University of Nevada, Reno

Social Distance: Isolating Relevant Variables Using a Prisoner's Dilemma Game

A dissertation submitted in partial fulfillment of the requirements for the degree of
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by
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Abstract

Social discounting describes the devaluation of an outcome as the recipient increases in social distance. The social discounting paradigm allows for a behavioral analysis of altruism and cooperation; however, the social distance variable has remained unexamined. Two studies were conducted to examine how social distance and cooperation change as a function of probability of reciprocation (Experiment 1) and delay to reciprocate (Experiment 2). In Experiment 1, three probabilities were assessed (25% for a strategy favoring defection, 75% for a strategy favoring neither defection nor cooperation, and 100% for a strategy favoring cooperation). Results across forty-eight participants indicated that while 100% probability of reciprocation resulted in the highest cooperation and closest social distance, social distance did not change precisely with probability of reciprocation. In Experiment 2, probability of reciprocation was held constant (100%) and delay to reciprocate was manipulated (3 s, 8 s, and 13 s). Results across forty participants showed that order of delays affected cooperation. Across all groups, the 3 s CP was ranked closest in social distance. Overall results suggest that delay to reciprocate influences social distance rankings. Both studies contribute to the social discounting literature by providing an empirical investigation of social distance and its influences.

Keywords: Social distance, social discounting, prisoner's dilemma game, altruism, cooperation

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Altruism and cooperation "refer to acts of one person by which another person benefits" (Rachlin & Jones, 2010, p. 416). Rachlin and Jones delineate the two by referring to altruistic acts as those that "benefit only the receiver" whereas cooperative acts "benefit the actor himself as well as the receiver of the benefit" (p. 416). In both altruistic and cooperative choice, outcomes to others have reinforcing value which influence the decision to choose altruistically/cooperatively or selfishly.

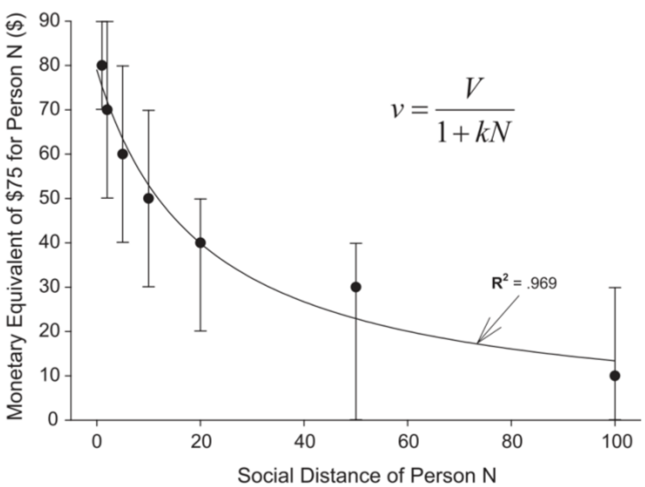
Social discounting has been used to assess reinforcer value that changes as a function of social distance (Jones & Rachlin, 2006; Strombach et al., 2014). This decreasing reinforcer value has been quantitatively defined by Equation 1, a hyperbolic formula, wherein *V* is the value of the outcome, *M* is the magnitude of the outcome, *N* is social distance, and *k* is the discount rate.

$$V = \frac{\mathrm{M}}{(1+k\mathrm{N})} \quad (1)$$

In a social discounting preparation, a participant is typically prompted to choose between a monetary outcome for themself or a monetary outcome for some socially distant person (Figure 1). Those choices yield a number that reflects the value (*V*) of some magnitude of a reinforcer (*M*) to a socially distant person (*N*). Multiple values (*V*) are found across different socially distant persons (*N*) and then fit to Equation 1 to find the discount rate (*k*). This social discount rate reflects how altruistic or cooperative choice changes as a function of social distance (Figure 2).

Figure 1
Example of a social discounting preparation (from Buddiga & Locey, 2022a).

Figure 2
Social discounting curve (from Rachlin & Jones, 2008a)



Many studies have been conducted on social discounting; including how social discounting correlates with other discounting tasks (e.g., probability and delay discounting; Rachlin & Jones, 2008a; Jones & Rachlin, 2009), theories of altruism using social discounting (Rachlin & Jones, 2008b; Osiński, 2009; Buddiga & Locey, 2022a), and how social discounting correlates with maladaptive behaviors (e.g., substance use; Yi et al., 2012). Sending actual money to socially distant persons based on participant choices is costly, so most social discounting studies use hypothetical outcomes to assess value (but see Locey et al., 2011). All studies use a hypothetical prompt to determine the social distance of other persons. For example, Locey and Rachlin (2015) presented participants with the following prompt:

> The following experiment asks you to imagine that you have made a list of the 100 people closest to you in the world ranging from your dearest friend or relative at position #1 to a mere acquaintance at #100. The person at number one would be someone you know well and is your closest friend or relative. The person at #100 might be someone you recognize and encounter but perhaps you may not even know their name. (p. 73)

Here social distance is referred to as the “psychological closeness” between two people. Jones (2022) described social distance as a “psychophysical measure of how close or distant an individual feels towards someone else” (p. 511). This prompt and the notion of “close” and “distant” for the social distance list produces orderly values for the discounting preparation, but the titrating variable of *social distance* warrants closer examination.

Social Distance as a Dependent Variable

Social discounting stems from research on delay discounting. Delay discounting refers to the devaluation of an outcome as the time to its receipt increases (Odum, 2011). In a delay discounting procedure, instead of social distance as the titrating variable, the titrating variable is time. Originally, studies in delay discounting were conducted with animal subjects, where subjects experienced differently delayed reinforcers (typically food pellets) in a highly controlled operant chamber (Mazur, 1987). This research was extended to human subjects wherein participants experienced delays to reinforcers (Rodriguez & Logue, 1988).

Rachlin and colleagues (1991) developed the hypothetical delay discounting questionnaire. In a hypothetical delay discounting questionnaire, participants are presented with two monetary choices, a smaller amount of money available sooner and a larger amount of money available later. Although participants do not experience the stated outcomes, research has shown behavioral similarities in hypothetical and real delay discounting research (Madden et al., 2004; Lagorio & Madden, 2005). The strength of this correspondence could be attributed to an individual's experience with time. If the hypothetical outcome is delivered in "two weeks" this is easily imagined because a participant has experienced a two-week timeframe before. Moreover, although time is experienced differently across participants (e.g., waiting one day for $100 might be more aversive for one person than another), it is a constant variable which does not change and the intervals between time points are equidistant (i.e., idemnotic; Johnston & Pennypacker, 1980)—the difference in time between 1 and 2 months is exactly the same as the difference in time between 59 and 60 months. Social distance, although titrating in a discounting preparation, does not share this constancy or equal interval property (i.e., vaganotic; Johnston & Pennypacker, 1980).

When has a person encountered the term "social distance"? In fact, the most familiar association is now to social distancing procedures implemented during the COVID-19 pandemic. But the notion of ranking people you know in terms of "social distance" is not a common practice (unless you remember your "Top 8" from MySpace™) making it an unfamiliar term compared to time.

Due to the extension of delay discounting into social discounting, the ordinal ranking of social distance (via the hypothetical prompt) has been used with the assumption that social distance has equal intervals. But that may not be the case. When Rachlin and Jones (2010) asked college students to imagine that the people on their social distance list were on a football field and the physical distance to each corresponded to "how close you feel to that person", it was determined that closer social distances (e.g., 1, 2) were typically closer together in physical distance than farther social distances (e.g., 99, 100). Thus, social distances were not equidistant as implied by the commonly used ordinal ranking. Moreover, social distances can change. If my sister is Person 2, but then starts behaving in an aversive way, she might become Person 15. Alternatively, she may stay at position #2, but the "psychological distance" between Persons 1 and 2 might increase.

So far, most researchers have treated social distance as an independent variable. But to understand social choice better, social distance must be treated as a dependent variable. This study aims to evaluate social distance as a dependent variable, but to do so, a simulated interaction between a participant and another person is needed.

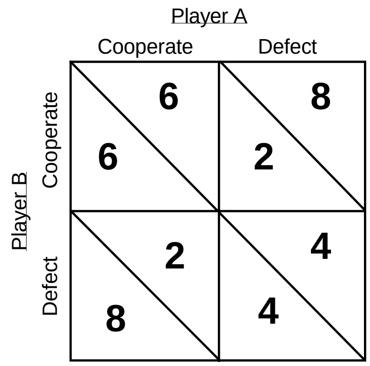
The Prisoner's Dilemma Game

Cooperation and altruism have been explored among various disciplines using a variety of tasks. Marwell and Schmitt (1975) conducted a series of cooperation experiments using a novel operandum through which participants chose to engage in a task cooperatively (working with the other player in the dyad) or alone. Dictator and ultimatum games are used to assess altruistic choice from one person to another (Cochard et al., 2021). These games have been used to determine how several variables, such as reciprocity and social distance, impact altruism (Johannesson & Persson, 2000; Rachlin & Jones, 2010).

A task used widely among disciplines interested in altruism and cooperation is the prisoner's dilemma game. The prisoner's dilemma game (PDG) is a task that presents a choice between acting for oneself (defection) and acting for a shared benefit with another (cooperation). Historically used to study game theory among economists and mathematicians, the PDG gained traction with psychologists interested in cooperation and self-control (Kendall et al., 2007). For behavior analysts, the experimenter-controlled consequences make this task amenable to various experiments. The PDG can be conducted in one trial or across many trials (i.e., iterated), with any number of players, and with a variety of outcomes (e.g., Brown & Rachlin, 1999; Lopez et al., 2022; Silverstein et al., 1998; Yi & Rachlin, 2004). A one-player game has been used to study self-control, while a two-player game has been used to study cooperation. The outcomes—commonly points or money—are determined by some matrix that weighs combinations of choices differently. For example, in a 2-4-6-8 matrix (Figure 3), if both players cooperate, they each receive 6 points. If both players defect, they each receive 4 points. If one player defects but the other cooperates, the defecting player earns 8 points whereas the cooperating player earns 2 points. Thus, if both players cooperate, they each receive an equal number of points (6 each) but forgo the chance of receiving the maximum number of points (8) on that trial.

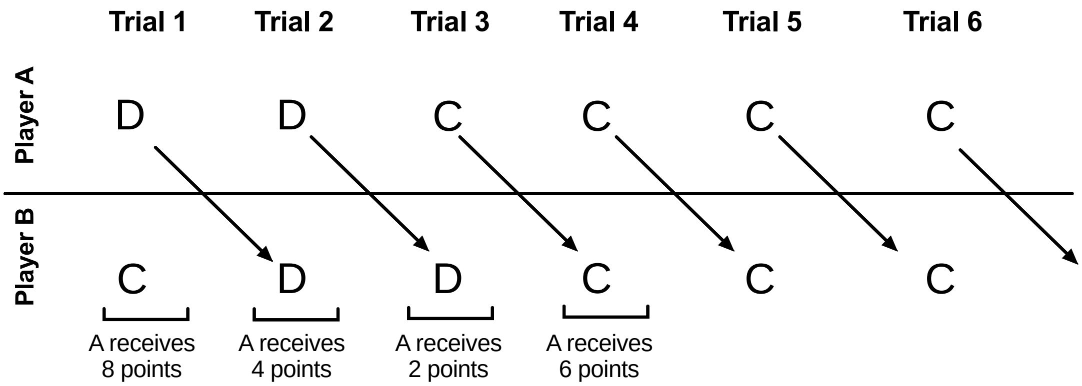
Figure 3

2-4-6-8 Prisoner's Dilemma Game matrix



In the one-player, self-control variation of the PDG, a participant plays with themself (i.e., no other player). So instead of Player A's choices affecting Player B, Player A's choices affect the next trial outcomes for Player A (Brown & Rachlin, 1999). The player must (typically) choose between maximizing reinforcement on the current trial or across several trials. A tit-for-tat game between two players reflects this self-control variation because Player B's choice copies Player A's choice from the previous trial (Rapoport & Chammah, 1965; Axelrod, 1984; Silverstein et al., 1998). Therefore, in a tit-for-tat game, Player A should select the response (cooperate or defect) that maximizes reinforcement overall (i.e., exclusive cooperation; Axelrod, 1984). Figure 4 depicts a tit-for-tat contingency between two players across six trials using the point matrix from Figure 3. For each successive trial, Player B copies Player A's choice on the previous trial (100% reciprocation) and points are maximized by cooperating on each trial (up until the last trial – which is typically not signaled as such).

Figure 4
Diagram depicting tit-for-tat choices between two players (whereby Player B copies Player A's last choice). In the standard tit-for-tat procedure, Player B always cooperates on the first trial.



Depending upon the particular outcome matrix used, different probabilities of reciprocation will favor defection, cooperation, or neither. For example, with the 2-4-6-8 PDG matrix and 75% probability of reciprocation, 4 cooperative choices would result in 20 points (3 Cooperate-Cooperate choices worth 6 points each and 1 Cooperate-Defect worth only 2 points) and 4 defection choices would also result in 20 points (3 Defect-Defect choices worth 4 points each and 1 Defect-Cooperate worth 8 points). With that particular matrix, any probability of reciprocation above 75% would favor cooperation (e.g., with 100% reciprocation, cooperate choices would be worth 24 points per 4 trials and defect choices worth 16 points per 4 trials) and any probability of reciprocation below 75% would favor defection (e.g., with 25% reciprocation, cooperate choices would be worth 12 points per 4 trials and defect choices would be worth 28 points per 4 trials).

Across three experiments, Baker and Rachlin (2001) found that cooperation increased with probability of reciprocation in a 100-trial PDG. Each participant was assigned to one of three conditions: 50%, 75%, or 100% probability of reciprocation. In the first two experiments, participants were told they were playing with a computer, but

Experiment 1 signaled the probability of reciprocation (with a spinner) whereas Experiment 2 did not. This visual stimulus (the spinner) increased cooperation in the 75% condition relative to no visual stimulus (with a 1-2-5-6 matrix, 63% or greater reciprocation favored cooperation). Across both experiments, 100% probability of reciprocation resulted in the greatest cooperation. In Experiment 3, participants were led to believe that they were playing with another participant (when it was actually a computer) in the version of the PDG without a spinner (no visual stimulus). The results of this study were similar to Experiment 2 insofar as participants cooperated significantly more in the 100% probability of reciprocation condition compared to the 50% and 75% conditions.

Given the controlled social dilemma provided by the PDG, social discounting research would benefit from using this procedure to explore social distance. The next section will describe research that links social discounting with findings from PDG studies.

Social discounting and the Prisoner's Dilemma Game

Both the social discounting procedure and the PDG assess choice between acting for oneself alone versus acting for the benefit of another. Given social distance, Equation 1 can predict choices made in a PDG (Locey & Buddiga, 2022). For example, Locey and colleagues (2013) used Equation 1 to successfully predict choices in a one-trial PDG. In a previous study (Rachlin & Locey, 2011), students at Stony Brook University identified the median social distance placement of another student as 75. Then, participants in Locey et al.'s (2013) study were told they were randomly assigned to another player at the university (N = 75) and to choose between X and Y (whereby X was a defection response and Y was a cooperation response; rewards were hypothetical). Participants were randomly assigned to a 1-2-3-4 or 1-2-9-10 matrix. According to Equation 1 (where $N = 75$), most participants should not cooperate in the 1-2-3-4 matrix because the socially discounted value of 2 points (the number of points gained by the other player) is 0.39 which is less than the undiscounted cost of cooperating (1 point). Whereas, in the 1-2-9-10 matrix, most participants should cooperate because the socially discounted value (of 8 points for the other player) is 1.56, which is greater than the cost of cooperating (also 1 point).[1] The results supported this prediction; most participants (65%) cooperated in the 1-2-9-10 matrix and most (56%) did not cooperate in the 1-2-3-4 matrix.

Safin and colleagues (2013) confirmed these results by testing the same matrices with an in-person PDG using real rewards. After the PDG, participants were asked to indicate the social distance of the other player (closer or farther than a random classmate). The results indicated that participants in the 1-2-9-10 matrix group were more likely to cooperate than the 1-2-3-4 matrix group. Furthermore, the participants who ranked the other player as closer in social distance than a random classmate cooperated more often than those who did not; thus, indicating a relationship between cooperation and social distance. But given that social distance was only assessed after the PDG, the exact nature of that relationship remains unclear (i.e., did social distance influence cooperation or did cooperation influence social distance).

Social discounting can also account for results in self-control versus cooperation PDG variations. Brown and Rachlin (1999) found that when playing a PDG alone,

[1] These predictions were based on median social distance placements and median (k) social discount functions.

participants were more likely to cooperate than when playing with another individual. In the Alone condition, the participant played with themself (a self-control variation). So, their selection on Trial 1 affected their choices on Trial 2 and so on and so forth. In the Together condition, two participants played, and the selection (cooperate or defect) of Player A affected the choices for Player B (social cooperation variation). The authors found that when participants played the self-control variation, they were more likely to cooperate than when they played the PDG with another person. These results can be explained through social discounting. When an individual is playing alone, the value of each outcome is not socially discounted. The social distance of oneself is zero ($N = 0$); so, given Equation 1, the socially discounted value equals the actual magnitude of the reinforcer regardless of the k value ($V = M$). But when playing with another person, the social distance value is greater ($N > 0$) –especially for an unfamiliar college student. Equation 1 would then predict a decline in value of the outcome to this socially distant person. So, cooperation is less likely with a socially distant person than with oneself – which is exactly what Brown and Rachlin (1999) found.

Reciprocation and Social Distance

The PDG can support an analysis of social discounting (Locey et al., 2013; Safin et al., 2013; Toledo & Avila, 2021). But no study has investigated if other players *change* in social distance after playing an iterated PDG. In fact, no variables have yet been shown to impact social distance, although one likely variable – reciprocation from others– has been explored within a social discounting framework.

Reciprocation occurs when two individuals deliver similar consequences to one another under similar circumstances. One study investigated the correlation between social discounting and reciprocal discounting—a questionnaire that asks participants to predict the altruistic choices of a socially distant person from their list with respect to themselves (the participant; Buddiga & Locey, 2022b). Moderate to strong correlations were found between social and reciprocal discount rates, suggesting that reciprocation and altruistic choice are controlled by the same variable or influence one another directly. As Baker and Rachlin (2001) also found that cooperation increased when probability of reciprocation increased in an iterated PDG, increased probability of reciprocation could covary with decreased social distance.

Present Study

More research is needed to isolate the variables impacting social distance. The current experiments used an iterated PDG, during which each participant experienced repeated interactions with three confederate players (CPs). In Experiment 1, each CP was programmed to reciprocate the participant's choices at different probabilities. In Experiment 2, each CP was programmed to reciprocate at a different average delay. The present study assessed how social distance placement and cooperation changed as a function of probability of reciprocation and delay to reciprocation using a within-subject analysis.

Experiment 1 Method

Participants and Apparatus

Forty-nine participants were recruited from the University of Nevada, Reno via the SONA System. Participants received SONA credit (i.e., course credit) and an Amazon gift card (amount dependent on study performance) for participation. During the study, each participant switched between two cubicles, each with a Dell PC computer and headphones that played brown noise to minimize distractions in the room (See Appendix A for diagram of study set up). The experiment was run using Visual Basic Programming software.

Experimental Design

Each participant contacted all programmed probabilities of reciprocation (25%, 75%, and 100%) but were assigned to one of four groups (Table 1). The general order of tasks for both experiments is depicted in Table 2.

Table 1
Order of experienced probabilities for each group in Experiment 1

Treasure Game #	Low-Medium N=12	Medium-Low N=12	Increasing N=12	Decreasing N=12
1	25%	75%	25%	100%
2	100%	100%	75%	75%
3	75%	25%	100%	25%

Table 2
Order of tasks in Experiment 1 and 2

Assessment Task	**Partner Tasks**				**Assessment Task**
Pre-Assessment	Treasure Game 1	Treasure Game 2	Treasure Game 3	Choice Allocation	Post-Assessment

Procedure

When each participant entered the study, they were told they would be engaging in computerized tasks with participants located in other rooms. At Computer 1, each participant completed Parts 1 and 3 of the study—the “Assessment” portions. During Part 1, the participant completed pre-assessments (see subsections for the NORC assessment, discounting tasks, and social distance ranking below) and during Part 3 they completed post-assessments (same discounting and social distance ranking tasks as the pre-assessments) with additional questions (see subsection below). When the participant was done with Part 1, they were instructed to flip a pink card over at the cubicle. This indicated to the researcher that the participant was ready for the next part.

At Computer 2, the participants completed Part 2—the “Partner Tasks” portion. Each participant was told the following:

> You will complete the next set of tasks in pairs. There are three other participants engaging in these tasks with you. Due to space constraints, they are located in other rooms but networked to your computer. Give me one moment while I text the other researchers and ensure their participants are ready.

The researcher pretended to text on their phone for 15 s. Then the researcher stated, “You will first be presented with a practice task. After that, you will play three games—each with one other player. Your objective is to earn money.” When the participant completed Part 2, they flipped the pink card back over to indicate they were ready for Part 3.

Pre-Assessments

NORC Diagnostic Screen for Gambling Disorders

Participants completed a NORC Diagnostic Screen for Gambling Disorders to determine if they met criteria for and, if they did, to what severity of Gambling Disorder. A score of 0 corresponded with no gambling problems, 1-2 was consistent with mild and subclinical risk for gambling problems, 3-4 was consistent with moderate and subclinical risk for gambling problems, and a 5 or greater was consistent with a likely diagnosis of pathological gambling.

Discounting Questionnaires

Social, reciprocal, delay, and probability discounting questionnaires were administered at the beginning and end of each session. Delay discounting questionnaires assessed the participant's preference for an immediate monetary outcome versus a variety of delayed monetary outcomes. Probability discounting assessed the participant's preference for a guaranteed monetary outcome versus a variety of probabilistic monetary outcomes. Social discounting assessed the participant's preference for a personal monetary outcome versus a monetary outcome for various individuals at specified social distances. Reciprocal discounting asked participants to assess what someone on their social distance list would choose when given the option between money for themself and money for the participant.

The delayed, probabilistic, and other person's (socially distant person for social discounting and the participant in reciprocal discounting) monetary outcome stayed at $100 while the immediate, guaranteed, and personal (the participant in social discounting and socially distant person in reciprocal discounting) monetary outcome consisted of $0, $10, $20, $30, $40, $50, $60, $70, $80, $90, $100 in ascending order. Seven delays (1 day, 1 week, 1 month, 3 months, 6 months, 1 year, 5 years), probabilities (95%, 90%, 70%, 50%, 30%, 10%, 5%), and social distances (1, 2, 5, 10, 20, 50, 100) were assessed.

Avatar Assignment

Prior to Social Distance Ranking tasks, participants were told that they will be randomly assigned to a player number and avatar. A timer counted down 5 s, then the participant was presented with each player's number and avatar assignment. All participants were assigned as Player #4 and the yellow avatar.

After this assignment, an attention check was conducted. This attention check asked the participant to verify their player number and avatar color. If the player answered incorrectly, the correct answer was displayed, and they were prompted to "try again". The participant had unlimited tries to answer the questions correctly. Once the participant answered both questions correctly, they were able to proceed.

Social Distance Assessments

Before and after the PDG trials (Treasure Game), participants were prompted to assess the other players' social distance in relation to themselves (the participant). Three different assessments were administered: a ratio scale, three-place ordinal rank, and unconstrained ordinal rank.

Ratio Scale. The screen showed a grey line that stretched from left to right. On the very left end was the participant's yellow avatar and the label "ME". Twenty grey boxes were shown from left to right. Beneath the line and boxes was a rectangle containing the confederate players' avatars and corresponding labels. The participant was instructed to drag and drop each avatar in correspondence with that confederate player's social distance in relation to themself (the participant). More than one avatar could occupy a box (Appendix B).

Three-Place Ordinal Rank. Following the ratio scale, the participant was prompted to rank order the confederate players. Four boxes were shown (labeled Rank #0 - #3). The participant's avatar was placed in Rank #0 and labeled (ME) while the other boxes were empty. A rectangle containing the confederate players' avatars and corresponding labels was underneath the boxes. The participant was instructed to drag and drop each avatar in correspondence with the CP's social distance ranking at that point. Only one avatar could be placed in each box (Appendix C).

Unconstrained Ordinal Rank. The participant was shown the following prompt: "Imagine that you have made a list of the people closest to you in the world in rank order.

You do not have to imagine only persons 1-100—imagine as long of a list as you can. You do not have to write the list down, just imagine that you have done so." Each other player's avatar was shown from top to bottom. Next to each avatar was this fill-in-the-blank statement: "Player #X would be… #[participant types response here]." In the box the participant can type any numeric value as their response (Appendix D).

Player Social Discounting

The participant completed social discounting for each CP. This task used the same format as the social discounting pre- and post-assessment task, except "Person N" was replaced with "Player X".

Prisoner's Dilemma Game

Confederate Players

The participant played three games, each with one of the three confederate players (CP). Each CP was programmed to reciprocate the participant's choices at different probabilities: 25% (Player 1; for a strategy favoring defection), 75% (Player 3; favoring neither cooperation nor defection), and 100% (Player 2; favoring cooperation).

Forced Trials

Before playing the games with other players, participants experienced an orientation to the "Treasure Game" (i.e., the PDG) and forced trials – during which only one choice alternative (circle [cooperate] or triangle [defect] key) was available. First, the Treasure Game screen was shown, and the participant clicked through directions on how to play. Next, a practice Treasure Game was presented, during which the participant played with a "Computer". During the forced trials, the participant could select the circle key twice and triangle key twice. Upon each selection, they experienced whether 2, 4, 6, or 8 cents (Figure 3) were received given different combinations of their own choice and the computer's choice. The computer's choice was reported to the participant when cents were received. The participant experienced all four matrix outcomes during the forced trials (earning 2, 4, 6, and 8 cents).

Treasure Game

The participant played the Treasure Game with each CP for 37 trials.[2] On the screen was a closed treasure chest and two keys below it—a circle key and triangle key. In the upper left corner, the other player was displayed (Appendix E). The background and colors of the screen reflected the CP's color assignment. For example, when the participant was playing with Player 2 (the blue avatar), the background and keys were light blue and some of the text was dark blue.

Upon the start of each trial, the participant selected either the circle key (a cooperate response) or triangle key (a defect response) within 30-seconds. If the participant did not select either key within 30-seconds, the trial restarted. Within the first six seconds of the 30-second choice time, the other player was programmed to make their selection (average of ~2 s across trials; see Appendix F for all trial delays). Upon the CP's "selection", this message was displayed: "The other player has chosen." Once both players responded, 4 s passed, then an open treasure chest picture was shown for 1 s. Then for 3 s, the number of cents (2, 4, 6, or 8) obtained by the participant was shown (2, 4, 6, or 8) as a coin with the number on it as well as the CP's choice (e.g., "Player 1 chose

[2] Thirty-seven trials were chosen because it allowed nine 4-trial sets (after the initial choice trial) in which consequences could be based on the previous trial.

the Triangle Key"). Next, a 2 s blackout was presented as an inter-trial interval. After 37 trials, the participant was shown the two avatars (their own avatar and the CP's avatar) and prompted to end the game.

Across 36 trials (not including the first trial where the CP always cooperated [no opportunity for reciprocation]), probability of reciprocation for the 25% and 75% CPs was determined by organizing the trials into sets (9 sets of 4 trials). Once the sets were determined, certain trials were programmed to reciprocate the participant's last selection (cooperate or defect; See Appendix G for reciprocation trials).

Choice Allocation Task

Following the main Treasure Game tasks, the participant experienced six abbreviated PDGs (APDGs), consisting of nine trials each (an initial trial followed by two sets of 4 trials with 25%, 75%, or 100% reciprocation – depending upon which CP was chosen). Before starting each APDG, the three CP avatars were shown next to each other with the text, "Please choose who you would like to play a short Treasure Game with." The participant chose a player by clicking on their icon. There was a prompt to wait for the other player and then the participant was prompted to start the nine-trial PDG. After Trial 9, the participant viewed the number of cents earned with that player (see Appendix H for reciprocation trials and delays).

Post-Assessments

Participants completed discounting questionnaires, social distance ranking, and player social discounting tasks again (see Pre-Assessments section for details).

Post-questionnaire

General Questionnaire. Participants were asked to report their general thoughts about the confederate players (this allowed the experimenter to gauge whether the participants believed the confederate players were actual players). Questions were then presented about their ranking criteria, who they would play again with, why they would play with that player again, and which player they chose the circle key the most with.

Likelihood Questionnaires. Participants were prompted to report the names of individuals on their social distance list (Persons 1, 2, 5, 10, 20, 50, 100). These names were used in a questionnaire asking each participant to report the likelihood that these individuals would give the participant some part of a $1,000 endowment. These names were also used to ask participants to report the likelihood that each socially distant person would reciprocate a nice favor done for them (by the participant).

Hypothetical Players Social Distance. Next the participant completed the Social Distance Ratio Scale for two hypothetical players. Player 5, who always chose the circle (cooperation) key, and Player 6, who always chose the triangle (defection) key. The participant was prompted to place these players on the scale.

Cooperative Behavior Assessment. Lastly, participants were asked about their general cooperativeness with others and other related behaviors (including social behaviors exhibited during the COVID-19 pandemic).

Demographic Questionnaire

At the end of the session, participants were asked to report their age, gender identity, ethnicity/race, income level, occupation, religion, tobacco use, alcohol use, and other drug use.

Experiment 1 Results

Forty-nine undergraduate students completed the study. Four participants were excluded from the demographic sample description due to missing data. Of the 45 participants who completed the demographic assessment, 62.22% identified as White or Caucasian, 20% identified as Hispanic or Latino, 13.33% identified as Asian, 2.22% identified as American Indian, and 2.22% preferred not to answer. Of the sample, 20% were male, 73.33% were female, and 6.67% answered other/prefer not to answer. The mean age of the sample was 19.9 years (SD = 4.3 years). Forty-eight participants were included in the present analysis (one excluded due to program errors).

Dependent variables

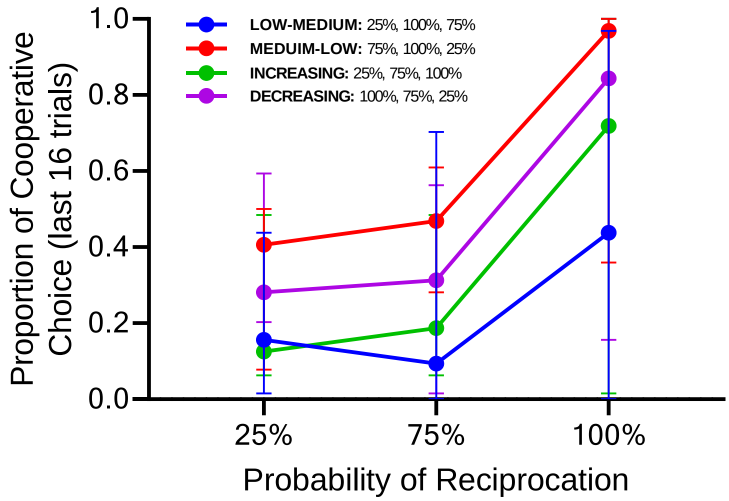
The primary dependent variables included (1) proportion of cooperation with each CP, (2) social distance placement of each CP, (3) choice allocation proportion, (4) player social discount values, and (5) hypothetical player placement.

Cooperation

Throughout each PDG, the participant chose to cooperate or defect with respect to the CP and each CP was programmed to reciprocate the participant’s choices at different delays. Figure 5 shows median proportion cooperative choice (y-axis) across the last 16 trials for each probability of reciprocation condition (x-axis).

Figure 5

Proportion of cooperative choice across the last 16 trials (median with interquartile range) across all CPs for each group.



Each group demonstrated increasing cooperation with probability of reciprocation, except for the Low-Medium group (less cooperation was observed at 75% than 25%). Participants groups exposed to the 75% and 100% reciprocation first (Medium-Low and Decreasing) showed higher levels of cooperation throughout all conditions compared to the two groups initially exposed to 25% reciprocation (Low-Medium and Increasing groups). Significantly different cooperation was observed across the two groups that ended with 25% reciprocation (Medium-Low [p = .002] and Decreasing [p = .04] groups). In the Medium-Low group, there was no significant difference between cooperation at 25% and 75% (p = .09), but both 25% and 75% cooperation differed significantly from 100% (25% and 100%: p = .002; 75% and 100%: p = .003). In the Decreasing group, there was no significant difference between cooperation at 25% and 75% (p = .93) or between 25% and 100% cooperation (p = .15). A significant difference was detected between 75% and 100% cooperation (p = .004).

The groups that started with 25% reciprocation did not yield a significant difference in cooperation across conditions according to a Friedman ANOVA (Low-Medium: $p = .08$; Increasing: $p = .23$). When comparing cooperation across groups for each probability of reciprocation, a Kruskal-Wallis test did not detect a significant difference for the 25% ($p = .48$), 75% ($p = .65$), or 100% probabilities ($p = .55$).

A between-groups comparison was conducted between the probabilities of reciprocation experienced first (25% included the Low-Medium and Increasing groups, 75% included the Medium-Low group, and 100% included the Decreasing group). A Kruskal-Wallis test detected a significant difference across cooperation at the three probabilities of reciprocation ($p = .008$). Mann Whitney tests were conducted to probe for significant differences. Significant differences were detected between 25% and 75% probabilities of reciprocation ($p = .03$) as well as between 25% and 100% probabilities of reciprocation ($p = .007$). No significant difference was detected between cooperation at 75% and 100% probabilities of reciprocation ($p = .11$).

Social Distance Placement

Prior to and after playing a PDG with each CP, participants indicated the social distance placement of each CP relative to themself (the participant). This allowed for an assessment of social distance placement change relative to the probability of reciprocation experienced with each CP. Table 3 depicts the median values for all three social distance assessments across orders. Given the limited variability in placement during the three-place ordinal rank and the extremely high variability during the unconstrained ordinal rank, the remaining analysis will use the social distance ratio scale placements for further evaluation.

Table 3
Median social distance across three assessment tasks. Depicts pre- and post-assessment placements for each group.

Social distance ratio scale						
	25%		75%		100%	
Group	Pre	Post	Pre	Post	Pre	Post
Low-Medium	12.5	7	14	12.5	12.5	3.5
Medium-Low	17.5	8.5	18.5	13.5	18	5
Increasing	18	9.5	19.5	12.5	18.5	8
Decreasing	14	15	15	15	14.5	6.5
Three-place ordinal rank						
	25%		75%		100%	
Group	Pre	Post	Pre	Post	Pre	Post
Low-Medium	1	2	3	3	2	1
Medium-Low	2	2.5	3	2	2	1
Increasing	1	2	3	2.5	2	1
Decreasing	1	2	3	3	2	1
Unconstrained ordinal rank						
	25%		75%		100%	
Group	Pre	Post	Pre	Post	Pre	Post
Low-Medium	75	60	79	75	78	40
Medium-Low	99	70.5	94	51	80	17.5
Increasing	94	63.5	99.5	75	95	60
Decreasing	96	97.5	97.5	99.5	97.5	72.5

Figure 6 depicts the results of the ratio scale assessment for social distance for all participants. Across all participants, social distance placement was not similar at pre-assessment according to a Friedman nonparametric ANOVA (p = .004). At post-assessment, all three CPs decreased significantly in social distance (25%: p = .0002; 75%: p = .001; 100%: p < .001).

A Friedman nonparametric test detected a significant difference across the CPs at post-assessment (p < .0001). Wilcoxon matched-pairs signed rank tests were conducted to probe for significance between CPs. A significant difference was found between the 25% and 75% CPs (p = .03) and between the 75% and 100 CPs (p < .0001). A significant difference was not found between the 100% and 25% CP (p = .13).

Figure 6

Ratio Scale Assessment median social distance placement at pre- and post-assessment (median with interquartile range) across all participants (orders combined). Solid bars depict pre-assessment and striped bars depict post-assessment.

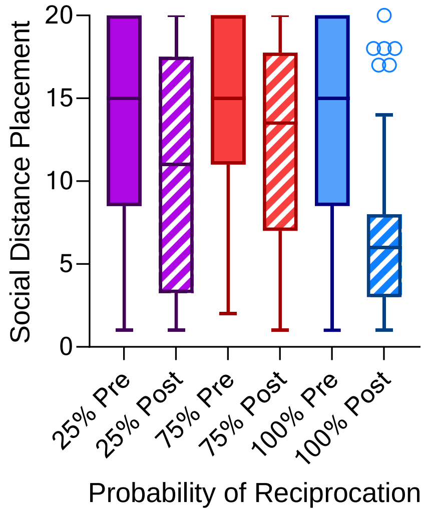


Figure 7 depicts the differences in social distance placement for each group. According to a Friedman ANOVA, for the Low-Medium group, no significant difference was detected at pre-assessment (p = .11). A significant difference was detected at post-assessment (p = .0004) between the 25% and 75% CPs (p = .03), 25% and 100% CPs (p = .04), and 75% and 100% CPs (p = .001). Relative to their pre-assessment placements, the 25% and 100% CPs were placed significantly closer in social distance (25%: p = 0.01; 100%: p = .001) whereas the 75% CP was not (p = .27).

The Medium-Low group did not place CPs differently at pre-assessment (p = .17) but did at post-assessment (p = .01). The 25% and 75% CPs were not placed differently from each other at post-assessment (p = .58) nor were the 25% and 100% CPs placed differently (p = .05). The 75% and 100% CPs were placed significantly differently from each other at post-assessment (p = .004). Relative to their pre-assessment placements, all CPs were placed significantly closer (25%: p = .03; 75%: p = .02; 100%: p = .004).

According to a Friedman ANOVA, for the Increasing group, a significant difference was not detected at pre-assessment (*p* = .31) or at post-assessment (*p* = .85). Relative to pre-assessment, the 25% and 100% CPs were placed significantly closer in social distance (25%: *p* = .01; 100%: *p* = .002) whereas the 75% CP did not change in social distance placement (*p* = .05).

The Decreasing group did not place CPs differently at pre-assessment (*p*=.3) but did at post-assessment (*p* = .03). The 25% and 75% CPs were not placed differently from each other at post-assessment (*p* = .98) but 25% and 75% differed significantly from 100% (both comparisons: *p* = 0.02). Relative to their pre-assessment placements, the 25% and 75% CPs were not placed significantly closer in social distance (25%: *p* = .91; 75%: *p* = .45) whereas the 100% CP social distance placement did change significantly (*p* = .02).

Figure 7
Median (with interquartile range) of social distance placement of each CP at pre- and post-assessment on the ratio scale task separated by group.

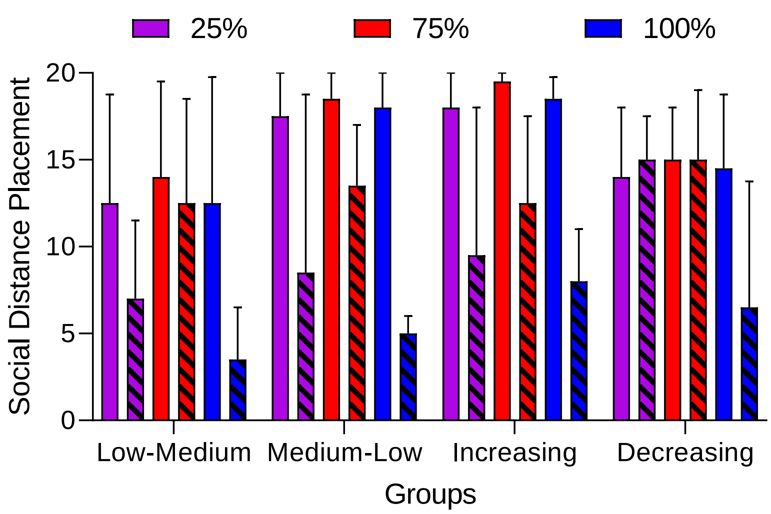
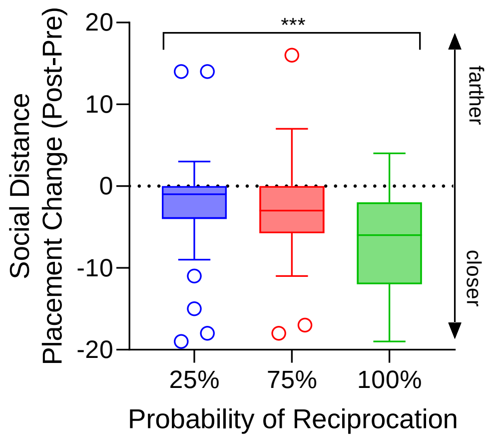


Figure 8 shows the median placement change of each CP across all participants. The 100% CP tended to show the greatest reduction in social distance during post-assessment, followed by the 75% CP, and lastly the 25% CP. The 100% CP change was significantly greater than the 25% CP ($p < .001$) and the 75% CP ($p = .001$).

Figure 8

Median (with Tukey range) change in social distance placement across all participants for each CP. A positive value indicates that the CP increased in social distance (placed farther away from the participant) whereas a negative value indicates that the CP decreased in social distance (placed closer to the participant).



Social distance placement could be influenced by money earned during PDG interactions as well as probability of reciprocation. In other words, participants might have placed CPs in a particular social distance order because of the number of cents earned with each CP. To facilitate this analysis, a correlational analysis was run between post-assessment social distance, probability of reciprocation, and cents earned in the PDG (Table 4). Across all groups, post-assessment social distance correlated weakly with both probability of reciprocation and cents earned. When separated by order, post-assessment social distance only correlated weakly with probability of reciprocation or cents earned. Thus, the results suggest that post-assessment social distance did not necessarily covary with either measure.

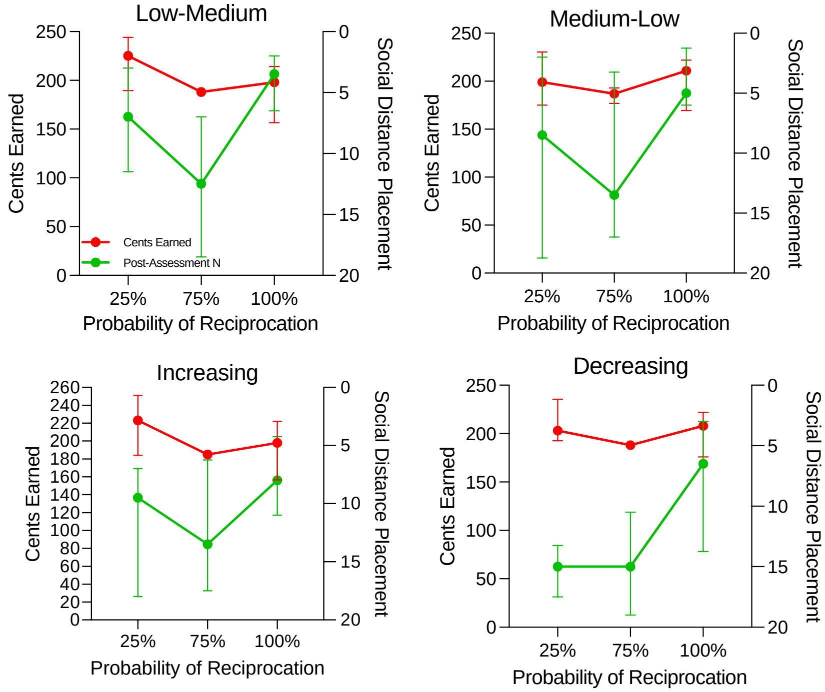
Table 4
Spearman rank correlations between post-assessment social distance placement, probability of reciprocation (25%, 75%, or 100%), cents earned, and cooperation (across the last 16 trials).

	Post-Assessment Social Distance				
	Low-Medium	Medium-Low	Increasing	Decreasing	Orders Combined
Probability of Reciprocation	r_s = -.20 *p* = .23	r_s = -.26 *p* = .13	r_s = -.19 *p* = .26	r_s =-.26 *p* = .13	r_s = -.22 *p* = .01
Cents Earned	r_s = .02 *p* = .93	r_s = -.29 *p* = .08	r_s = -.24 *p* = .17	r_s = -.26 *p* = .13	r_s = -.17 *p* = .04
Cooperation	r_s= 0.08 *p* = .63	r_s = 0.02 *p* = .9	r_s = 0.14 *p* = .41	r_s = 0.07 *p* = .67	r_s = .08 *p* = .33

Figure 9 depicts the median cents earned with each CP along with the median post-assessment social distance of that CP. This analysis explains the weak correlations as the 75% CP was typically placed farther in social distance than the 25% CP. Between the 25% and 75% CPs, the 25% CP typically did result in more cents earned. However, cents earned does not explain the placement of the 100% CP. Although the 100% CP did not always result in the highest earnings (only the Medium-Low order shows the highest earnings with the 100% CP), it was still the socially closest CP across all groups.

Figure 9

Median (with interquartile range) cents earned and post-assessment social distance of each CP.

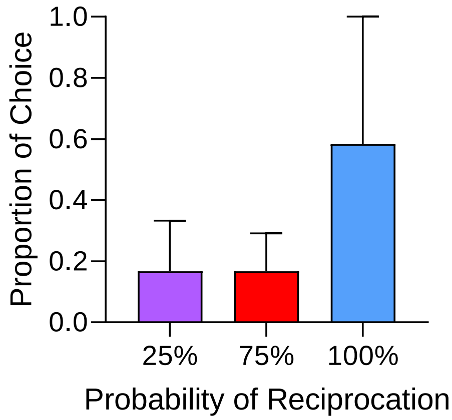


Choice Allocation

Following the main PDGs, participants were prompted to play six abbreviated PDGs (APDGs) with a CP of their choosing. For each APDG, the participant was prompted to choose who they wanted to play with. Across all participants, the 100% CP was chosen the most often for the APDGs (Figure 10).

Figure 10

Median (with interquartile range) proportion of choice for each CP across all participants (groups combined).

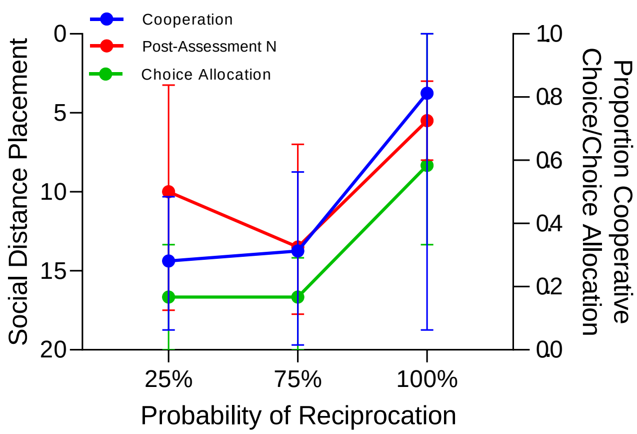


Across all participants (groups combined), probability of reciprocation with the participant's choice produced a significant, moderate positive correlation with choice during the APDGs (as CP's probability of reciprocation increased, choosing to play with that CP increased; Table 5). Choice during the APDGs also produced a moderate, significant negative correlation with the post-assessment social distance; meaning CPs chosen more often during APDGs were placed closer in social distance on the ratio scale task. When separated by group, each group demonstrated similar trends (although not all results were statistically significant). This suggests as probability of reciprocation increases, the participant was more likely to play with that CP again. But those CPs who reciprocated more often (higher probabilities), were not necessarily placed at a closer social distance (Figure 11).

Table 5
Spearman rank correlation coefficients for proportion of choice for each CP and that CP's probability of reciprocation and post-assessment social distance.

	Choice Allocation				
	Low-Medium	Medium-Low	Increasing	Decreasing	Orders Combined
Probability of Reciprocation	$r_s = 0.33$ $p = .05$	$r_s = 0.51$ $p = .001$	$r_s = 0.44$ $p = 0.01$	$r_s = 0.34$ $p = .04$	$r_s = 0.40$ $p < .01$
Post-Assessment Social Distance	$r_s = -0.33$ $p = .05$	$r_s = -0.51$ $p = .002$	$r_s = -0.58$ $p < .01$	$r_s = -0.25$ $p = .15$	$r_s = -.41$ $p < .01$

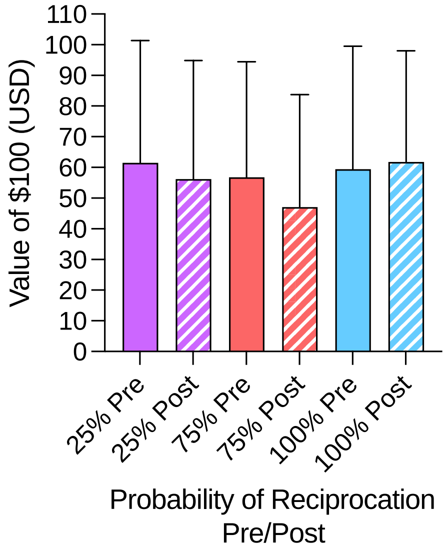
Figure 11
Median (with interquartile range) of post-assessment social distance, cooperative choice (across last 16 trials), and choice allocation proportion across participants (groups combined). The primary y-axis for social distance placement is reversed (lowest value at the top).



Player Social Discounting

During pre- and post-assessment, participants completed the Player Social Discounting questionnaire. During this task, participants indicated the value of $100 when the recipient was one of the CPs. There was no significant difference at pre-assessment ($p = .05$; participants valued $100 similarly across CPs before playing the PDGs), but values were significantly different at post-assessment ($p = .002$; Figure 12). The value of $100 was significantly higher for the 25% CP than the 75% CP ($p = .04$). The 100% CP was also significantly higher than the 75% CP ($p = .001$). There was no significant difference between 25% and 100% CP values ($p = .18$). Thus, participants typically valued $100 highest for the 100% CP after the PDGs, followed by the 25% CP, and, lastly, the 75% CP. There was a significant, moderate negative correlation between post-assessment social distance and the post-assessment value of $100 ($r_s = -.38$, $p <$ .001).

Figure 12
Value of $100 for each CP at pre- and post-assessment (median with interquartile range). Two participants excluded from post-assessment analyses due to program errors (N = 46).



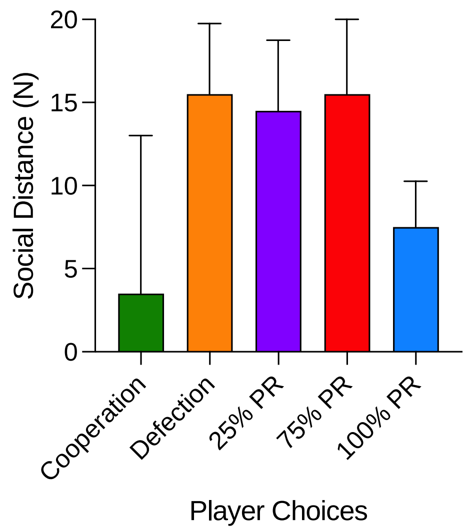
Hypothetical Player Social Distance

At the end of the study, some participants (N=12; program errors prevented the remaining participants from completing this task) indicated where they would place a hypothetical Player 5 and Player 6 on the social distance ratio scale task (Figure 13). Hypothetical Player 5 always chooses the circle key (cooperation response) whereas hypothetical Player 6 always chooses the triangle key (defection response). Results show that Player 5 (cooperative player) was placed significantly closer in social distance than Player 6 (defective player; $p = .002$). Also depicted in Figure 13 is the post-assessment social distance of the CPs encountered during the experiment (25% reciprocation [Player

1], 75% reciprocation [Player 3], and 100% reciprocation [Player2]). The 100% reciprocation player was not placed significantly differently in social distance than the cooperative player (*p* = .33) but was placed significantly closer than the defection player (*p* = .007). The 75% reciprocation player was not placed significantly differently from the defection player (*p* = .25), but the 25% reciprocation player was placed significantly closer than the defection player (*p* = .002).

Figure 13

Median (with interquartile range) social distance placement of hypothetical Player 5 (always chooses the cooperative response) and hypothetical Player 6 (always chooses the defective response). Players 1-3 (25%, 75%, and 100% probability of reciprocation) post-assessment social distance placement shown for comparison.



Discounting Analyses

Before and after the PDGs, each participant completed delay, probability, social, and reciprocal discounting questionnaires. Table 6 depicts the Spearman's rho correlation for pre- and post-assessment discounting questionnaires. The only significant correlations were between the delay discount rates at pre- and post-assessment, probability discount rates at pre- and post-assessment, reciprocal and probability discount rates at pre-assessment, reciprocal discount rates pre- and post-assessment, probability, and reciprocal discount rates at post-assessment.

Table 6

Spearman's rho correlations between discount rates (log[*k*+1]). Asterisks indicate a significant correlation.

		Pre-Assessment				Post-Assessment			
		Delay	Probability	Social	Reciprocal	Delay	Probability	Social	Reciprocal
Pre	Delay	1.00							
	Probability	-0.04	1.00						
	Social	0.01	0.05	1.00					
	Reciprocal	0.01	0.27	0.18	1.00				
Post	Delay	0.78*	0.08	-0.02	0.08	1.00			
	Probability	0.19	0.56*	0.12	0.32*	0.23	1.00		
	Social	-0.11	0.23	0.72*	0.03	-0.05	0.09	1.00	
	Reciprocal	-0.01	0.43*	-0.01	0.66*	0.10	0.37*	0.15	1.00

Experiment 1 Discussion

Experiment 1 evaluated how probability of reciprocation in a Prisoner's Dilemma Game affected cooperation and social distance in a within-group experimental study. Each group experienced all probabilities of reciprocation (25%, 75%, and 100%) across four different orders (Low-Medium, Medium-Low, Increasing, and Decreasing; delay to reciprocate held constant). The present results indicate that probability of reciprocation influenced cooperation and social distance, but it is not a precise function whereby increased probability of reciprocation necessarily results in significantly more cooperation or closer social distance.

Every group demonstrated the highest cooperation rates with the 100% CP. Each group indicated no significant difference in cooperation between the 25% and 75% CPs. Yet, in a between-groups analysis of the probability of reciprocation encountered first, the 100% and 75% reciprocation conditions resulted in significantly more cooperation than the 25% reciprocation condition. But no difference was detected in cooperation between 100% and 75%. Such results comport with Baker and Rachlin (2001)'s Experiment 1 where, in a between-group study with a discriminative stimulus signaling probability of reciprocation, participants did not cooperate differently with the 100% versus 75% conditions but cooperated in those conditions significantly more than the 50% condition. These results suggest that when probabilities of reciprocation are contacted in isolation, higher probabilities of reciprocation could result in more cooperation.

In typical real-life situations, we do not encounter people's reciprocation in isolation. Rather, our experiences with others are constantly in comparison with each other. Thus, analyses were conducted comparing cooperation across each group (looking at order effects). Interestingly the groups who experienced 75% and 100% reciprocation first (Medium-Low and Decreasing) demonstrated significantly more cooperation with the 100% CP compared to the other CPs, but no significant difference across cooperation with CPs was found in groups who experienced the 25% reciprocation first (Low-Medium and Increasing). So, the cooperation response was not acquired as quickly with the tit-for-tat CP in these groups as those who experienced a higher probability of reciprocation first. In the higher-reciprocation-first groups, the participants more quickly adapted to the strategy that would maximize earning for that particular CP, learning the defection strategy faster than the other groups learned the cooperation strategy.

Why was defection learned faster than cooperation? In an iterated PDG where there is little to no reciprocation (e.g., 25%), cooperation is punished quickly in favor of defection: When Player 1 cooperates, Player 2 defects, the cooperating player earns 2 cents (the lowest possible outcome) whereas the defecting player earns 8 cents (the highest possible outcome; Figure 3). When a tit-for-tat contingency (100% reciprocation) is implemented, cooperation emerges between players, presumably because it maximizes reinforcement over many trials (Figure 4; Rachlin et al., 2001). But the punishing effect on defection is not as quick; if both players are defecting, they are each earning 4 cents—a low value but not as low as 2 cents. Cooperating is only 2 cents more for both players (6 cents each) and not the maximum possible value (8 cents); thus, it should take longer to reinforce cooperation. In the present experiment, participants who experienced the PDG with the 25% CP first resulted in more severe punishment of cooperation responses, hindering the acquisition of cooperation with the 100% CP later on (where cooperation only leads to 6 cents on the immediate trial). Whereas for the participants who encountered 100% before 25%, cooperation was punished quickly and effectively in the 25% condition.

Green and colleagues (1995) found that pigeons did not acquire a cooperation response when playing against a computer programmed tit-for-tat. The authors assert that temporal discount rates provide an explanation of why the pigeons did not acquire cooperation responses as quickly as humans tend to acquire them. In other words, humans tend to value future rewards more highly than pigeons do. The present study demonstrates that delayed consequences (i.e., reinforcement maximization over many trials of cooperation in tit-for-tat) is initially valued less than immediate consequences (i.e., immediate defection resulting in 8 cents). However, over many trials, participants do eventually acquire a cooperation response as this pattern of responding increases in value.

Curiously, the participants in the Medium-Low group (who encountered the 75% CP then the 100% CP) engaged in more cooperation with the 100% CP than the participants in the Decreasing order (who encountered the 100% CP first and the 75% CP second). This difference is likely the result of participants learning the contingencies of the PDG. In the Medium-Low group, participants have become acquainted with the PDG after the first exposure and can then learn the 100% contingency faster. In the Decreasing order, the participants likely cooperated less with the 100% CP (which was experienced first) because they were still learning the contingencies of the game.

It is notable that the 25% and 75% cooperation responses were not significantly different from one another across all groups. This suggests that the higher reciprocation probability in the 75% condition was not apparent to many participants – which is consistent with Baker and Rachlin (2001)'s experiments that did not signal probability of reciprocation. In their study, participants in the 75% probability of reciprocation group cooperated more than participants in the 50% probability of reciprocation group when a spinner indicating the probability of reciprocation was present (discriminative stimulus). However, in Experiments 2 and 3, when the spinner was removed, cooperation did not significantly differ between the 50% and 75% groups (even though the 50% reciprocation favored defection and the 75% reciprocation favored cooperation according to their 1-2-5-6 matrix). In the present study, given the similar cooperation rates with the 25% and 75% CPs, the participants likely did not discriminate the different reciprocation contingencies.

Participants indicated the social distance of the CPs before and after experiencing the PDGs. CPs differed significantly in social distance at pre-assessment (Figure 6). But when separated by group, no significant different was detected at pre-assessment across groups. This suggests that never engaging with the CPs results in similar social distance.

Once the participant interacted with each CP in the PDGs, all CPs decreased in social distance, but social distances were not similar to one another: The 100% CP was placed closest in social distance, most commonly followed by the 25% CP, and then the 75% CP. Thus, an effect of probability of reciprocation on social distance was found.

It is interesting that the 25% CP, which reciprocated less often and resulted in less cooperation, was considered socially closer than the 75% CP. Cents earned might have influenced this different ranking. While the 100% CP did not always result in the most cents earned, that CP was still placed closest in social distance. When evaluating cents earned with the remaining two CPs, though, the 75% CP typically resulted in less earnings than the 25% CP. If the participants did not necessarily discriminate between the reciprocation contingency (as evidenced by the cooperation rates), the participant might have then placed the 25% CP socially closer based on the amount of money earned.

"Predictability"—being able to predict (or know) someone's behavior in a certain context before the behavior occurs—might influence participant cooperation and social distance placement. For example, Safin and colleagues (2015) had participants play a PDG with "another player" (a computer) but the participant was told that the other player already chose their responses across all trials. All responses were shown to the participant while they chose cooperation or defection for each trial. So, while the possibility of reciprocation was removed, participants still cooperated when they knew what responses were coming. In the present study the 100% CP might be considered more "predictable" since a consistent strategy was reinforced, and probability of reciprocation was constant. To test this prediction, some participants were asked to place a hypothetical Player 5 and Player 6 on the social distance ratio scale task. Player 5 always chose the circle key (cooperation response) while Player 6 always chose the triangle key (defection response). The results indicated that the cooperation-only player (Player 5) was placed significantly closer in social distance than the defection-only player (Player 6) and the 100% reciprocation player (Player 2). Moreover, the defection-only player was placed at a similar social distance as the 75% reciprocation player. If predictability was the only influence on social distance placement, these hypothetical players should have been placed similarly to each other and Player 2.

The present study used two other measures that could provide more information about social distance: the choice allocation task and player social discounting. The choice allocation task measured social preference after the PDGs were experienced. It is in a similar vein to Hackenberg et al. (2021) who used a concurrent chains schedule to measure social preferences in rats. But this study differs as there was no preference measured between social and non-social consequences nor was familiarity with the CP manipulated. In the present study, all participants had experienced the same number of trials with each CP and all choices in the choice allocation task resulted in an abbreviated PDG with that CP. The results of this choice allocation task showed that participants tended to choose to play with the 100% CP again. Participants tended to choose higher probability of reciprocation CPs and socially closer CPs (i.e., the 100% CP) more often during the choice allocation task. These results suggest that choice allocation might be a useful way to measure social preference.

Social preference could be inferred from the player social discounting task. In standard social discounting, participants indicate the discounted value of an outcome when a socially distant person is the recipient. While Safin et al. (2015) used a player social discounting task, too, they only evaluated the value of $75 to another player *after* the PDG. In the current study, participants reported the value of $100 when the recipient was one of the CPs before *and* after interacting through the PDGs. There was no significant difference between the value of $100 across participants prior to the PDG (before interaction), but a significant difference was found *after* playing the PDGs. Post-assessment social distance correlated moderately with the value of $100 (participants valued $100 greater to socially closer CPs). The current study demonstrates that value of $100 changed as a function of interacting with CPs in the PDG.

It is interesting that, with the exception of the 100% CP, the value of $100 reduced after the PDG interactions. Such a result is inconsistent with the social distance placement of the CPs. All CPs decreased in social distance after the PDG (Figures 5 and 6). Therefore, it is expected that the value of $100 should increase for all CPs after the PDG (with the highest value for the 100% CP, followed by 25%, and then 75%). Previous research suggests that increased familiarity with another person should increase cooperation (Marwell & Schmitt, 1975). The present study used hypothetical outcomes for the player social discounting task. Previous research has found that real and hypothetical outcomes in a standard social discounting task did not result in significantly different discount rates (Locey et al., 2011). But there might be poor instructional control in the present task. Perhaps if the player social discounting task was conducted with real outcomes relevant to the study (e.g., cents earned through the study), there would be concordance between the social distance and social discounting results.

Discount rates were obtained at pre- and post-assessment. As expected, pre- and post-assessment discounting questionnaires of the same type (e.g., delay discounting and pre- and post-assessment) correlated strongly with one another. Buddiga and Locey (2022b) found moderate to strong correlations between social and reciprocal discounting, indicating that as altruism increased so did reciprocal altruism (reported altruistic choice from socially distant persons to the participant). But this was not found in the current study at pre-assessment nor post-assessment. Instead a moderate, significant correlation was found between probability and reciprocal discount rates at post-assessment. Another moderate correlation was detected post-assessment probability and pre-assessment reciprocal as well as between pre-assessment reciprocal and post-assessment probability discount rates. The present study sought to investigate how probability of reciprocation in a Prisoner's Dilemma Game influenced social distance. If probability and reciprocal discount rates are correlated moderately this suggests that perhaps the reciprocal discounting questionnaire is capturing some probabilistic element, like probability of reciprocation.

The other discounting questionnaires results did not correlate significantly with one another. The lack of correlations detected between discount rates is not unusual. Some previous studies have reported no to weak correlations between delay and probability discounting (Białaszek, et al. 2019). However, Jones and Rachlin (2009) found a moderate correlation between social and probability discounting. It is possible that, in the current study, participant's discounting responses were not under proper stimulus control. In other words, the participants were not responding in relation to the prompts but rather in relation to other aspects of the task (e.g., moving quickly to the next page).

Experiment 1 found that probability of reciprocation affects both cooperation and social distance placement. Social distance placement did not change exactly with cooperation or probability of reciprocation. Experiment 2 will evaluate the effect of delay to reciprocation on social distance and cooperation.

Experiment 2 – Delay to Reciprocate

Social and delay discounting are fit by a similar hyperbolic function (Rachlin & Jones, 2008a). Moreover, cooperation in an iterated PDG appears to change as a function of delay to reciprocate (Locey & Rachlin, 2012; Komorita et al., 1991). Locey and Rachlin (2012) conducted a between-groups design in which the participants were assigned to either All Gains or Mixed Outcome with a delayed or immediate outcome (four groups total). Across the four groups, those who experienced immediate consequences of their choices learned to cooperate faster and engaged in greater cooperation overall across a majority of trials. Although the authors attributed this to immediate contingencies being more effective at reinforcing cooperation and punishing defection, differences in social distance might also have played a role. Specifically, faster reciprocation might reduce social distance (we might well feel closer to those who reciprocate in a timelier manner). Experiment 2 was designed to assess how social distance changes as a function of delay to reciprocate.

Experiment 2 Method

Participants and Setting

Forty participants completed the study. Participants received SONA credit (i.e., course credit) and an Amazon gift card (amount dependent on study performance) for participation. There were four groups, each of which experienced different delay orders (Table 7).

Table 7
Order of experienced delays for each group in Experiment 2

Treasure Game #	Low-Medium N=10	Medium-Low N=10	Increasing N=10	Decreasing N=10
1	3 s	8 s	3 s	13 s
2	13 s	13 s	8 s	8 s
3	8 s	3 s	13 s	3 s

Pre-Assessments

The pre-assessment tasks were the same as Experiment 1.

Prisoner's Dilemma Game

The PDG was conducted as described in Experiment 1, however, instead of different probabilities of reciprocation, each CP was programmed to reciprocate the participant's choice (100% reciprocation) at different delays: Player 1 with a short delay (average of 3 s), Player 2 with a medium delay (average of 8 s), and Player 3 with a long delay (average of 13 s). When a new trial began, the CP was programmed to make their choice at the delay listed in Appendix I.

Choice Allocation Task

Following the main Treasure Game tasks, the participant experienced six abbreviated PDGs (APDGs), consisting of nine trials each. Before starting each APDG, the three CP avatars were shown next to each other with the text, "Please choose who you would like to play a short Treasure Game with." The participant chose a player by clicking on their icon. There was a prompt to wait for the other player and then the participant was prompted to start the nine-trial PDG. After Trial 9, the participant viewed the number of cents earned with that player (see Appendix J for delays).

Post-Assessments

General Questionnaire. The post-assessments were the same as Experiment 1.

Delay Questionnaire. Participants were asked how long it would take for Person N to reciprocate something nice that was done for them.

Cooperative Behavior Assessment. Participants were asked about their general cooperativeness with others and other related behaviors (including social behaviors exhibited during the COVID-19 pandemic).

Demographic Questionnaire

At the end of the session, participants were asked to report their age, gender identity, ethnicity/race, income level, occupation, religion, tobacco use, alcohol use, and other drug use.

Experiment 2 Results

Forty participants were included in the study results. Demographic data was collected among 38 of those participants (two participants did not complete demographic information due to program errors). Of the 38 participants, 55.26% of the sample identified as White or Caucasian, 18.42% identified as Hispanic or Latino, 15.79% identified as Asian, 2.63% identified as African American, 2.63% identified as American Indian, and 5.26% preferred not to answer. Of the sample, 31.58% were male, 65.79% were female, and 2.63% answered other/prefer not to answer. The mean age of participants was 20.3 years (SD = 4.6 years).

Dependent variables

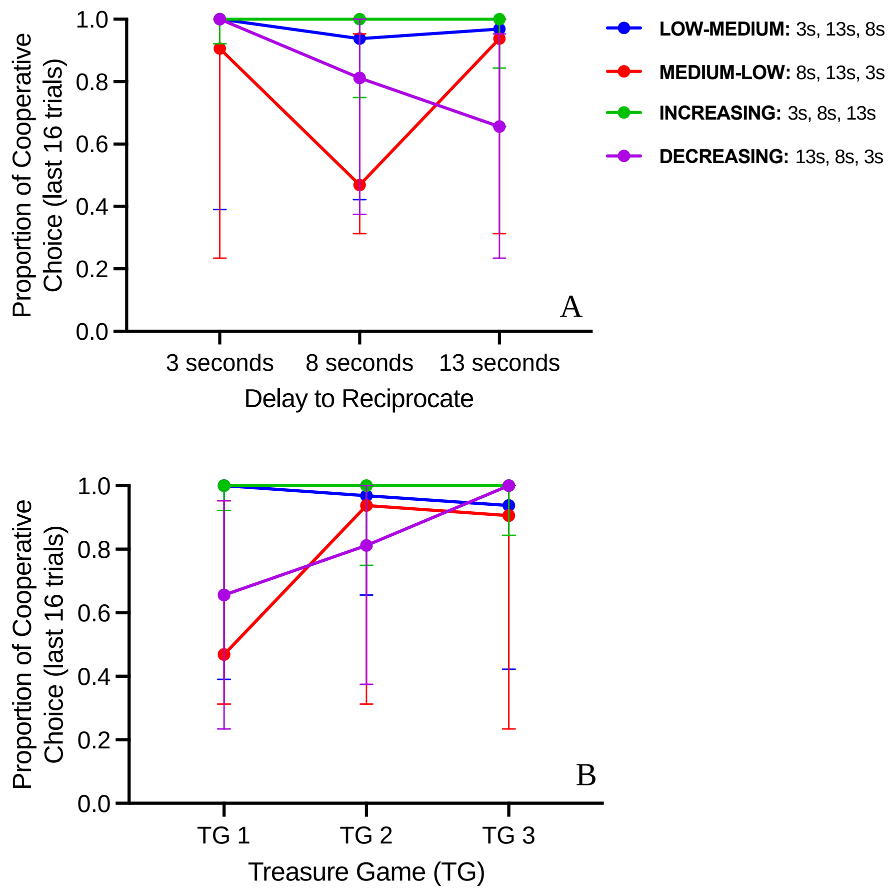
The primary dependent variables included (1) proportion of cooperation with each CP, (2) social distance placement of CPs, (3) choice allocation proportion, and (4) player social discount rates.

Cooperation

Throughout each PDG, the participant chose to cooperate or defect with respect to the CP and each CP was programmed to reciprocate the participant's choices at different delays. Figure 14 shows median proportion cooperative choice (y-axis) across the last 16 trials for each delay to reciprocate condition (x-axis).

Figure 14

Proportion of cooperative choice across the last 16 trials (median with interquartile range). Panel A's x-axis depicts the average delays in increasing order. Panel B's x-axis depicts the order in which each delay CP was experienced for each group.



Two distinct trends emerged at the median level. Participants first exposed to 3 s reciprocation (Low-Medium and Increasing groups) demonstrated high levels of cooperation throughout all conditions with the Low-Medium group demonstrating a slight decreasing trend (but not statistically significant, p = .21). Participants in the Medium-Low and Decreasing groups demonstrated the lowest proportion of cooperation in the condition experienced first (8 s for Medium-Low and 13 s for Decreasing). The Decreasing group depicts increasing cooperation with decreased average delay to reciprocate while the Medium-Low group depicts slightly more cooperation in the 13-second condition than the 3-second condition. Across all groups, only the Decreasing group demonstrated a significant difference in cooperation across conditions (p = 0.01). When comparing cooperation across groups for each delay to reciprocate (e.g., cooperation at 3 s across all orders), a Kruskal-Wallis test did not detect a significant difference for the 3 s (p=.12), 8 s (p=.22), or 13 s delays (p=.17).

Social Distance Placement

Prior to and after playing a PDG with each CP, participants indicated the social distance placement of each CP relative to themself (the participant). This allowed for an assessment of social distance placement change relative to the delay to reciprocate experienced with each CP. Table 8 depicts the median values for all three social distance assessments across orders. Given the limited variability in placement during the three-place ordinal rank and the extremely high variability during the unconstrained ordinal rank, the remaining analyses will use the social distance ratio scale placements.

Table 8
Median social distance across three assessment tasks. Depicts pre- and post-assessment placements for each order.

Social distance ratio scale						
	3 s		8 s		13 s	
Group	Pre	Post	Pre	Post	Pre	Post
Low-Medium	14	5.5	18.50	8.5	15.50	7.5
Medium-Low	11.5	6.5	16	10	14	13
Increasing	16	12	16.5	13	17.5	13.5
Decreasing	19	4.5	20	11.5	19.5	17
Three-place ordinal rank						
	3 s		8 s		13 s	
Group	Pre	Post	Pre	Post	Pre	Post
Low-Medium	1.5	1	2	2	2	3
Medium-Low	1	1	2	2	3	3
Increasing	2	1	2	2	2	3
Decreasing	1	1	2	2	3	3
Unconstrained ordinal rank						
	3 s		8 s		13 s	
Group	Pre	Post	Pre	Post	Pre	Post
Low-Medium	50	50	62	61	74	62
Medium-Low	17.5	27.5	35	55	57.5	82.5
Increasing	98.5	95.5	99	97.5	99	98
Decreasing	76.5	37.5	74.5	45	75	65

Figure 15 depicts the results of the ratio scale assessment for social distance. Across all participants (groups combined), social distance placement was similar at pre-assessment according to a Friedman nonparametric ANOVA (p=.08). At post-assessment, all CPs decreased in social distance relative to pre-assessment with the 3 s delay CP being placed closest in social distance, followed by 8 s, then 13 s. The 3 s and 8 s CPs demonstrated a significant decrease in social distance (3 s pre/post: $p < .0001$; 8 s pre/post: $p < .0001$). The 13 s CP did not decrease in social distance significantly ($p =$ .13). A Friedman nonparametric test detected a significant difference across the CPs at post-assessment ($p < .0001$). Wilcoxon matched-pairs signed rank tests were conducted to probe for significance between CPs. A significant difference was found between all CP pairs (3 s and 8 s: $p < .0001$; 3 s and 13 s: $p < .0001$; 8 s and 13 s: $p = .0003$).

Figure 15
Ratio Scale Assessment social distance placement of each CP at pre- and post-assessment (median with interquartile range) across all participants (groups combined).

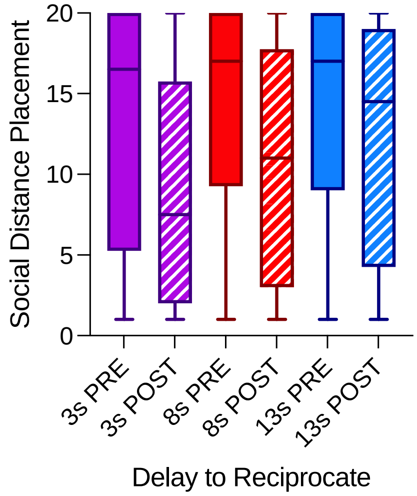


Figure 16 depicts the median social distance placement for each group. Upon visual analysis, it is apparent that all groups except Low-Medium depict increasing social distance with increasing delay to reciprocate. According to a Friedman ANOVA, for the Low-Medium group, no significant difference was detected at pre-assessment ($p = .53$), but a significant difference was detected at post-assessment ($p = .02$) between the 3 s and 8 s CPs ($p = .008$). According to Wilcoxon tests, no significant difference was observed between the 3 s and 13 s CPs ($p = .06$) and 8 s and 13 s CPs ($p = .59$). In this group, the 3 s CP decreased significantly in social distance (3 s: $p = .004$) while the 8 s and 13 s CPs did not decrease significantly (8 s: $p = .09$; 13 s: $p = .06$).

The Medium-Low group did not place CPs differently at pre-assessment ($p = .69$) but did at post-assessment ($p < .0001$). All CP pairs were placed differently from each other at post-assessment (3 s and 8 s: $p = .02$; 3 s and 13 s: $p = .02$; 8 s and 13 s: $p = .03$).

Relative to their pre-assessment placements, the 3 s and 8 s CPs were placed significantly closer in social distance (3 s: p = .03; 8 s: p = .04) whereas the 13 s CP social distance placement did not change significantly (p > .99).

The Increasing group did not place CPs differently at pre-assessment (p = .36) but did at post-assessment (p = .005). The 3 s and 8 s CPs were not placed differently from each other at post-assessment (p = .31) nor were the 8 s and 13 s CPs (p = .06). The 3 s and 13 s CPs had significantly different social distances (p =.03). Relative to their pre-assessment placements, none of the CPs were placed significantly closer in social distance (3 s: p = .12; 8 s: p = .05; 13 s: p = .63).

The Decreasing group participants did not place CPs differently at pre-assessment (p = .43) but did at post-assessment (p = .02). The 3 s and 8 s CPs were placed differently from each other at post-assessment (p = .02) as were the 3 s and 13 s CPs (p = .02) and the 8 s and 13 s CPs (p = .04). The 3 s and 13 s CPs had significantly different social distances (p = .03). Relative to their pre-assessment placements, the 3 s and 8 s CPs were placed significantly closer in social distance (3 s: p = .03) whereas the 8 s and 13 s CP social distance placement did not change significantly (8 s: p = .05; 13 s: p = .98).

Figure 16

Median (with interquartile range) social distance placement of each CP separated by group.

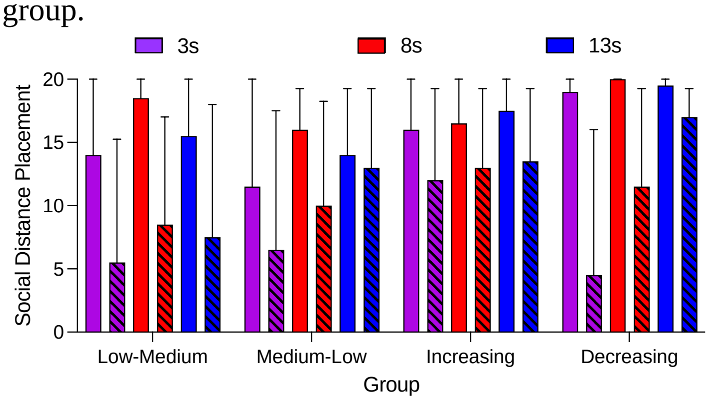
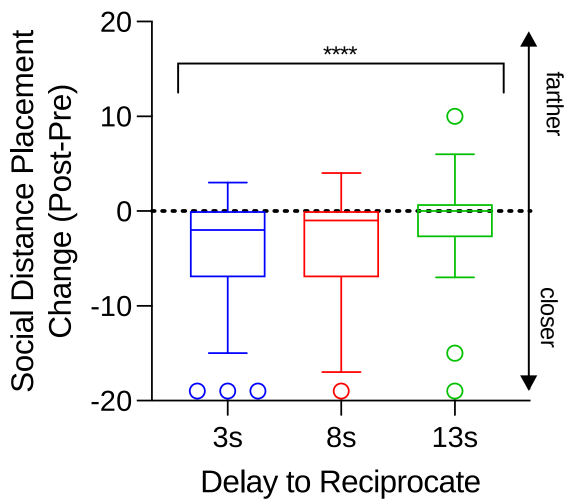


Figure 17 shows the median placement change of each CP across all participants. The 3 s CP tended to be placed closer in social distance during post-assessment followed by the 8 s CP. There was no significant difference between 3 s and 8 s CP changes (p = .29), but there was a significant difference between 3 s and 13 s CPs (p < .0001) and 8 s and 13 s (p = .002).

Figure 17

Median change (with Tukey range) in social distance placement across all participants. A positive value indicates that the CP increased in social distance (placed farther away from the participant) whereas a negative value indicates that the CP decreased in social distance (placed closer towards the participant).



Social distance placement could be influenced more by cents earned opposed to the delay to reciprocate. To facilitate this analysis, a correlational analysis was run between post-assessment social distance, delay to reciprocate, and cents earned in the PDG (Table 9). Across all orders, post-assessment social distance correlated weakly with delay to reciprocate and cents earned. When separated by order, delay to reciprocate correlated moderately with post-assessment social distance in the Decreasing group (as delay to reciprocate increased so did social distance). Cents earned correlated moderately with the Medium-Low and Increasing group social distance placements (as cents earned increased, social distance increased).

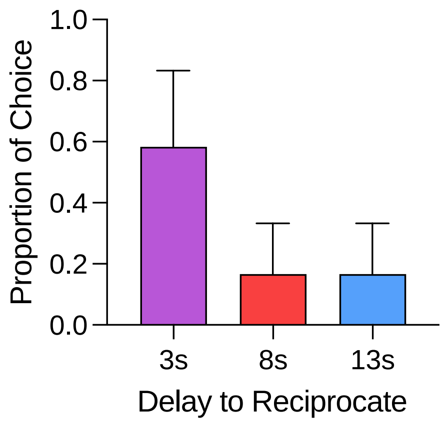
Table 9
Spearman rank correlations between post-assessment social distance placement, delay to reciprocate, cents earned, and cooperation (among the last 16 trials).

	Post-Assessment Social Distance				
	Low-Medium	Medium-Low	Increasing	Decreasing	Orders Combined
Delay to Reciprocate	r_s =.18 *p* = .35	r_s =.24 *p* = .21	r_s = .24 *p* = .21	r_s = .37 *p* = .04	r_s = .23 *p* = .01
Cents Earned	r_s =.01 *p* = .95	r_s =.38 *p* = .04	r_s =.42 *p* = .02	r_s =.06 *p* = .75	r_s = .18 *p* = .06
Cooperation	r_s = .18 *p* = .34	r_s = .50 *p* = .01	r_s = .28 *p* = .13	r_s = .18 *p* = .36	r_s = .14 *p* = .12

Choice Allocation Tasks

Following the main PDGs, participants were prompted to play six abbreviated PDGs (APDGs) with a CP of their choosing. For each APDG, the participant was prompted to choose who they wanted to play with. Across all participants, the 3 s CP was chosen the most often for the APDGs (Figure 18).

Figure 18
Median (with interquartile range) proportion of choice across delay to reciprocate conditions (orders combined).



Across all participants (groups combined), choice allocation showed a strong negative correlation with delay to reciprocate but no significant correlation with post-assessment social distance ranking (Table 10). When separated by group, a strong, significant negative correlation was found will all orders except the Decreasing group. This suggests that the average delay to reciprocate could have impacted the participant's choice to play with that CP again (as delay to reciprocate decreases, the participant chose to play with them more often).

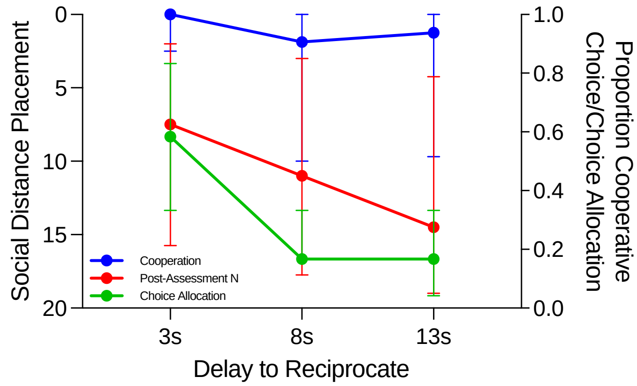
Table 10
Spearman rank correlation coefficients for proportion of choice for each CP and that's CP's average delay to reciprocate and post-assessment social distance.

	Choice Allocation				
	Low-Medium	Medium-Low	Increasing	Decreasing	Orders Combined
Delay to Reciprocate	$r_s = -0.66$ $p = 0.0001$	$r_s = -0.71$ $p < 0.0001$	$r_s = -0.57$ $p < 0.01$	$r_s = -0.26$ $p = 0.16$	$r_s = -.57$ $p < .01$
Post-Assessment Social Distance	$r_s = -.08$ $p = .68$	$r_s = -.10$ $p = .62$	$r_s = -.24$ $p = .19$	$r_s = -.24$ $p = .19$	$r_s = -.12$ $p = .24$

Figure 19 shows that, across all participants, delay to reciprocate appeared to influence the post-assessment social distance more than cooperation with that CP. It also shows that choice allocation does not covary with post-assessment social distance since participants opted to play with the socially closest CP most often. The lack of covariation between post-assessment social distance and choice allocation is expected because the social distance measure allows for gradation whereas choice allocation is likely to result in one highly preferred player.

Figure 19

Median (with interquartile range) of post-assessment social distance, cooperative choice (across last 16 trials), and choice allocation proportion across participants. The primary y-axis for social distance placement is reversed (lowest value at the top).

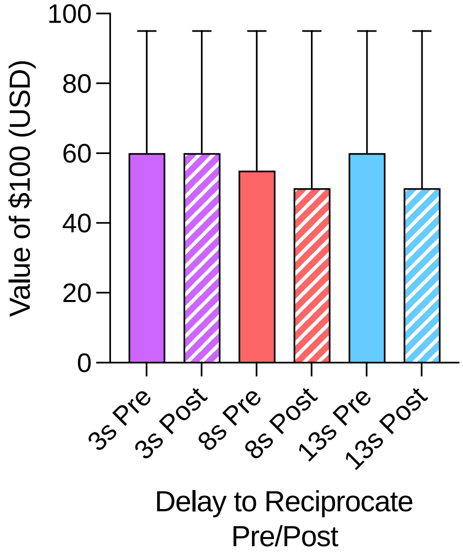


Player Social Discounting

During pre- and post-assessment, participants completed the Player Social Discounting questionnaire. During this questionnaire, participants indicated the value of $100 when the recipient was one of the confederate players. There was no significant difference at pre-assessment value (*p* = .4), but values were significantly different at post-assessment (*p* = .01; Figure 20). The value of $100 was significantly higher for the 3 s CP than the 8 s CP (*p* = .03) and the 13 s CP (*p* = .02). The 8 s and 13 s CP values were not significantly different (*p* = .25). A weak negative correlation was detected between post-assessment values of $100 and post-assessment social distance (r_s = -.22, *p* = .02).

Figure 20

Value of $100 for each CP at pre- and post-assessment (median with interquartile range).



Discounting Analyses

Before and after the PDGs, each participant completed delay, probability, social, and reciprocal discounting questionnaires. Table 11 depicts the Spearman's rho correlation for pre- and post-assessment discounting questionnaires. The only significant correlations were between the delay and social discount rates pre-assessment, delay discount rates at pre- and post-assessment, probability discount rates at pre- and post-assessment, social and reciprocal discount rates at pre-assessment, social and delay discount rates pre-assessment, social discount rates and pre- and post-assessment, social discount rates at pre-assessment and reciprocal discount rates at post-assessment, reciprocal discount rates at pre- and post-assessment, and social and reciprocal discount rates at post-assessment.

Table 11
Spearman's rho correlations between discount rates (log[*k*+1]). Asterisks indicate a significant correlation.

		Pre-Assessment				Post-Assessment			
		Delay	Probability	Social	Reciprocal	Delay	Probability	Social	Reciprocal
Pre	Delay	1.00							
	Probability	0.25	1.00						
	Social	0.35*	0.08	1.00					
	Reciprocal	0.16	0.03	0.56*	1.00				
Post	Delay	0.79*	0.28	0.32*	0.20	1.00			
	Probability	0.09	0.45*	0.17	0.16	0.01	1.00		
	Social	0.19	-0.11	0.72*	0.53*	0.21	0.07	1.00	
	Reciprocal	-0.01	0.01	0.35*	0.68*	-0.06	0.25	0.48*	1.00

Experiment 2 Discussion

Experiment 2 evaluated the effects of delay to reciprocate on cooperation and social distance using a within-group analysis. All CPs were programmed to reciprocate tit-for-tat (100% reciprocation), but the average delay of choosing their key was manipulated (3 s, 8 s, or 13 s). Results suggest that both delay and order mattered for cooperation, but delay seemed to have the biggest impact on social distance placement.

Two trends appeared at the median level of cooperation. Participants who experienced the 3 s delay CP first (Low-Medium and Increasing) exhibited higher rates of cooperation with other CPs whereas participants who experienced more delayed reciprocation (8 s and 13 s) first took longer to acquire the cooperation response (Medium-Low and Decreasing). These patterns are consistent with previous research where the authors saw that increased delay resulted in longer time to acquire the cooperation response (Locey & Rachlin, 2012; Komorita et al., 1991).

Delay affected social distance placement. Across all participants, there was no significant difference in pre-assessment social distance placement. However, at post-assessment there was a significant difference in social distance placement, indicating that the participants differentially ranked the participants after experiencing delay to reciprocation (where probability of reciprocation was held constant). The 3 s CP was ranked closest, followed by the 8 s CP, and then the 13 s CP—a trend present in three of the four groups. While not all groups exhibited a major difference in social distance placement, the 3 s CP was always placed socially closest exhibiting some effect of delay.

In addition to being considered socially closest, the choice allocation task demonstrated a preference for the 3 s CP. Moreover, increased choice with decreased delay to reciprocate. Given that choice allocation was not presented before the PDGs, a causal claim of delay to reciprocate cannot be made. However, like in Experiment 1, the choice allocation provides information about the highest preferred CP. In order to demonstrate differential preference between CPs (e.g., a rank order), a preference assessment format or demand analysis (Reed et al., 2009) may be used and compared to the ordinal ranking scale used in the present study.

Participants indicated the value of $100 before and after interacting with the CPs (player social discounting). The value of $100 did not differ significantly at pre-assessment, but did at post-assessment, indicating that delay to reciprocate in the PDGs influenced reinforcer value. However, it is important to note that there was no change in the median 3 s value of $100 (whereas value to the other two CPs decreased). Like Experiment 1, value of $100 is inconsistent with the social distance placement of the CPs. Since all CPs decreased in social distance after the PDG, it is expected that the value of $100 should increase for all CPs after the PDG (with the highest value for the 3 s CP, followed by 8 s, and then 13 s). As stated earlier, this might not have been the case if real, relevant discounting outcomes were used.

There are several differences in discount rate correlations from Experiment 1. First, Experiment 2 observed moderate correlations between social and reciprocal discount rates at pre- and post-assessment. These results replicate Buddiga and Locey (2022b), indicating a change in participant's altruistic choice as the participant's report of a socially distant person's altruism changes. Next, unlike Experiment 1, no significant correlation was detected between reciprocal and probability discounting. Lastly, Experiment 2 detected a moderate correlation between pre-assessment social and delay discounting. Such inconsistencies require additional research to be conducted on the exact relations between discounting questionnaires.

Experiment 2 found that delay to reciprocate affects both cooperation and social distance placement. Delay and the order in which delays were experienced affected cooperation for participants across different orders. Social distance placement was affected by delay to reciprocate, with the quickest responding CP (3 s) ranking closest in social distance across orders.

General Discussion

Altruistic and cooperative choice decreases as the beneficiary of those choices increases in social distance. While many studies have confirmed the declining value of reinforcement as social distance increases (Jones & Rachlin, 2006; Yi et al., 2011; Strombach et al., 2014; Białaszek et al., 2019), no study has investigated how social distance changes as a function of interaction with other people. Cooperation has been shown to change with probability of reciprocation and delay to reciprocate in a PDG

(Baker & Rachlin, 2001; Locey & Rachlin, 2012) so the present set of experiments evaluated the effects of those variables on both cooperation and social distance in a within-subject analysis. This study demonstrates that social distance and cooperation are influenced by probability of reciprocation and delay to reciprocate in a prisoner's dilemma game.

Experiment 1 manipulated probability of reciprocation (25%, 75%, 100%) while keeping delay to reciprocate constant. Reciprocating 100% of the time (playing tit-for-tat; Axelrod, 1984) resulted in the highest cooperation rates relative to the other probabilities. Moreover, the CP programmed to reciprocate 100% of the trials, was considered socially closest (according to the social distance post-assessments) and most preferred for future interactions (according to the choice allocation task). In Experiment 2, where delay to reciprocate was manipulated (3 s, 8 s, and 13 s) and probability of reciprocation was held constant (at 100%), the delay and order of delay affected cooperation rates. Specifically, participants who initially experienced a CP with a longer reciprocation delay took longer to acquire the cooperation response that maximized reinforcement. Generally, the quick delay CP (3 s) was placed socially closest and most preferred for future interactions. Thus, it is suggested that people who always reciprocate choices and reciprocate quickly are likely to be socially closer to an individual.

Interestingly, social distance was not a precise function of probability of reciprocation; participants placed the 25% CP socially closer than the 75% CP, despite the lower probability of reciprocation. Baker and Rachlin (2001) have found that among 50% and 75% probabilities of reciprocation, participant cooperation was not significantly different across the two conditions when a discriminative stimulus was not present. In the present study, despite the similar cooperation rates observed, the 25% CP was considered socially closer than the 75% CP – perhaps due to the greater amount of money earned with the 25% CP.

Delay to reciprocate seemed to have a more precise effect on social distance placement. The 3 s CP was considered socially closest, followed by the 8 s CP, and then the 13 s CP – although not all groups yielded significant differences in CP post-assessment social distance. This is likely due to the delays chosen for the experiment. Although these small differences in delay (e.g., 3 s vs 8 s) were enough to differentially impact cooperation in both this and previous studies (Locey & Rachlin, 2012), actual delays experienced in real life are generally much longer than 3-13 s. For example, if I help a friend study for an exam one night, they might reciprocate that action with helping me study the following week. Therefore, it is possible that the participant may not place the CPs at significantly different social distances when each CP was programmed to reciprocate at generally short delays.

This study did not compare delay and probability of reciprocation directly. Therefore, minimal conclusions may be drawn from which affects social distance "more". But one commonality was found throughout these studies: order matters. In the probability of reciprocation manipulation, participants who experienced the 25% CP first took longer to acquire the cooperation response in the 100% CP exposure. Similarly, in the delay to reciprocate manipulation, those who experienced the longer delay CPs first, took longer to acquire the cooperation response. Stimulus generalization can account for these results (Mednick & Freeman, 1960). While the CPs differed in color (i.e., blue, purple, or red), all other stimulus qualities were the same (size, shape, pattern). So, once a particular pattern of responding is acquired, the organism is likely to continue engaging in that pattern with a structurally similar stimulus.

The choice allocation task presented concurrently available social interactions. Social distance has been an unexamined facet of the social discounting literature with any elucidation of social distance depending on verbal report (e.g., participants report socially distant persons asked about in social discounting; Locey et al., 2011; Buddiga & Locey, 2022a). The choice allocation procedure demonstrated some covariation with social distance placement (moderate correlation with probability of reciprocation and weak with delay to reciprocate), suggesting social distance verbal reporting is accurate. However, more research is needed to compare this procedure to social distance verbal reports.

The Player Social Discounting task and inconsistent correlational relationships during pre-and post-assessment discounting elucidates issues with general social discounting procedures. It shows that there may be poor instructional stimulus control of verbal report. This is evident by the decreasing value of $100 to some CPs, even though all CPs decreased in social distance. It seems unlikely that a participant would value money more towards a stranger (CPs before the PDG interactions) than someone familiar (CPs after the PDG interactions) unless they disliked someone after interacting with them. Given that CPs decreased in social distance, it is unlikely that the participants “disliked” the CPs. But the social distance ratio scale does have a ceiling on social distance. So, if the participant placed a CP at social distance 20 before interaction, the participant could not place the CP any further than 20 after interaction. The unconstrained ordinal ranking task in this study should alleviate this issue, however the variability in participant rankings was so extreme that, again, there might have been poor instructional control.

This poor instructional control is not limited to the present studies. Previous studies presenting the social distance prompt typically have not specified the variable by which social distance should be ordered (e.g., Jones & Rachlin, 2006; Buddiga & Locey, 2022a; Romanowich, 2022). Instead, researchers use the following (or something very similar):

> The following experiment asks you to imagine that you have made a list of the 100 people closest to you in the world ranging from your dearest friend or relative at position #1 to a mere acquaintance at #100. The person at number one would be someone you know well and is your closest friend or relative. The person at #100 might be someone you recognize and encounter but perhaps you may not even know their name. (Locey & Rachlin, 2015, p. 73)

The frame "closest to you" can be interpreted very differently across participants (e.g., time spent with a person, 'likability', etc.). The present study did not control for framing—a variable shown to influence delay discount rates (e.g., Barcelos Nomicos et al., 2020; DeHart & Odum, 2015). Increasing the specificity of the social distance frame should be the center of future research.

Implications for Research

Conceptual Refinement

Social distance as a construct has not undergone much evaluation since its introduction to behavior analysis (Rachlin et al., 1991). Thus, not enough attention has been drawn to whether this construct is meaningful to the research as its conception is an imposed construct from economics (Simon [1995] talks about 'interpersonal allocation' between people) rather than one derived from contacts with events (Fryling, 2017).

Given that the construct was borrowed, it has not been derived properly from the behavior analyst's contacts with events. Rather it was imposed onto behavior analytic investigations of altruism. Imposing constructs is problematic because they are assumed to adequately describe events but they often fall short of a naturalistic definition. This is demonstrated by the following social distance definition by Rachlin and Jones (2010): "*the closer you feel* to another person or group of people, the more likely you should be to cooperate with that person or group." (pp. 416-417; italics added). This feeling of closeness constitutes a person's "social space" (p. 417)—another construct used to describe social distance. A construct should avoid using feelings to define a term as there is no naturalistic referent. The referent should be of the natural world and thus available for scientific investigation. Instead, when an internal construct is inferred, there is no naturalistic referent that the scientist can further examine, preventing scientific investigation. The present study brings to light this critical limitation of social discounting research—one of which requires major conceptual refinement.

Experimental Directions & Applied Implications

There are several experimental studies that could be conducted in the future. The present study found that probability of reciprocation does not covary with social distance exactly; further research should be conducted on a wider range of probabilities (and across varying degrees of stimulus control with respect to those different probabilities) to confirm this finding. Delay to reciprocate influences social distance but longer delays should also be used in future research. Other variables that have been shown to influence cooperation (e.g., verbal communication, inequity, risk, power; Sampaio, 2020; Marwell

& Schmitt, 1975; Lopez et al., 2022) could also influence social distance and should be the target of future studies.

Upcoming research may wish to use a different interpersonal task than the PDG. The PDG was chosen for the present study due to the previous research on social discounting and cooperation during this task. For example, predictions in other cooperative tasks can be conducted to examine the utility of the social discount function.

Another direction for future research could be the impact of shared aversive and reinforcing histories with other players on social distance. Dyads could be recruited and placed in either an aversive partner task (e.g., response cost contingencies) or reinforcing partner task. Then social distance and cooperation with the other player may be assessed. Similarly, changing the probability of reciprocation from a confederate player could differentially impact social distance and cooperation.

While the present study is a preliminary investigation of social distance at the experimental level, there are some applied implications that can be addressed in the future. For example, political science has a concept of *social capital* that can be informed by social distance research. Social capital refers to the "features of social life—networks, norms, and trust—that enable participants to act together more effectively to pursue shared interests" (Putnam, 1995). Social distance research provides an enhanced understanding of interpersonal relationships and how this may affect larger social structures (e.g., governmental relations). Those who always reciprocate quickly might have more successful interpersonal relationships with other people—although given the experimental nature of the current study, this implication must be extrapolated with caution.

Limitations

There are several limitations to these studies. First, only 37 trials were experienced with each CP. If more trials were experienced, cooperation might have been significantly different between the CPs across all orders in both experiments. For example, Baker and Rachlin (2001) had participants experience 100-trials with the CP. But Baker and Rachlin implemented a between-group analysis, so each participant only played with one other CP. The study here opted to implement a within-subject analysis so 37 trials were chosen to prevent fatigue effects of playing multiple PDGs. Still, future research might investigate a between-groups design for these probabilities and delays with a greater number of trials.

Another limitation is the lack of control confederates. While the present results demonstrate a social distance change for all experienced CPs, including one or two CPs that the participant does not interact with through the PDGs would provide more information about whether social distance changes were due to probability of reciprocation or delay to reciprocate. Next, the present studies depended on believability of the CPs as real people. While no participants in Experiment 1 reported playing with a computer and only one participant in Experiment 2 reported not believing the CPs were real people, more participants might have believed they were playing with computers but did not report it. Lastly, poor instructional control could account for the inconsistencies between player social discounting and social distance values. Future research should evaluate these tasks with real, relevant outcomes in order to improve control of responding.

Conclusions

As behavior analysts grow more interested in increasing prosocial choice in our environments, a comprehensive understanding of altruism and cooperation is needed. While the social discounting framework provides a behavior analytic account of these choices, a complete understanding is hindered by the lack of research on social distance. The present study contributes to the current literature by examining social distance as a dependent variable.

It has been demonstrated that both probability and delay of reciprocation influence social distance and cooperation. The present set of experiments provides an initial framework for conducting an exploration of social distance. However, it is apparent that conceptual refinement is needed before proceeding with further investigation. Future experiments and conceptual work may contribute greatly to such refinement and should be conducted in the future.

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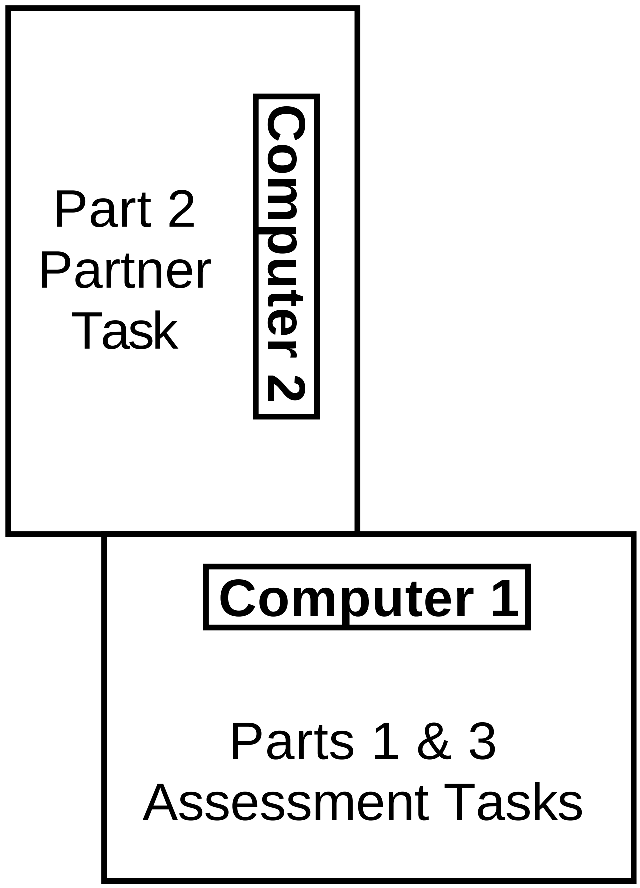
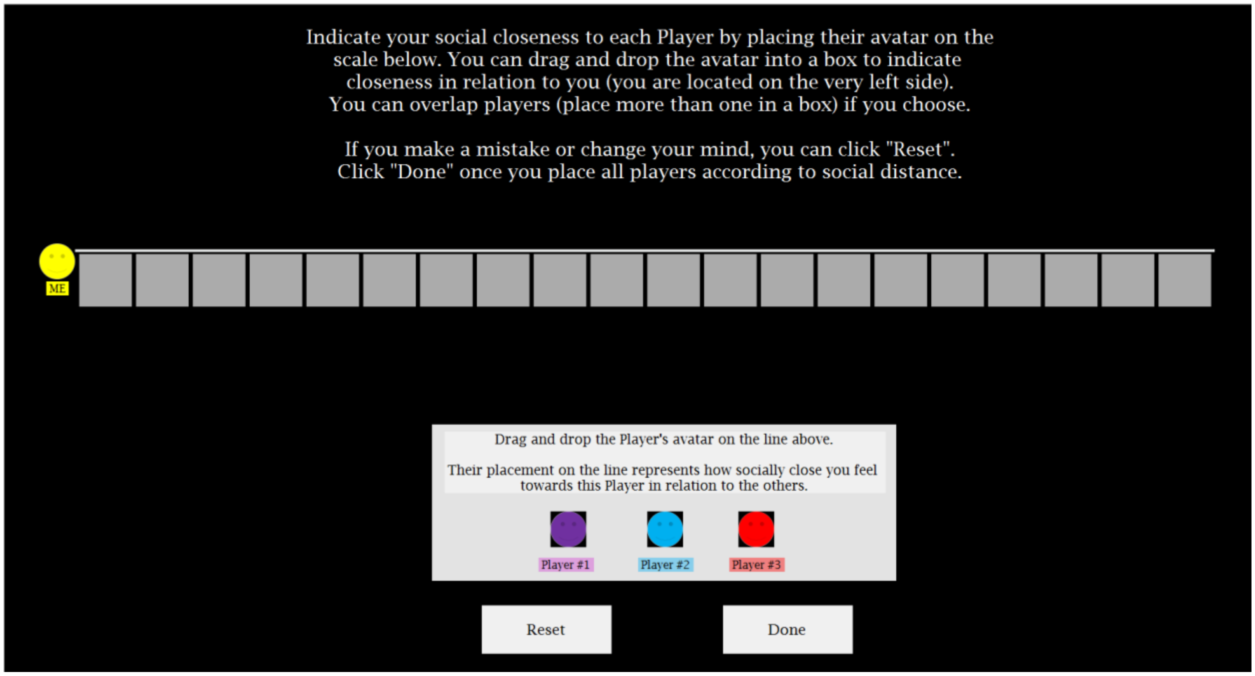
Appendix A

Study Set-up
Participants completed Assessment Tasks (Parts 1 and 3) at Computer 1 and the Partner Tasks (Part 2) at Computer 2.



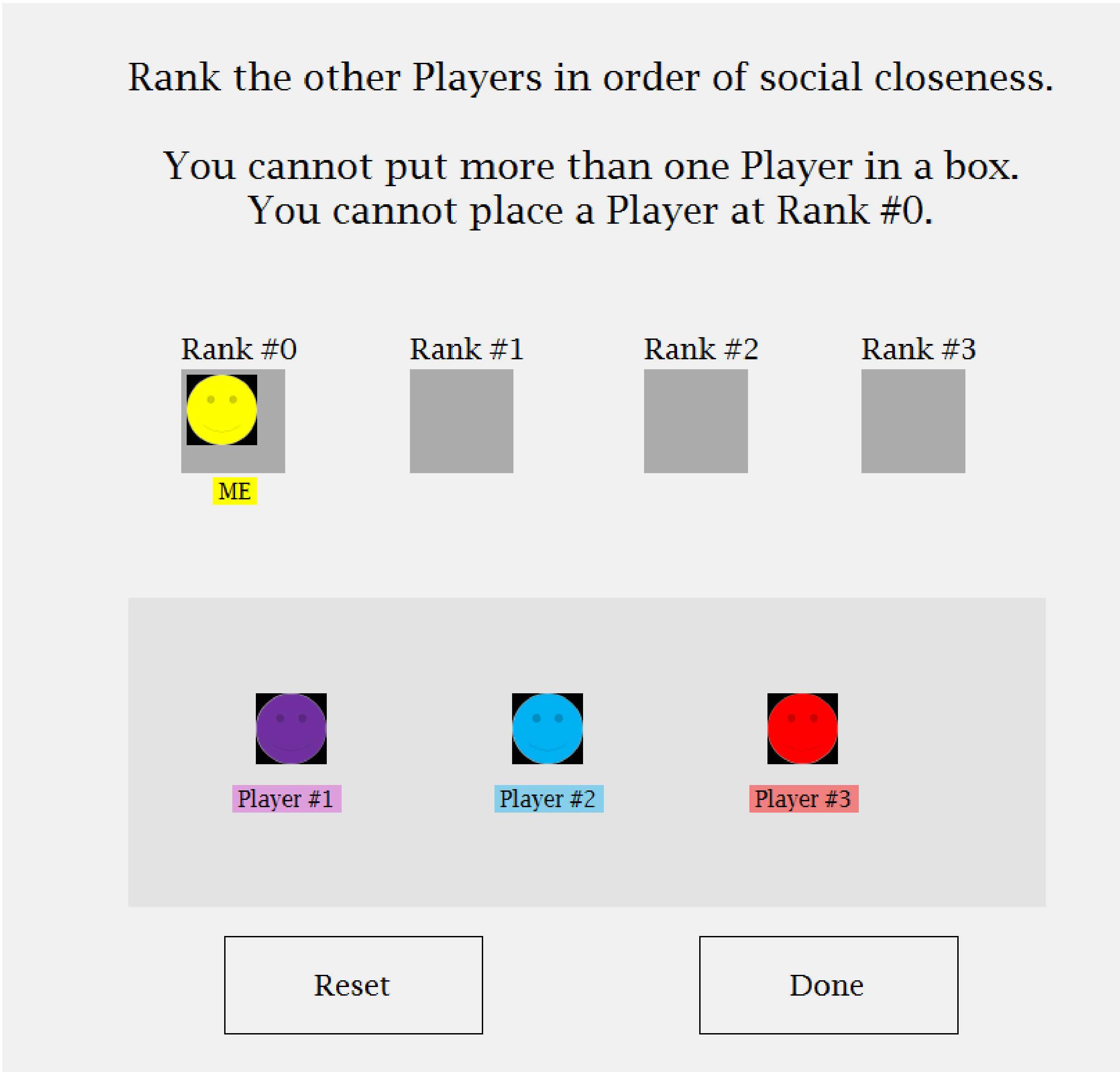
Appendix B

Social Distance Assessment – Ratio Scale



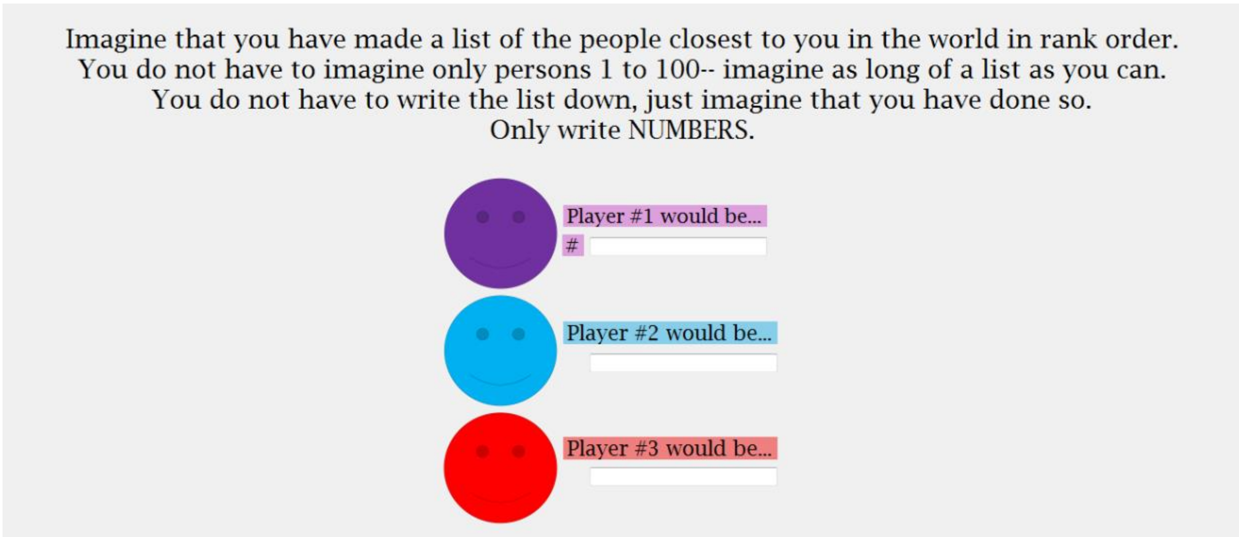
Appendix C

Social Distance Assessment – Three-Person Ordinal Rank



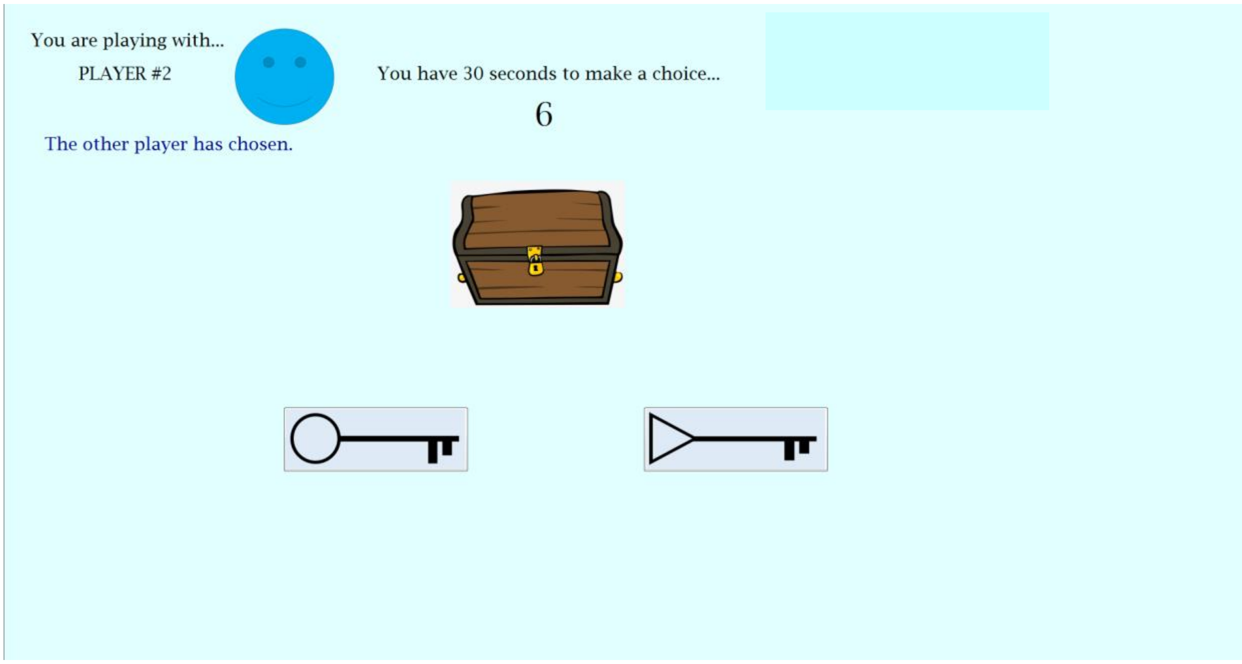
Appendix D

Social Distance Assessment – General Ordinal Rank



Appendix E

Treasure Game with Player #2



Appendix F

Experiment 1 – CP latency (in seconds) to selection. PR = Probability of Reciprocation

25% PR				**75% PR**				**100% PR**			
Order A		**Order B**		**Order A**		**Order B**		**Order A**		**Order B**	
Delay	**Trial**	**Delay**	**Trial**	**Delay**	**Trial**	**Delay**	**Trial**	**Delay**	**Trial**	**Delay**	**Trial**
4	2	6	1	4	1	4	1	4	7	4	2
	1		3		2		2		5		5
	10	5	2		4		4		6		6
	12	4	4		6		6		8		8
3	9		6	3	3	3	3	3	1	3	1
	11	3	5		5		5		2		7
	24		24		16		28		12		12
	25		33		24		29		32		32
2	3	2	7	2	7	2	7	2	3	2	3
	4		8		8		8		4		4
	5		13		9		9		9		9
	7		15		11		11		10		10
	13		21		13		21		11		11
	15		22		14		22		17		17
	21		23		15		24		19		19
	22		25		21		25		21		21
	23		26		22		26		22		22
	26		28		23		27		24		24
	29		29		25		30		25		25
	30		30		26		33		26		26
	32		32		28		34		28		28
	33		34		29		36		29		29
	34		37		30		37		30		30
	36	1	9		32	1	10		31		31
	37		10		33		12		33		33
1	6		11		34		13		34		34
	8		12		36		14		36		36
	14		14		37		15		37		37
	16		16	1	10		16	1	13	1	13
	17		17		12		17		14		14
	18		18		17		18		15		15
	19		19		18		19		16		16
	20		20		19		20		18		18
	27		27		20		23		20		20
	28		31		27		31		23		23
	31		35		31		32		27		27
	35		36		35		35		35		35

Appendix G

Experiment 1 – Reciprocation trials. R is "reciprocate" and C is "cooperate".

Set	Trial	Player 1 (25%)	Player 3 (75%)	Player 2 (100%)
	1	C	C	C
1	2	R	R	R
	3		R	R
	4			R
	5		R	R
2	6		R	R
	7		R	R
	8	R	R	R
	9			R
3	10		R	R
	11			R
	12		R	R
	13	R	R	R
4	14		R	R
	15	R	R	R
	16			R
	17		R	R
5	18			R
	29		R	R
	20		R	R
	21	R	R	R
6	22			R
	23		R	R
	24	R	R	R
	25		R	R
7	26	R	R	R
	27		R	R
	28			R
	29		R	R
8	30			R
	31	R	R	R
	32		R	R
	33		R	R
9	34		R	R
	35		R	R
	36		R	R
	37	R		R

Appendix H

Experiment 1 – Reciprocation trials and trial delays during choice allocation APDGs.

Set	Trial	Player 1 (25%)		Player 3 (75%)		Player 2 (100%)	
		Reciprocation	Delay (seconds)	Reciprocation	Delay (seconds)	Reciprocation	Delay (seconds)
	1	C	3	C	1	C	2
1	2	R	3	R	3	R	3
	3		2	R	2	R	3
	4		5		5	R	1
	5		1	R	1	R	5
2	6		3	R	3	R	1
	7	R	2	R	3	R	1
	8		1	R	2	R	3
	9		1		1	R	2

Appendix I

Experiment 2 – Delays (in seconds) to reciprocate on trials.

Set	Trial	Player 1 (3 s)	Player 3 (8 s)	Player 2 (13 s)
	1	3	8	13
1	2	2	7	12
	3	3	8	13
	4	4	9	14
	5	2	8	13
2	6	3	8	13
	7	1	6	11
	8	5	10	15
	9	3	8	13
3	10	3	8	13
	11	4	9	14
	12	3	8	13
	13	2	7	12
4	14	1	6	11
	15	3	8	13
	16	5	10	15
	17	3	8	13
5	18	3	8	13
	29	4	9	14
	20	3	8	13
	21	2	7	12
6	22	3	8	13
	23	3	8	13
	24	1	6	11
	25	5	10	15
7	26	3	8	13
	27	1	6	11
	28	3	8	13
	29	5	10	15
8	30	4	9	14
	31	2	7	12
	32	2	7	12
	33	4	9	14
9	34	3	8	13
	35	3	8	13
	36	3	8	13
	37	3	8	13

Appendix J

Experiment 2 – Trial delays (in seconds) during choice allocation APDGs

Set	Trial	Player 1 (3 s)	Player 3 (8 s)	Player 2 (13 s)
	1	3	8	13
1	2	3	8	13
	3	2	7	12
	4	5	10	15
	5	2	7	12
2	6	3	8	13
	7	3	8	13
	8	3	8	13
	9	3	8	13