5-6-2021

Better together? Effects of dyadic collaboration on intertemporal preference

Emily Edgington

Better Together? Effects of Dyadic Collaboration on Intertemporal Preference

Emily Edgington

A thesis submitted to the Graduate Faculty of

JAMES MADISON UNIVERSY

In

Partial Fulfillment of the Requirements

for the degree of

Master of Arts

Department of Graduate Psychology

May 2021

FACULTY COMMITTEE:

Committee Chair: Dr. Daniel Holt

Committee Members: Dr. Trevor Stokes and Dr. Bryan Saville

Table of Contents

List of Figures

Abstract

Intertemporal choices have been researched extensively in the context of individual choices. However, empirical evidence is absent regarding intertemporal preferences when two individuals collaborate on a choice task. This study aimed to compare the rates of discounting under the condition of dyadic collaboration and individual decisions. Furthermore, this study examined the collaboration sessions in an online video conferencing platform. Results showed a strong, positive correlation between average individual discounting rates and corresponding dyad rates of discounting. The findings of this study should be considered when making intertemporal decisions.

Key Words: delay discounting, group decision-making, online collaboration

Introduction

Herrnstein (1970) claimed that all behavior is choice behavior. In his assertion, choice is nothing more than "an interrelating of one's observations of behavior and not…a special kind of behavior in its own right" (Herrnstein, 1970). Put simply, to respond is to choose. Under this assumption, organisms are constantly responding to outcomes that vary on a multitude of dimensions. One standard choice paradigm is the choice between a smaller reward received sooner and a larger reward delayed in its receipt. For example, a graduate student might choose between watching television (a smaller, sooner reward) and studying for an exam (a larger, later reward of receiving a favorable grade). The smaller, sooner reward is often referred to as the impulsive choice, while the larger later reward is the self-controlled choice (Odum, 2011). If both rewards (an A on an exam and watching television) were immediately available, it is reasonable to assume that the graduate student would choose the A on an exam. As the test date is delayed, the subjective value of studying is decreased. In general, organisms prefer to obtain rewards sooner rather than later. The longer an organism must wait for an outcome, the less valuable it is at the present moment (Green & Myerson, 2013). A decline in the subjective value of a reward with delay to its receipt is called delay discounting.

Delay Discounting

Delay discounting is a measure of impatience, one facet of impulsivity. Green and Myerson (2013) proposed a multidimensional conceptualization of impulsivity in which there are at least two so-called "impulsivities": impatience and risk-taking. Studies showing no correlation between discounting rates of delayed outcomes and probabilistic outcomes provide further evidence that there are at least two distinct facets of impulsivity (Green & Myerson, 2013; Holt et al., 2003). Steep rates of delay discounting are correlated with many maladaptive behaviors such as drug use, alcohol abuse, obesity, and cigarette smoking (McKillop et al., 2011). Madden et al. (1997) found that compared to non-drug users, opiate users discounted both monetary and heroin outcomes more steeply. Similar results have been found with cigarette smokers (Bickel et al. 1999; Johnston & Bickel, 2007) and alcohol abusers (Petry, 2001; Vuchinich & Simpson, 1998). Steep rates of delay discounting have also been shown to be highly correlated to obesity and overeating (Amlung et al., 2016; Weller et al., 2008). The correlations between delay discounting and these behaviors suggest that they are partially due to an inability to delay gratification. The social relevancy of these maladaptive behaviors makes delay discounting an essential topic for future research. Delay discounting has also been found to correlate with environmental factors such as age and socioeconomic status. Myerson et al. (1996) found that older individuals discounted more steeply than younger individuals, but adults of middle and high socioeconomic status discounted similarly compared to lower-income adults. This study suggests a relation between age and socioeconomic status in relation to delay discounting

Magnitude and Domain Effects

Several environmental manipulations have been found to influence discounting rates. One such manipulation is the magnitude of the outcome. For human subjects, smaller outcomes are discounted more steeply than larger magnitudes (Estle et al., 2006). For example, people are more likely to indicate a preference for $25,000 at a year's delay than they are for $100 at the same delay. This common finding is known as the magnitude effect. Magnitude effects are thought to be moderated by domain effects. Holt et al. (2016) conducted a study where the degree of fungibility and perishability of different outcomes was systematically manipulated. Fungible outcomes are exchangeable for a vast number of other items. For example, money is highly fungible, while a slice of pizza is non-fungible. Alternatively, food items are highly perishable, while money and gift cards are non-perishable. Holt et al. found that highly fungible and non-perishable rewards, such as money, were discounted less steeply than perishable and non-fungible outcomes, such as pizza slices. Items that were non-perishable and non-fungible (pizza gift card, jeans) were discounted somewhere in the middle. The findings in this study indicate that rates of discounting of one commodity may not generalize to other commodities. Jimura et al. (2009) also found results suggesting that the domain of the outcome affects discounting rates. Humans were asked to choose between different amounts of liquids that they would experience in the lab setting. Unlike choices between monetary rewards, the task with liquid rewards yielded much steeper discounting

rates, showing that humans are less patient when choosing between small amounts of directly consumable rewards.

Delay Discounting Tasks

When assessing delay discounting, the primary interest is to identify indifference points. In human research, an indifference point is an average amount at which the participant switches their preference. Indifference points are most commonly derived from a series of binary choices made between hypothetical outcomes. Participants are asked to choose between a smaller outcome that will be received sooner and a larger outcome received after some delay (Odum, 2011). An example question might resemble the following: "Would you prefer $10 now, or $200 in two weeks?" Amounts of the smaller outcome are then increased until the participant switches their choice to indicate a preference for the smaller, sooner outcome. This series of questions is then repeated for the same amount but at larger delay conditions. From this series of questions, multiple indifference points can be extrapolated and plotted for visual inspection.

This reliance on hypothetical outcomes is occasionally met with skepticism in the behavior-analytic community, as it differs drastically from the traditional animal studies and resembles a self-report measure. However, research shows that hypothetical tasks yield similar results as tasks with real outcomes. Lagorio and Madden (2005) considered two main differences between human and animal tasks: Humans do not typically experience real outcomes or delays, and human studies do not typically conduct repeated measures. Lagorio and Madden (2005) conducted a within-subjects study of

college students in which the participants were repeatedly exposed to each choice task involving both real and hypothetical outcomes. They did not find any consistent difference in the degree of discounting between real and hypothetical outcomes. Furthermore, they found no difference between a one-time assessment of delay discounting compared to repeated measures. Lagorio and Madden (2005) was one of many studies that provides validation to hypothetical outcome tasks to study delay discounting in humans (Johnson & Bickel, 2002; Madden et al., 2004, Madden et al., 2003). Odum (2011) details several reasons why there might be a lack of distinction between real and hypothetical rewards. For one, participants are not reporting on past behavior, but rather making a choice of preference. The choice is real even if the outcome might not be. Furthermore, questions in delay discounting tasks do not have an obviously "socially desirable" answer like other self-report measures (Odum, 2011). Because the outcome type (real or hypothetical) has not been shown to produce a systematic difference in discounting rates, there is no pressure to use real outcomes in discounting research, but studies that use real outcomes illustrate a novel means of measuring this phenomenon in a way that may be more applicable to real-world scenarios.

Data-Analytic Models

There are four main mathematical models used to analyze delay discounting rates from a theoretical perspective. Theoretical models fit indifference points to curves using non-linear regression. Each model utilizes the same parameters but has different interactions between the parameters. The common parameters are as follows: *V* is

the subjective value of the delayed reward; *A* is the objective amount of the delayed reward; *D* is the delay; and *k* is a free parameter that reflects the discounting rate, or the effect that delay has on the subjective value of the outcome (McKerchar et al., 2009; Odum, 2011).

One commonly used model is the exponential discounting model (Samuelson, 1937). This model assumes that organisms discount outcomes in a rational and time-consistent manner and is commonly used by economists. The equation for exponential discounting is $V = Ae^{kD}$. This equation represents a compounding decline in value as delay increases and has an underlying assumption that humans discount delayed rewards in a rational manner. Because of this flawed assumption, this model overestimates discounting rates in the short-term and underestimates them in the long-term (McKerchar et al., 2009).

A second commonly used model is the hyperbolic discounting model (Mazur, 1987). This model uses the equation $V = \frac{A}{1+kD}$. This equation provides a curve that more closely resembles the actual data than the exponential model does. The hyperbolic discounting model predicts that preferences are time-inconsistent and accounts for preference reversals. This model does not rely on the assumption that agents discount delayed outcomes rationally, but rather that the choice between two outcomes at different times is a choice between rates of rewards, and therefore provides a better fit for observed data.

A third model is the hyperbola-like formula proposed by Green, Fry, and Myerson (1994). This model is described by the equation. $V = A/(1+kD)^s$ where *s* is a second parameter that represents a non-linear scaling of amount or time. Typically, *s* is less than 1.0. Because this model includes two parameters, it provides a discounting curve that is more closely aligned to the actual data than both the exponential and the one-parameter hyperbolic equations. Furthermore, studies have also shown that the two-parameter model accounts for a greater proportion of variance than the previous equations, and overall describes discounting rates of both individuals and groups better than the exponential and one-parameter hyperbolic models (Green & Myerson, 2004; McKerchar et al., 2009).

A second way of analyzing delay-discounting data is by using area under the curve (AUC). Myerson et al. (2001) proposed an alternative measure of discounting that is "theoretically neutral" compared to the previously discussed models. It alleviates some of the problems that are inherent to theoretical models, like varying assumptions underlying each of these models. The area under the curve is calculated by drawing a connecting line between each data point and the *x*-axis, calculating the area of each of these resulting trapezoids, and then calculating the summation. AUC is calculated on a scale from 0.0 to 1.0. With 0.0 being the steepest level of discounting and 1.0 being the least steep. The advantage to using the AUC measure is that it is derived from the actual indifference points rather than a theoretical model reliant on a priori assumptions. A second advantage is that it can be used for measures of both probability and

delay discounting. While this measurement is advantageous because of its theoretical neutrality, it does not provide any information about the shape of the curve, which is paramount when interpreting discounting research. Myerson et al. (2001) did not suggest that this measure replace the theoretical models, but merely provide supplemental information that should complement the theoretical findings.

Group Decision Making

To date, delay discounting research in behavior analysis has focused almost exclusively on individual choice behavior (Bixter & Luhmann, 2020). However, many intertemporal decisions are made in collaboration with two or more agents. Legislative bodies, households, business partners, and students paired up for a class project are a few examples of decision-making units. A married couple might have to decide between taking a vacation or saving for retirement. Business partners might decide between spending money now or investing it. Two students might decide between attending a party or working on their class project. These hypothetical decisions include an intertemporal element where one choice could be considered "inpatient" and the other is the "patient" choice. While there is not an objective right or wrong choice in these scenarios, one values the present more than the future and vice versa.

The fields of both economics and social psychology have produced much research on the topic of group decision making. Blinder and Morgan (2000) found that small groups of strangers make economically “superior” decisions when compared to individual decisions. Bateman and Munro (2005) found similar results when

comparing decisions made by two married individuals when collaborating versus making independent decisions. They found that when married couples collaborated on economic decisions, the outcomes were better financially than their decisions made independently.

Bixter et al.'s (2017) study was one of the first to examine delay discounting in a small group context. The aim of the study was to examine the intertemporal preferences of small groups through two experiments. Both experiments split participants into groups of 3-4 participants and consisted of three phases. The first phase was the pre-collaboration phase, in which participants completed a matching task to determine intertemporal preference. Prior to this phase, they were not informed that there would be any aspect of collaboration in the study. In the next phase, the collaboration phase, participants were broken into pairs and made to complete the same type of task with two or three other participants. In the post-collaboration phase, participants completed the independent discounting task a second time. There were no rules on how they were to make decisions or any time limits. The findings of this experiment were twofold. First, they found an averaging effect between the pre-collaboration and collaboration phase, meaning that group preferences were equal to the average of the group members' individual preferences. The first experiment also showed a convergence effect. In the post-collaboration phase, participants' results were more similar to the groups preferences and had changed from their original pre-collaboration preferences. This suggests that not only does collaboration influence the decision at hand, but also decisions made post-collaboration at least for a short period of time.

These provocative findings only lead to further inquisition into the processes that affect intertemporal preference in a small group context. Schwenke et al. (2017) sought to answer a similar research question and found that not only were decisions made in dyads more patient (i.e., shallower rates of delay discounting), but also that the intertemporal preferences of the agents could predict preferences in the dyad as individuals and that the less "patient" agent was more likely to change their preference in a dyadic decision than the more "patient" agent.

Much about intertemporal group decisions is left unknown by excluding group decision-making from the previous discounting literature. Exploring this line of research has important implications for topics of social significance. Because many decisions of societal importance are made in collaboration with others, understanding the facets of decision-making in groups could potentially improve intertemporal decisions made by two or more agents. This study aims to examine the effects of collaboration of intertemporal preferences in a dyadic context and, more specifically, to answer the question of whether decisions made in collaboration with another are more or less patient than intertemporal decisions made individually. This study will further the research on this topic by examining collaboration in an online context.

Methods

Participants and Setting

84 undergraduate students were recruited from James Madison University, a mid-sized university in rural Virginia. Participants were 64 women and 20 men. Participants consisted of 62 Caucasians, 9 African Americans, 5 Asians, 3 Middle Easterners, and 1 Native American. All were between the ages of 18 and 27. Participants were recruited through Sona Systems, a participant pool used by James Madison University, and through undergraduate psychology classes. Completion of this study was worth one research credit towards a psychology class requirement. Written informed consent was provided before the study began, and participants consented to being video and audio recorded. This study took place fully online through Zoom's web conferencing platform. All procedures were approved by James Madison University's Institutional Review Board.

Materials

Participants completed two surveys throughout this study. Both surveys were administered via Qualtrics and involved choosing between two amounts of hypothetical money at varying delays. A titrating adjusting amounts procedure was utilized to assess both individual and collaborative intertemporal preference (Johnston & Bickel, 2002; Rachlin et al., 1991). An adjusting amounts procedure was chosen because, compared to similar methods, it produces the most systematic discounting data (Siri, Rung, & Madden, 2015). This procedure asks participants to select one of two

hypothetical monetary outcomes. For example: "Would you rather receive $500 now or $1,000 in two weeks?" Answers on earlier questions influence the presentation of subsequent questions. Take the previous question for example. If the participant chooses $1,000 then the next question, they will be shown is $750 now or $1,000 in 2 weeks. They are shown $750 because that is halfway between $500 and $1,000. If they still choose $1,000, then the same procedure will occur. The next amount they would be shown is $875. This process will continue until they make a switch to the smaller sooner choice. Say this time they choose $875; they will be shown $810 vs. $1,000 because $810 is halfway between $875 and $750. The indifference point is calculated by finding the midpoint between the last smaller amount shown and the smaller amount from the last time they switched. The same adjusting amounts survey will be used for the collaboration sessions.

Procedures

Participants selected a 45-min time slot when they signed up via Sona Systems and were sent a link to join a Zoom meeting at their chosen date and time. Each participant was also sent a link to a Qualtrics survey. At the time of their session, participants joined the Zoom meeting where the principal investigator and another participant were also logged on. Once both participants had logged on, the link to the first Qualtrics survey was provided. In this survey, the participants made choices independently. The principal investigator asked the participants to open their Qualtrics link and go to the first page, which contained a consent form. The principal

investigator described the form to them and asked if they had any questions about it before they provided consent. Next, the principal investigator instructed the participants to move to the next page of the survey, which displayed instructions for the adjusting amounts task and a practice question. Once the participants demonstrated an understanding of the instructions, they were instructed to complete the independent survey, which consisted of the monetary choice task and a short demographic survey.

When participants finished their individual task, they were instructed to private message the primary investigator via Zoom. Once both participants were finished, the principal investigator then explained that there would be a collaboration portion of the study. The collaboration task was an adjusting amounts task similar to that of the individual condition, with the same values. One of the participants was instructed to pull up the second Qualtrics survey and share their screen. This participant was responsible for making the selection on the survey that the pair agreed upon. Participants were told to collaborate on their choices and that it might be helpful to discuss their specific reasonings for choosing one amount over another. They were not, however, given any further instructions on how they were to collaborate.

Data Analysis

Participants' responses on each task were converted into indifference points by finding the midpoint between the last choice they were shown and the point where they had previously switched. An area under the curve (AUC) measure was calculated for each individual participant, and each corresponding dyad. AUC results were used

to graph individual results and dyad results using GraphPad Prism. A Pearson's correlation between mean AUC for each individual and the AUC of each dyad was also plotted.

Results

Figure 1 shows the median subjective value of $1,000 across six delays ranging from 1 week to 1 year. Delays in this graph are represented in months. Median calculation of subjective values was used instead of an average because this measure of central tendency is less influenced by outlying data sets. This figure shows that both individuals and dyads discounted $1,000, meaning that the subjective value decreased as delay to the outcome increased.

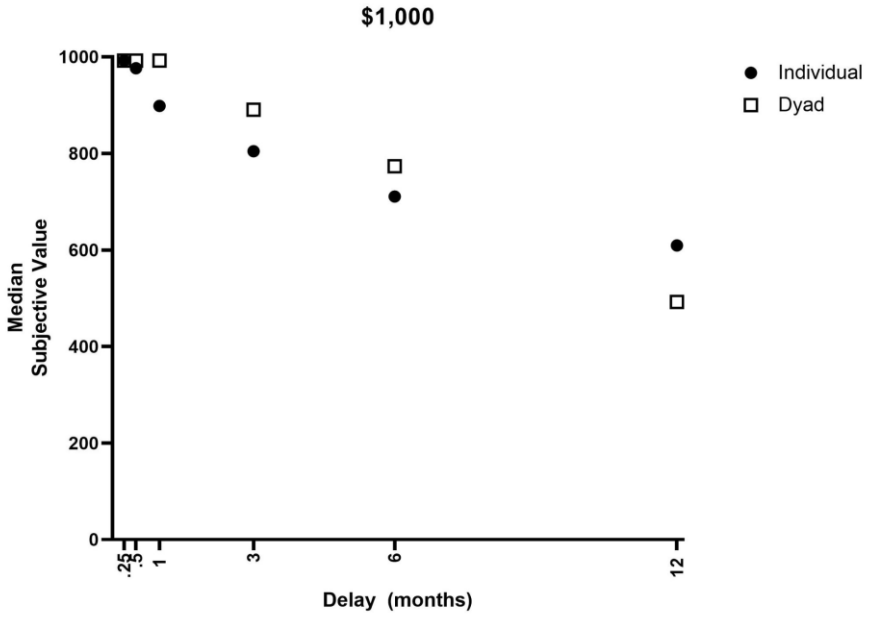


Figure 1: Median subjective value of both individuals and dyads for each delay condition.

The primary measure used to analyze discounting was AUC. AUC was calculated for all individuals and for every dyad by calculating the trapezoid below every subjective value and calculating the sum. AUC results are displayed on a scale of 0.0 to 1.0, where 0.0 represents the steepest discounting and 1.0 represents the least steep. Figures 2-4 show graphs that represent common patterns found in the data. These figures demonstrate that the dyadic discounting rates can be predicted by the individuals discounting. Two shallow discounters produced a shallow dyadic discounting rate, and two steep discounters produced a steep dyadic discounting rate. Similarly, when one shallow and one steep discounter were paired together, the dyadic discounting rate was roughly an average of their individual rates.

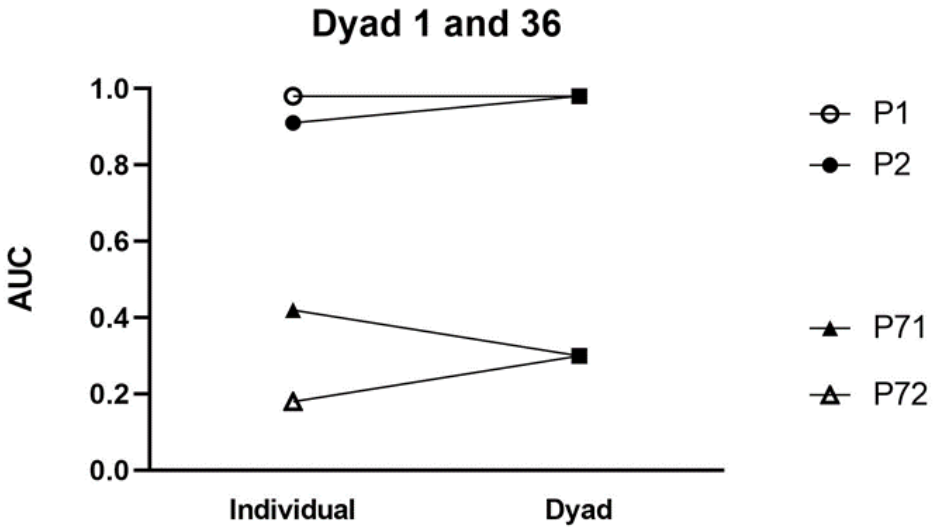


Figure 2: shows the AUC for individuals of two different dyads and how these contributed to their dyadic AUCs. P1 and P2 made up dyad one and P71 and P72 made up Dyad 36.

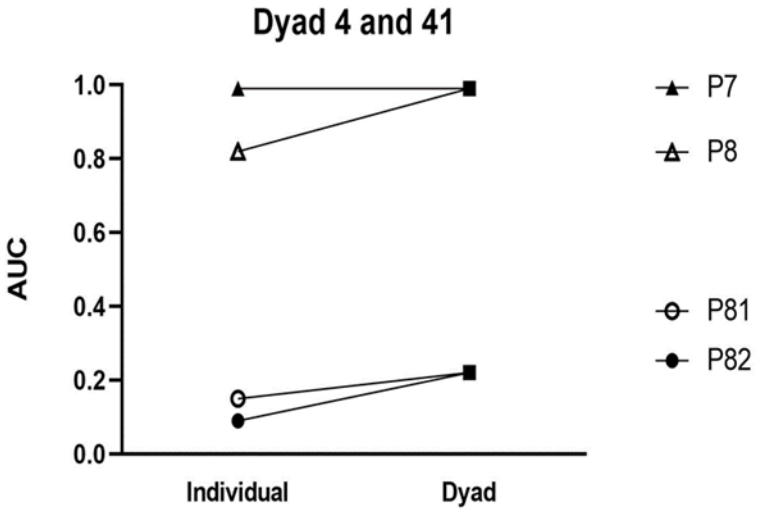


Figure 3: shows the AUC for individuals of two different dyads and how these contributed to their dyadic AUCs. P7 and P8 made up dyad four and P81 and P82 made up Dyad 41.

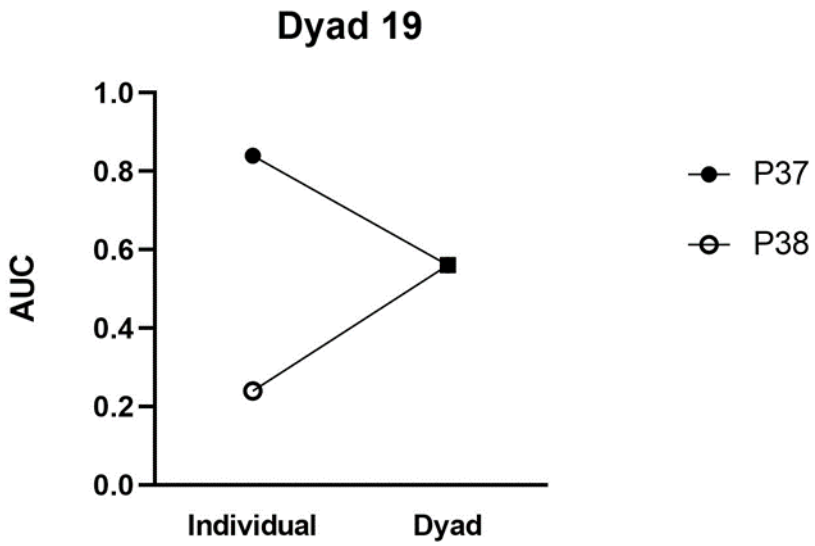


Figure 4: Shows the AUC for two individuals (P37 and P38) and how these contributed to their Dyadic AUC's.

To further assess the averaging effect that was demonstrated in the above figures, a correlation analysis was conducted. The results of this analysis are shown below in Figure 4. This figure shows a Pearson's correlation of the mean AUC of individuals and their corresponding dyad. There was a strong positive correlation between the two, which provides further support of the averaging effect. The correlation between the two variables is .68 and $p < .00$. Based on this correlation, knowing the averaged AUC for

two individuals allows one to predict the Dyadic AUC. Two individuals who have a low AUC will produce a low dyad AUC and two individuals with high AUC's will produce a high dyad AUC.

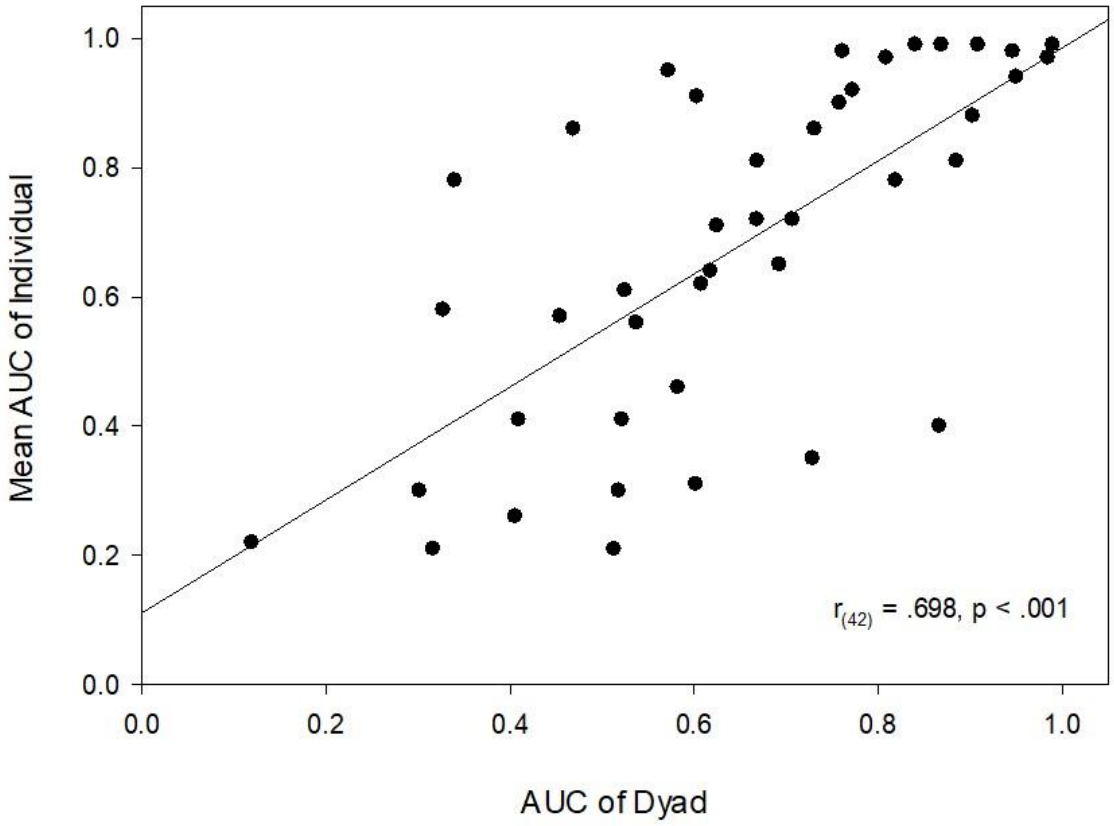


Figure 5: Correlation of average AUC of two individuals and their corresponding dyadic AUC.

Discussion

The results of this study suggest that when participants completed discounting tasks in collaboration with another individual, the rate of discounting was roughly an average of their two individual discounting rates. Many decisions in everyday life are made in collaboration with at least one other individual. As many decisions are made in this manner, it is important to understand how collaboration affects the outcome of decisions. The literature in this area is minimal and inconsistent. This study extends the current literature in several ways. First, this study adds to the few studies that have examined collaboration using a delay discounting paradigm and replicates the findings of Bixter et al. (2017) in that the collaborative discounting rates were an average of the individual rates. Second, this is the only study that the author is aware of that has examined collaboration on discounting tasks using an online video conferencing platform. The recent increase in the use of online platforms due to COVID-19 has made this a particularly relevant area of study especially considering the target population of undergraduate students are particularly likely to use online video conferencing platforms (Aguilera-Hermida, 2020).

This study shows that individuals' responses on independent discounting tasks affect their responses on a collaborative task in a systematic and predictive manner, showing that participants were influenced to make different responses when discussing these choices with another individual. An averaging effect was found that demonstrates how the AUC of the dyadic indifference points was strongly correlated with the average

AUC of the individuals scores on the independent task. When two steep or "impatient" discounters were paired together, their dyadic discounting rate was similarly steep. The same results held true when two shallow or "patient" individuals were paired together. When one shallow and one steep discounter were paired together, the dyadic AUC was almost an exact average between the two independent rates. This can be seen in figure 4.

The main finding of an averaging effect between individual and dyadic discounting rates is consistent with the findings of Bixter et al. (2017). This is shown by the strong correlation between the mean AUC of two individuals and the AUC of their dyadic choices (figure 1). These results differ from Schwenke et al. (2017) where they found that dyads consistently made more patient choices than individuals. One key difference between this study and Schwenke et al. (2017) is that their participants collaborated via joystick maneuvers and never verbally or physically interacted with each other while making decisions, while the current study had participants verbally interact over video conference.

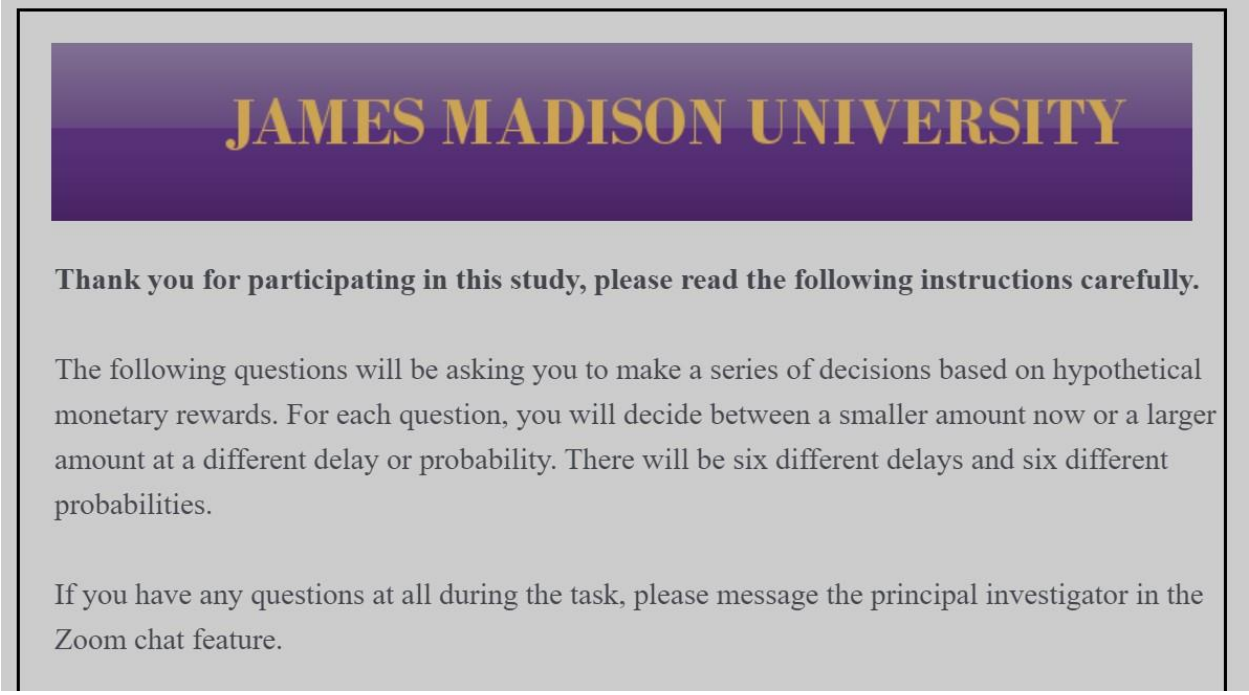
The findings from this study have implications in numerous areas. These results should inform the way individuals make choices when outcomes are delayed. Many decisions are made in dyads under the assumption that group decisions lead to “better” outcomes. However, these results suggest that for patient individuals, being paired with an impatient individual can negatively affect their decisions. This should be taken into consideration when choosing whether to make decisions with another person. However, additional research will have to be done to further support these implications

Finally, some limitations should be noted. First, this study did not control for order effects by having half of the individuals complete the independent tasks after the collaboration task. It is possible that there was an order effect, and results might have differed had participants contacted the conditions in a different order. Second, this study was conducted during the COVID-19 pandemic, and it is possible that the circumstances surrounding this global event might have affected how individuals are currently valuing money. Third, all participants in this study were undergraduate university students, and the results should not be generalized outside of this population. Future research could expand the delays and amounts that are presented in the discounting tasks. Because this study only examined one amount and six delays, we are not able to generalize to delays beyond 1 year or amounts greater than $1,000. Future studies could also attempt to replicate these results of individuals who know each other in some capacity. While it does happen, that individuals make decisions with strangers, it is more common to make decisions with someone you are familiar with. Another area for future research is to extend this study to probability discounting. It would be important to examine how dyads make decisions between varying probabilities as many decisions in life include an element of probability. For example, purchasing stocks or betting on sports includes an element of risk. Probability discounting represents risk seeking behavior while delay discounting measures impatience and the two facets of impulsivity are not always correlated (Green & Myerson, 2013).

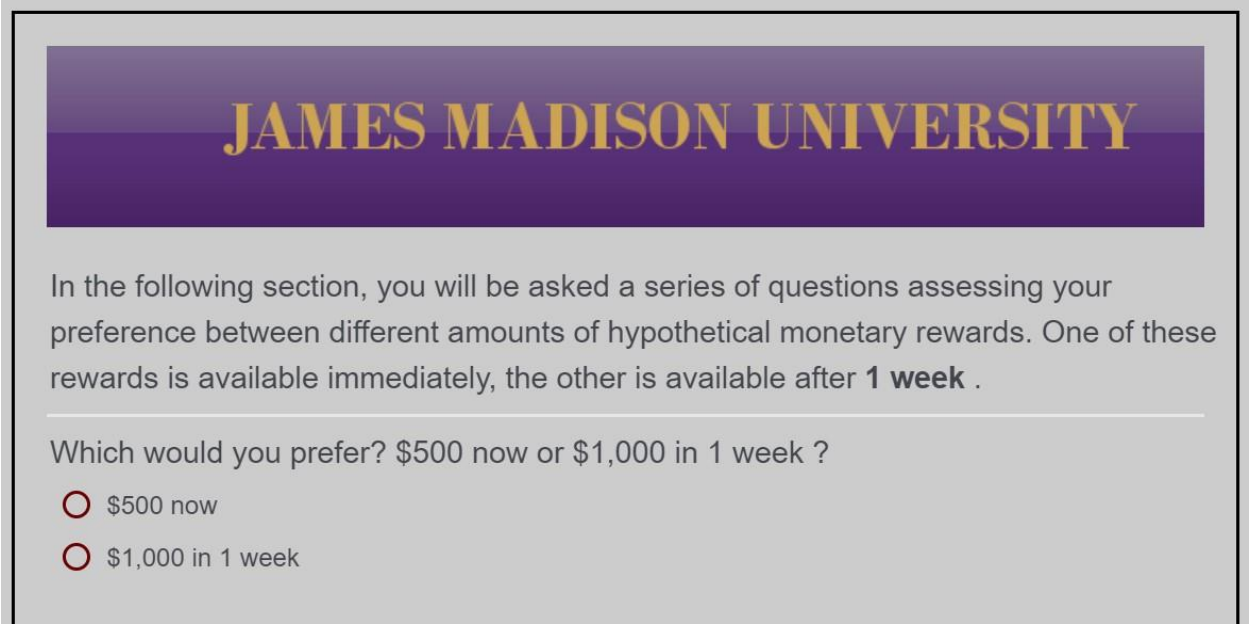
While many decisions are made involving two or more individuals, the behavioral literature has neglected to study this topic in depth. The results of this study replicate previous findings and support the hypothesis of an averaging affect between individual discounting rates and dyadic discounting rates. This study also lays the ground for continued research on the topic and practical applications for improving decision making.

Appendices

Appendix A: Instructions



Appendix B: Example Question



Appendix C: Script

Independent Task Instructions

- Thank you all for signing up to participate in this study. My name is Emily, and I am the primary investigator on this research project. This study consists of two surveys that will be administered to participants via Zoom. You will be asked to make choices between hypothetical amounts of money and will be asked to collaborate with another participant on some of these choices. The collaboration sessions will be video, and audio recorded for data collection purposes. Should the results of this study be presented or published, no identifying information will be revealed. Your participation in this study is entirely voluntary. Should you consent to participate, you are free to withdraw at any time. On the first page of the survey, there will be an informed consent question. If you have any questions, please feel free to message me on the chat feature.
- Now I will assign each of you a # and change your screen name to this. There will be a question on the survey that will ask for this.
- I will now put a link to a survey in the chat box. Please click on this link and complete the survey, should you choose to consent. This is the independent survey, please indicate this on question number 2. If you would like to turn your cameras off during this portion, please feel free to do so. When you are finished, please message me that you have finished. If you have questions at any point, do not hesitate to direct them to me in the chat.

INSERT SURVEY LINK

Collaboration Instructions

- Thank you for completing the first portion of this study. For the next portion, you and the other participant will collaborate on a survey similar to the first one. While making decisions, it might be helpful to discuss your reasonings for choosing one answer over another. One participant will be assigned to pull up the survey, share their screen, and record the responses. For this survey do not worry about filling out the demographic information questions.
- When asked for your numbers, please type both of your numbers separated by a comma. And please select collaboration on question # 2. If you have any questions, please send me a chat.

(ASSIGN RECORDER)

(START RECORDING)

References

Aguilera-Hermida, A. P. (2020). College students' use and acceptance of emergency online learning due to Covid-19. *International Journal of Educational Research Open, 1*, 100011.

Bateman, I., & Munro, A. (2005). An experiment on risky choice amongst households. *The Economic Journal*, *115*(502), C176-C189.

Bixter, M. T., & Luhmann, C. C. (2020). Delay discounting in dyads and small groups: Group leadership, status information, and actor-partner interdependence. *Journal of Experimental Social Psychology*, *86*, 103902.

Bixter, M. T., & Rogers, W. A. (2019). Age-related differences in delay discounting: Immediate reward, reward magnitude, and social influence. *Journal of Behavioral Decision Making*, *32*(4), 471-484.

Bixter, M. T., Trimber, E. M., & Luhmann, C. C. (2017). Are intertemporal preferences contagious? Evidence from collaborative decision making. *Memory & cognition*, *45*(5), 837-851.

Blinder, A. S., & Morgan, J. (2000). *Are two heads better than one?: An experimental analysis of group vs. individual decision-making* (No. w7909). National Bureau of Economic Research

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.

Green, L., & Myerson, J. (2004). A discounting framework for choice with delayed and probabilistic rewards. *Psychological bulletin*, *130*(5), 769.

Green, L., & Myerson, J. (2013). How many impulsivities? A discounting perspective. *Journal of the experimental analysis of behavior*, *99*(1), 3-13.

Green, L., Myerson, J., & Ostaszewski, P. (1999). Discounting of delayed rewards across the life span: age differences in individual discounting functions. *Behavioural Processes*, *46*(1), 89-96.

Herrnstein, R. J. (1970). On the law of effect 1. *Journal of the experimental analysis of behavior*, *13*(2), 243-266.

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.

Holt, D. D., Green, L., & Myerson, J. (2003). Is discounting impulsive?: Evidence from temporal and probability discounting in gambling and non-gambling college students. *Behavioural processes*, *64*(3), 355-367.

Johnson, M. W., & Bickel, W. K. (2002). Within-subject comparison of real and hypothetical money rewards in delay discounting. *Journal of the experimental analysis of behavior*, *77*(2), 129-146.

Lagorio, C. H., & Madden, G. J. (2005). Delay discounting of real and hypothetical rewards III: Steady-state assessments, forced-choice trials, and all real rewards. *Behavioural processes*, *69*(2), 173-187.

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.

Madden GJ, Petry NM, Badger GJ, Bickel WK (1997). Impulsive and self-control choices in opioid-dependent patients and non-drug-using control participants: drug and monetary rewards. *Experimental and Clinical Psychopharmacology.*

Madden, G. J., Begotka, A. M., Raiff, B. R., & Kastern, L. L. (2003). Delay discounting of real and hypothetical rewards. *Experimental and clinical psychopharmacology*, *11*(2), 139.

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.

Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. *Commons, ML.; Mazur, JE.; Nevin, JA*, 55-73.

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*(2), 256-259.

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.

Odum, A. L. (2011). Delay discounting: I'm a k, you're a k. *Journal of the experimental analysis of behavior*, *96*(3), 427-439.

Rachlin, H., Raneri, A., & Cross, D. (1991). Subjective probability and delay. *Journal of the Experimental Analysis of Behavior*, 55, 233-244

Samuelson, P. A. (1937). A note on measurement of utility. *The review of economic studies*, *4*(2), 155-161.

Schwenke, D., Dshemuchadse, M., Vesper, C., Bleichner, M. G., & Scherbaum, S. (2017). Let’s decide together: Differences between individual and joint delay discounting. *PloS one*, *12*(4), e0176003.