as they show significant correlations in all conditions that vary between .22 and .64. The highest consistency is found in the monetary domain between opposed signs (r =.60), and with losses between domains (r= 0.59), while the lowest consistency is found when domains and signs are crossed (monetary loss vs. health gain, r =.22 and monetary gain and health loss, r =.34). These values coincide with those previously reported in these domains and show that there is relative low reliability of the measure across contexts (Chapman, 1996; Chapman & Elstein, 1995).

In conclusion, the reported data contribute to the growing literature showing the domain and sign effect on monetary and health domain using a within-subject design and with a fixed sequence task. Additionally, the data support the existing effects with a different sample, which does not have a disease and are not consumers of substances, thus increasing the generality of the findings. In this regard, there may be potential applications of these results in health scenarios in which healthy choices might be promoted when offering alternatives to patients. The framing of losses or gains will influence the decision, and we can help people make better health decisions with this type of information. These data could contribute to the literature and their links with health-related behaviors or with policies to promote healthy behaviors (Muñoz Torrecillas, et al., 2021).

Potential criticisms of the methodology might relate to the use of hypothetical alternatives, rather than actual outcomes. However, the study with healthy choices in a non-hypothetical environment may generate ethical problems that make the research with humans unattainable, and studies with hypothetical and non-hypothetical commodities have shown similar discount functions (Green & Lawyer, 2014; Johnson & Bickel, 2002; Kirby & Herrnstein, 1995; Kirby & Maracovic, 1996; Madden et al., 2004). Not equating the monetary and health outcomes is a significant limitation of this work, although it is a common practice in studies where they compare different commodities, because it is difficult to equate the magnitudes of reinforcers of different nature. Future research should consider the interchangeability of commodities such as money with others such as primary or liquid reinforcers (Stuppy-Sullivan et al., 2016) or the degree of fungibility and perishability (Holt, Glodowski et al., 2016). In addition, framing time as specific dates, as describe by DeHart and Odum (2015), or time in units of days, instead of combining months and years, might also affect the degree of discounting differently depending on the domain.

References

Baumann, A. A., & Odum, A. L. (2012). Impulsivity, risk taking, and timing. *Behavioural Processes, 90,* 408-414. doi:http://dx.doi.org/10.1016/j.beproc.2012.04.005

Benzion, U., Rapport, A., & Yagil, J. (1989). Discount Rates Inferred from Decisions: An Experimental Study. *Management Science, 35*, 270-284. doi:http://dx.doi.org/10.1287/mnsc.35.3.270

Chapman, G. B. (1996). Temporal discounting and utility for health and money. *Journal of Experimental Psychology: Learning, Memory and Cognition, 22*(3), 771-791. doi:http://dx.doi.org/10.1037/0278-7393.22.3.771

Chapman, G. B. (2002). Your money or your health: time preferences and trading money for health. *Med Decis Making*, 22(5): 410-416. doi: 10.1177/027298902236929

Chapman, G. B., & Elstein, A. (1995). Valuing the future: temporal discounting of health and money. *Medical decision making, 5*(4), 373-386. doi:http://dx.doi.org/10.1177/0272989X9501500408

Chapman, G. B., Nelson, R., & Hier, D. B. (1999). Familiarity and time preferences: Decision making about treatments for migraine headaches and Crohn's disease. *Journal of Experimental Psychology: Applied, 5*(1), 17–34. https://doi.org/10.1037/1076-898X.5.1.17

Charlton, S. R., & Fantino, E. (2008). Commodity-specific rates of temporal discounting: does metabolic function underlie differences in rates of discounting? *Behavioural Processes, 77*(3), 334-342. doi:http://dx.doi.org/10.1016/j.beproc.2007.08.002

Cisneros, M. P., & Silva, L. H. (2017). Temporal Discounting and Health Behavior: A Review. *MOJ Public Health, 6*(6), 189. doi:10.15406/mojph.2017.06.00189

Critchfield, T. S., & Kollins, S. H. (2001). Temporal discounting: Basic research and the analysis of socially important behavior. *Journal of Applied Behavior Analysis, 34*, 101–122. https://doi.org/10.1901/jaba.2001.34-101

DeHart, W. B., & Odum, A. L. (2015). The effects of the framing of time on delay discounting. *Journal of Experimental Analysis of Behavior, 103*(1), 10-21. DOI: 10.1002/jeab.125

Estle, S. J., Green, L., Myerson, J., & Holt, D. D. (2006). Differential Effects of Amount on Temporal and Probability Discounting of Gains and Losses. *Memory & Cognition, 34*(4), 914-928. doi:http://dx.doi.org/10.3758/BF03193437

Ganiats T. G., Carson, R. T., Hamm, R. M., Cantor, S. B., Sumner, W., Spann, S. J., Hagen, M. D., & Miller, C. (2000). Population-based time preferences for future health outcomes. *Med Decis Making,* 20(3): 263-70. doi: 10.1177/0272989X0002000302

Grace, R. C., & McLean, A. P. (2005). Integrated versus segregated accounting and the magnitude effect in temporal discounting. *Psychonomic Bulletin & Review, 12*(4), 732-739. doi:http://dx.doi.org/10.3758/BF03196765

Green, L., & Myerson, J. (2004). A discounting framework for choice with delayed and probabilistic rewards. Psychological Bulletin, 130(5), 769-792. https://doi.org/10.1037/0033-2909.130.5.769

Green, L., Fristoe, N., & Myerson, J. (1994). Temporal discounting and preference reversals in choice between delayed outcomes. *Psychonomic Bulletin & Review, 1*(3), 383-389. doi:http://dx.doi.org/10.3758/BF03213979

Green, R. M., & Lawyer, S. R. (2014). Steeper delay and probability discounting of potentially real versus hypothetical cigarettes (but not money) among smokers. *Behavioural Processes, 108*, 50- 56

Green, L., Myerson, J., & Calvert, A. L. (2010). Pigeons' Discounting of Probabilistic and Delayed Reinforcers. *Journal of Experimental Analysis of Behavior, 94*(2), 113-123. doi:http://dx.doi.org/10.1901/jeab.2010.94-113

Green, L., Myerson, J., & Mcfadden, E. (1997). Rate of temporal discounting decreases with amount of reward. *Memory & Cognition, 25*, 715-723. doi:http://dx.doi.org/10.3758/BF03211314

Green, L., Myerson, J., Lichtman, D., Rosen, S., & Fry, A. (1996). Temporal discounting in choice between delayed rewards: The role of age and income. Psychology and Aging, 11(1), 79–84. https://doi.org/10.1037/0882-7974.11.1.79

Hardisty, D. J., & Weber, E. U. (2009). Discounting Future Green: Money Versus the Environment. *Journal of Experimental*

Psychology: General, 138(3), 329-340. doi:http://dx.doi.org/10.1037/a0016433

Holt, D. D., Glodowski, K., Smits-Seemann, R. R., & Tiry, A. M. (2016). The domain effect in delay discounting: The roles of fungibility and perishability. Behavioural Processes, 131, 47-52. http://dx.doi.org/10.1016/j.beproc.2016.08.006

Johnson, M., & Bickel, W. (2002). Withing-subjet comparison of real and hypothetical money rewards in delay discounting. *Journal of the experimental analysis of behavior, 77*(2), 29–146.

Johnson, M. W., Bickel, W. K., & Baker, F. (2007). Moderate drug use and delay discounting: A comparison of heavy, light, and never smokers. *Experimental and Clinical Psychopharmacology, 15*(2), 187-194. doi:http://dx.doi.org/10.1037/1064-1297.15.2.187

Jones, B., & Rachlin, H. (2006). Social Discounting. *Psychological Science, 17*(4), 283-286. doi:http://dx.doi.org/10.1111/j.1467-9280.2006.01699.x

Kirby, K. N. (2009). One-year temporal stability of delay-discount rates. *Psychonomic bulletin & review, 16*(3), 457-462. doi:http://dx.doi.org/10.3758/PBR.16.3.457

Kirby, K. N., & Herrnstein, R. J. (1995). Preference reversals due to myopic discounting of delayed reward. *Psychological Science, 6*, 83-89. doi:http://dx.doi.org/10.1111/j.1467-9280.1995.tb00311.x

Kirby, K. N., & Maracovic, N. N. (1996). Delay-discounting probabilistic rewards: Rates decrease as amounts increase. *Psychonomic Bulletin & Review, 3*, 100-104. doi:http://dx.doi.org/10.3758/BF03210748

Madden, G. J., Raiff, B. R., Lagorio, C. H., Begotka, A. M., Mueller, A. M., Hehli, D. J., & Wegener, A. A. (2004). Delay discounting of potentially real and hypothetical rewards: II. Between- and within subject comparisons. *Experimental and Clinical Psychopharmacology, 12*(4), 251-26

Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In J. E. Mazur, J. A. Nevin, & H. Rachlin (Eds.), The Effects of Delay and of Intervening Events on Reinforcement Value (Vol. 5, pp. 55–73). New Jersey: Erlbaum.

Mazur, J. (2006). Mathematical models and the experimental analysis of behavior. *Journal of the experimental analysis of behavior, 85*(2), 275-291. https://doi.org/10.1901/jeab.2006.65-05

McKerchar, T. L., Green, L., & Myerson, J. (2010). On the scaling interpretation of exponents in hyperboloid models of delay and probability discounting. *Behavioural Processes, 84*, 440-444. doi:http://dx.doi.org/10.1016/j.beproc.2010.01.003

McKerchar, T. L., Green, L., Myerson, J., Pickford, T. S., Hill, J. C., & Stout, S. C. (2009). A comparison of four models of delay discounting in humans. *Behavioural Processes, 81*, 256-259. doi:http://dx.doi.org/10.1016/j.beproc.2008.12.017

McKerchar, T. L., & Renda, C. R. (2012). Delay and probability discounting in humans: an overview. *The Psychological Record, 62*, 817–834. https://doi.org/10.1007/BF03395837

Muñoz Torrecillas, M. J., Cruz Rambaud, S., & Takahashi, T. (2021). Editorial: Discounting Models in Behavioral Health Economics and Quantitative Health Psychology. *Frontiers in Public Health, 11*, 1175519. https://doi.org/10.3389/fpubh.2021.658808

Myerson, J., & Green, L. (1995). Discounting of delayed rewards: Models of individual choice. *Journal of Experimental Analysis of Behavior, 64*(3), 263-276. doi:http://dx.doi.org/10.1901/jeab.1995.64-263

Myerson, J., Green, L., & Warusawitharana, M. (2001). Area under the curve as a measure of discounting. *Journal of the Experimental Analysis of Behavior, 76*(2), 235-243. doi:http://dx.doi.org/10.1901/jeab.2001.76-235

Odum, A. L. (2011a). Delay discounting: I'm a k, you're a k. *Journal fo the Experimental Analysis of Behavior, 96*(3), 427-439. doi:http://dx.doi.org/10.1901/jeab.2011.96-423

Odum, A. L. (2011b). Delay discounting: Trait variable? *Behavioural Processes, 87*(1), 1-9. doi:http://dx.doi.org/10.1016/j.beproc.2011.02.007