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Authors

Moreira, Joao
Tashjian, Sarah
Galván, Adriana
et al.

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Computational and Motivational Mechanisms of Human Social Decision Making Involving Close Others

João F. Guassi Moreira[*], **Sarah M. Tashjian**, **Adriana Galván**, **Jennifer A. Silvers**[*]

Department of Psychology, University of California, Los Angeles

Abstract

Every day, human beings make decisions with social consequences. These social consequences matter most when they impact those closest to us. Recent research has shown that humans exhibit reliable preferences when deciding between conflicting outcomes involving close others – for example, prioritizing the interests of one's family member over one's friend. However, virtually nothing is known about the mechanisms that drive these preferences. We conducted a pre-registered study in a large (maximum *N*=375) sample to quantify the computational and motivational mechanisms of human social decision-making preferences involving close others. By pairing assessment techniques from behavioral economics and psychological science with computational modeling and random coefficient regression, we show that value-based cognitive computations (e.g., risk and loss aversion) drive social decision-making preferences involving financial outcomes, whereas socioemotional motivations (e.g., relationship quality) underlie preferences involving social outcomes. These results imply mechanistic heterogeneity, underscoring a need for greater attention to contextual specificity in social decision-making.

Keywords

social decision-making; close others; motivation; computational modeling; discounting

As members of a highly social species, humans frequently make decisions that have consequences for other individuals. In real life, our decisions most commonly impact

[*]**Corresponding authors at:** A191 Franz Hall, 502 Portola Plaza, Los Angeles, CA, 90095-1563 jguassimoreira@ucla.edu, silvers@ucla.edu.

Author Contributions

J. F. Guassi Moreira and J. A. Silvers developed the study concept with input from S. M. Tashjian. J. F. Guassi Moreira, and J. A. Silvers designed the study. Data were collected by J. F. Guassi Moreira. Data were prepared and analyzed by J. F. Guassi Moreira under the supervision of J. A. Silvers. All authors interpreted the results. J. F. Guassi Moreira drafted the first version of the manuscript with extensive input from J. A. Silvers. S. M. Tashjian, A. Galván, and J. A. Silvers all provided critical revisions. All the authors approved the final manuscript for submission.

Open Practices

All data and materials for this study, in addition to its pre-registration, can be accessed at the Open Science Framework (https://osf.io/6278m/?view_only=3264b80da15b44cca983e3c45e1f8e6b & https://osf.io/d42ar/?view_only=3264b80da15b44cca983e3c45e1f8e6b).

Supplementary data

Supplementary material

those closest to us, including our friends and family (Henrich, 2002; Mathews, 1987). Indeed, observational research suggests that close others can strongly influence decisions regarding education, employment, health, and finances (Fareri, Smith, & Delgado, 2020; Johnson, 2009; Kirchler, Holzl, Rodler, & Meier, 2001; Lavner, Weiss, Miller, & Karney, 2018). However, the vast majority of social decision-making experiments to date have relied upon paradigms wherein participants make decisions involving a single unfamiliar confederate (Camerer, 2011; Feldmanhall & Chang, 2018; Rilling & Sanfey, 2011). Drawing broad inferences about social decision-making from paradigms with anonymous others is problematic because close relationship status, and even general familiarity, can profoundly influence social behavior (Ahmed & Chloe, 2014; Dunham, 2018; Fareri, Chang, & Delgado, 2015; Guassi Moreira & Telzer, 2018; McKelvey & Kerr, 1988; Meyer & Anderson, 2000; Telzer, Masten, Berkman, Lieberman, & Fuligni, 2010). For example, individuals are inclined to be highly generous to close others, sometimes even at a cost to oneself, but less so to strangers (Lockwood et al., 2017; Powers et al., 2018; Telzer et al., 2010). Consistent with this, when decision makers are forced to choose whose interests to prioritize, they rely heavily on the identity of those involved – for example, young adults are more likely to allocate resources to a parent at the expense of a friend than the contrary (Guassi Moreira, Tashjian, Galván, & Silvers, 2018, 2019). This suggests that social decision preferences may differ depending on whom they affect.

At least two issues have yet to be addressed, with regard to how humans make decisions impacting close others. First, it is unknown whether or not individuals consistently prioritize the same close others when different outcomes are at stake (e.g., do I spend both money and time on my parent instead of my friend?). This knowledge gap stems from the fact that prior social decision-making work involving close others has primarily examined decision-making preferences when monetary outcomes are at stake (Fareri et al., 2020; Guassi Moreira et al., 2018, 2019; Powers et al., 2018). Determining how stable social preferences are across different contexts (e.g., social, financial) is a necessary first step in forming comprehensive and unifying theories of social decision-making, which could promote integration between different research lines, generate future scientific predictions, and inspire applications outside of the laboratory. Second, extant research has failed to tell us the '*why*' behind social decision-making preferences. We do not know why an individual might prioritize one close other over another. Recent research suggests that value-based psychological systems are involved in tracking important social information (e.g., social status) and close-other status strongly modulates the subjective value of rewards (Feng, Zhao, & Donnay, 2013; Hackel, Doll, & Amodio, 2015; Morelli, Chang, Carlson, Kullar, & Zaki, 2018; Parkinson, Kleinbaum, & Wheatley, 2017; Wang, Cheng, Lee, & Chuang, 2019; Zerubavel, Bearman, Weber, & Ochsner, 2015; Zhao, Feng, & Kazinka, 2014) Coupled with the fact that prior studies on social decision-making with close others have found evidence of consistent preferences with monetary outcomes (Guassi Moreira et al., 2019), it is likely that a value-based psychological architecture may be driving these preferences while also leaving open the possibility that non-value-based architectures may drive preferences involving other outcomes (e.g., social motivations).

In light of the aforementioned gaps in the literature, our study had two major aims. First, we examined whether parent-over-friend preferences previously observed in the monetary

domain would generalize to decision-making contexts that involved social consequences (time spent with close other). We used two forms of discounting (delay: overweighting of smaller, immediate rewards over larger, delayed rewards; probabilistic: overweighting more certain rewards with a smaller expected value over less certain rewards with larger expected values) as our model decision-making paradigm largely due to its ability to accommodate both social and monetary rewards and amenability to fitting models that can account for both within and between subject effects. If prior research generalizes to discounting decisions, we would expect that individuals would temporally and probabilistically discount on trials when a parent benefitted and refrain from doing so when a parent did not. Moreover, if social preferences are domain-general, we expected parents would be prioritized both in decisions with financial and social outcomes.

Our second aim was focused on testing two candidate mechanisms that could potentially drive parent-versus-friend preferences. The first candidate mechanism was value-based computations, the implicit or explicit cognitions that support the subjective appraisal of value. Several frameworks have been proposed to formally articulate value-based computations thought to underlie decision-making (Feldmanhall & Chang, 2018; Glimcher, 2004; Niv & Chan, 2011). While each framework can provide uniquely meaningful information, we elected to adopt prospect theory—a dominant decision-making framework from behavioral economics (Tversky & Kahneman, 1992)—due to its success in characterizing decision-making behavior and ubiquity in the field. Prospect theory suggests computations of value are fueled by attitudes towards loss and risk. Briefly, loss aversion is the extent to which individuals overweigh losses relative to gains. Risk aversion is the extent to which diminishing sensitivity to marginal rewards reduces one's subjective valuation and engenders "safe'', risk averse behavior. Our focus on these two parameters was motivated by the facts that they both inform subjective computation of value and are sensitive to social cognitive demands such that they can be flexibly manipulated to support broader goals (Sokol-Hessner et al., 2009). In the present study we suspected that differences in social decision-making behaviors among close others—at both the group and individual level— could be mechanistically driven by differences in how averse individuals are to loss and risk for different close others, in turn influencing the subjective value computations for each close other. We note that our use of behavioral economics tasks in conjunction with computational modeling is a strength of this study for two major reasons. First, models make precise predictions about phenomena in ways that are easily verifiable and generative (i.e., probabilistic). Second, they can do not require introspection, and thus provide complementary insights to information gathered by self-report (Nisbett & Wilson, 1977).

The second candidate mechanism tested was socioemotional motivations. Socioemotional motivations were operationalized as reported relationship quality with each close other, under the assumption that individuals are motivated to maintain high quality relationships (Gable & Impett, 2012). Support for this mechanism would suggest that social preferences are not driven by differences in appraisals of value, but instead rely on the fulfillment of socioemotional goals. Finally, we also pursued an exploratory aim that tied the former two mechanisms together: assessing whether individual differences in candidate mechanisms tracked with individual differences in social decision-making preferences.

Methods

Study Overview & Hypotheses

In the current study, 225 participants completed discounting tasks involving two close others, a nominated parent and close friend, to probe social decision-making preferences. Decisions were compared under four conditions, a crossed design with two types of discounting—probabilistic, delay—and two types of outcomes—social, monetary. We employed two types of discounting and two types of outcomes to enhance the generalizability of our findings. Value-based computational (or simply,'computational') mechanisms (risk and loss aversion, as defined by prospect theory) were derived from behavior on an independent gambling task that a set of partially overlapping (overlap: N = 75) participants completed on behalf of a parent and friend (separate runs for each, N = 225). All participants (N = 375) additionally completed a self-report measure of relationship quality to assess socioemotional motivational mechanisms of social decision-making preferences (Inventory of Parent and Peer Attachment; IPPA (Armsden & Greenberg, 1987)). Hypotheses, methods, and analyses were pre-registered on the Open Science Framework prior to the beginning of the study. See the Methods section for more details. Our hypotheses follow (*H1* and *H2* were pre-registered, *H3* was not).

H1.—Based on prior research (Guassi Moreira et al., 2018), participants will favor parents over friends during decision-making that involves discounting across two outcome domains (social and monetary). As noted in the methods, we operationalize a preference for a given close other as discounting when it benefits that individual and refraining from discounting when it does not benefit the individual.

H2.—If decision-making preferences (e.g., prioritizing parents over friends) are informed by value-based computations, then participants will show group-level differences in loss and risk aversion parameters when making decisions on behalf of a parent and close friend (i.e., participants will have different loss and/or risk aversion values for parents compared to friends).

H3.—If socioemotional motivations are consequential for social decision-making preferences, then participants will show group-level differences in self-reported relationship quality (our measure of said mechanism) with a parent and close friend (i.e., participants will report different levels of relationship quality for parents compared to friends).

We had additional, exploratory aims to relate individual differences in computational and motivational mechanisms to decision-making preferences (both aims were pre-registered).

A1.—Determine whether individual differences in computational mechanisms (loss aversion, risk aversion) track with individual differences in decision-making preferences.

A2.—Determine whether individual differences in motivational mechanisms (relationship quality) track with individual differences in decision-making preferences.

Participants and Sampling Strategy

Participants were recruited from the metropolitan area of a large university in the Western United States via the undergraduate psychology subject pool. This study was part of a broader data collection effort aimed at understanding social decision-making processes involving close others—more information is given our pre-registration document (https://osf.io/6278m/?view_only=3264b80da15b44cca983e3c45e1f8e6b). For this study, we selected a subset of participants who either completed one of two computerized tasks, or both of them. N = 225 participants completed a task meant to index social decision-making preferences; N = 225 completed a task aimed at capturing computational mechanisms underlying social decision-making preferences; N = 75 completed both tasks. Thus, our sample size for the study was set at 375 total participants. The sample size for these cells were determined *a priori*. In setting our sample size, our goal was to recruit enough participants for well-powered tests for each task while also having a minimum number to examine cross-task, exploratory correlations (see preregistration document for further details). Two participants were excluded from analyses for non-compliance and one for being unable to nominate an appropriate close other. Thus, our final total sample was comprised of $N = 372$ (71 males, Mean age = 20.32 years, SD = 1.57, range = 18–29). Ethnically, 76 participants identified as Hispanic/Latinx whereas the remainder of the sample did not. Racially, 153 participants identified as Asians (41.1%), 119 identified as Caucasian (32%), 11 identified as African American (3%), 0 identified as Pacific Islander (0%), 1 identified as Native American (0.3%), 68 considered themselves to be another race, or mixed race (18.3%), and the remaining participants declined to respond about their race. Participants provided written consent in accordance with the policies of the local Institutional Review Board, and were compensated with course credit for their time. Data, code, and materials are publicly available on the Open Science Framework (OSF; https://osf.io/d42ar/?view_only=3264b80da15b44cca983e3c45e1f8e6b).

Procedure

Upon arriving to the laboratory participants provided informed consent, nominated a parent and close friend of their choice, underwent a manipulation to increase the salience of their nominated parent and friend, took a survey containing several self-report measures of interest, and then completed one of nine possible pairings of two computerized tasks. Though all nine pairings were part of a broader data collection effort concerning social decision-making, we only report data from two tasks here (other tasks have yielded results published elsewhere Guassi Moreira et al., 2019), , or have not yet been analyzed). An experimenter extensively trained participants on how to complete each task, and proceeded with the experiment only after the experimenter judged the participant adequately understood the instructions. The experimenter then unobtrusively observed each participant as they completed the experiment to ensure compliance. Key measures involved in the current report are described in detail below. Full measures are disclosed in the supplement and available on our OSF page (https://osf.io/6278m/?view_only=3264b80da15b44cca983e3c45e1f8e6b).

Parent—Friend Nomination & Salience Manipulation.—At the beginning of the study, participants were told they would be completing hypothetical decisions that would

affect a parent and close friend, and that they would be required to choose the parent and close friend discussed in the scenarios. Participants were told to nominate any parent and any close friend that satisfied the following conditions: both individuals were still alive, the friend was not a current romantic partner, the friend was not a family member (e.g., sibling, cousin), and the friend was still an active friend (e.g., a friend who they no longer kept in touch with was not allowed). Afterwards, we asked participants to write down basic information about each person (e.g., name, age, sex), a memory they had with each person, and a handful of words and phrases describing each person. The memory manipulation was used to enhance the likelihood that close others would be salient in participants minds while making hypothetical decisions about them (Guassi Moreira et al., 2018).

Experimental Tasks and Measures

Overview.—At least one of the following two tasks was administered to all participants in the current study. A subset of participants completed both sets of tasks. Participants who did not complete both tasks described here completed additional tasks, but those data have been reported elsewhere (the full list of tasks is available online in our pre-registration document). All tasks were programmed in PsychoPy (v1.90.3) and run on PCs running Windows 10; all surveys were administered via Qualtrics. Though all rewards (monetary or social) were hypothetical, participants were carefully and repeatedly instructed to complete the tasks as if the rewards were truly real. The use of hypothetical rewards here was virtually necessary for social rewards, as we could not force participants to actually spend time with a parent or friend of their choice

Discounting Task.: Social decision-making preferences were assessed using a suite of discounting decisions. We chose to focus on discounting for several reasons. First, we hoped to expand prior work demonstrating a preference for parents over friends in risk taking and probabilistic learning contexts (Guassi Moreira et al., 2018, 2019) by assessing whether this preference generalized to an entirely different kind of decision-making context. Second, discounting decisions are thought to be heavily consequential for wellbeing and adjustment outcomes (e.g., 12) since they simulate value-based trade-offs that individuals often encounter in everyday life. Last, discounting tasks are flexible and allow for modeling behavior across many different reward outcomes (Seaman et al., 2016).

Participants completed discounting decisions in a fully crossed 2 X 2 design that yielded four conditions: one dimension varied in terms of the type of discounting (delay and probabilistic) and the other varied in terms of the type of hypothetical reward (monetary and social). Regardless of condition, participants were presented with two scenarios and were told one would affect their parent and the other would affect their friend. One scenario involved a more immediate or certain reward, and another involved a more delayed or uncertain reward. Half of the trials in each run involved the parent receiving the former and the friend receiving the latter, while the other half involved the opposite. In the delay discounting conditions, participants could choose between a relatively immediate reward or a larger delayed reward—the time delays could take the value of zero (i.e.,'Today'), 2 weeks, 4 weeks, and 6 weeks. In the probabilistic discounting conditions, participants could choose between a relatively more certain reward or a larger, more uncertain reward—the

certainties could take the value of 100% (i.e., no uncertainty), 75%, 50%, and 25%. Reward values ranged from 2 to 30 in all tasks. In the monetary rewards condition, reward values were treated as being equivalent to US Dollars; in the social reward condition, rewards were treated as time spent with either close other (e.g., 16 minutes spent with one of the nominated close others). There is an inherent asymmetry to this design (monetary rewards are *won for* a close other, social rewards are *shared with* them), but attempts to equate the two could introduce other, more serious confounds (e.g., participants could have made social decisions that involved allowing parent/friend to spend time with another loved one, but that is unlikely to represent a meaningful preference). For example, on the delay discounting task involving monetary rewards, one might choose between earning $6 for their parent now or earning $14 for their friend in four weeks. In this particular case, choosing $6 for a parent, thereby discounting the $14 reward for a friend, would be consistent with a parent preference. Further, someone with such a preference would make the opposite choice when the parent-friend labels were reversed (e.g., choosing $14 for a parent in four weeks over $6 for a friend now). We assume the same for the social condition—a parent preference is indicated by selectively discounting when the parent benefits, and refraining from discounting when it also benefits the parent (the opposite pattern would be indicative of a friend pattern). The exact values for each trial were adapted from an open resource (osf.io/bths8/). Participants completed 98 trials per run and the runs were self-paced (although participants were told not to dwell on any individual choice for too long). Figure 1 (left panel) depicts a schematic of the task. Although all rewards were hypothetical, it was heavily stressed to participants they were to complete the task as if the rewards were real.

Gambling Task.: In order to understand the computational mechanisms of social decision-making preferences (i.e., an individual's tendency to prioritize their parent or friend), we employed a simple binary gambling task in which participants played for hypothetical monetary rewards. Data from this task are widely used in the behavioral economics literature as a means to quantify subjects' loss and risk aversion (Sokol-Hessner et al., 2009; Sokol-Hessner, Raio, Gottesman, Lackovic, & Phelps, 2016). During the task, participants are required to make 150 binary decisions between a certain guaranteed reward and a gamble with two potential outcomes (50% chance each). Most trials (120) involved a gamble whose two potential outcomes were a positive amount and a negative amount (amounts varied across trials), compared to a guaranteed option of zero dollars. A subset of trials (30) involved a gamble whose two potential outcomes were a positive amount and zero dollars, compared to a guaranteed option of a smaller positive amount. See Figure 1 (right panel) for a schematic. The inclusion of these two trial types in the task allowed us to tease apart attitudes towards risk and loss[1], each of which involve unique underlying computations. Probabilities were made explicit to participants during training. Trial order was randomly selected across participants. Participants were given unlimited time to make their decision on each trial (but were encouraged to not dwell too long on any individual choice), and decision outcomes were presented for 1500ms. Monetary values for each trial were used from a prior study with open data (Sokol-Hessner et al., 2015; osf.io/i5knh/). Participants

[1]Loss and risk aversion tend to be highly correlated. As a result, gain and loss trials are necessary to estimate each parameter in the same dataset (See Sokol-Hessner et al., 2009).

completed two runs of the task, one in which they were instructed to make decisions as if their nominated friend were to be affected and another as if their nominated parent was to be affected. Although decisions involved hypothetical monetary outcomes, it was heavily stressed that participants were asked to complete the task as if their parent and friend stood to actually gain or lose based on the outcomes of the task.

Inventory of Parent & Peer Attachment (IPPA).: We operationalized social motivations using a measure of relationship quality with parents and friends. We specifically used relationship quality to index motivational mechanisms contingent upon the notion that individuals are motivated to maintain high quality relationships. We hypothesized that relationship quality might serve as a prospective motivational mechanism behind social decision-making. As we had done in prior, related studies, relationship quality with parents and friends was assessed using the Inventory of Parent and Peer Attachment (IPPA; Armsden & Greenberg, 1987). The IPPA has been widely used to assess relationship quality (e.g., Fanti, Henrich, Brookmeyer, & Kuperminc, 2008) and was initially validated in college-age samples. Using a 5-point Likert scale (1 = *almost never or never*, 5 = *almost always or always*), participants answered 28 items about their relationships with their nominated parent (example item: ”My parent respects my feelings”), and 25 items about their relationship with their nominated friend (example item: ”When we discuss things, my friend considers my point of view”). Reponses for parents and friends were reverse scored as needed and averaged to yield a single mean score of parent and friend relationship quality, respectively. Model based reliability statistics show that our administration of both parent and friend scales are internally consistent and that composites appropriately capture multidimensionality (Parent: ω = .96, ω-hierarchical = .76; Friend: ω = .96, ω-hierarchical = .71). A list of additional self-report measures that were collected can be found online in our pre-registration document as well as the Supplement.

Modeling

Discounting.—Data from all four runs of the discounting task (one for each condition, delay discounting with monetary rewards, delay discounting with social rewards, probabilistic discounting with monetary rewards, and probabilistic discounting with social rewards) were analyzed in four separate random coefficient regression models using the HLM for Windows computer program (Raudenbush & Byrk, 2002). We modeled trial-level decisions nested within participants using the following equation.

$$\text{Logit}(\text{Decision}_{it}) = \pi_{0i} + \pi_{1i}(\text{Condition}_{it}) + \pi_{2i}(\text{RewardRatio}_{it}) + \varepsilon_{it}$$

Here we modeled the log odds of the *t*-th decision from the *i*-th participant (1 = discount, = 0 non-discount) as a function of condition (0 = Friend associated with discounting choice, parent associated with non-discounting choice; 1 = parent associated with discounting choice, friend associated with non-discounting choice) (note that this condition parameter is different from the conditions of the discounting tasks, e.g., delay monetary), and a grand-mean centered reward ratio (a ratio of the non-discounting option over the discounting option—greater values indicated a greater difference between the more delayed/more

uncertain reward and the more immediate/more uncertain reward). The π_{0i} parameter represents the intercept (i.e., when expected log-odds of making a discounting choice when condition = 0 and when RewardRatio is at the grand mean), the π_{1i} parameter is the adjusted logit(odds ratio) of choosing to discount when a parent's outcome is associated with the discounting option (and friend's outcome is associated with non-discounting option) compared to the opposite, and the π_{2i} parameter represents the expected change in the log odds of choosing to discount given a 1 unit increase in the RewardRatio (non-discounted reward option divided by the discounted reward option), over and above the effect of condition. The Condition variable is coded in such a way that a positive value indicates that individuals favor parents over friends (e.g., individuals are more likely to discount when a parent benefits at the expense of a friend, less likely to discount when a friend benefits at the expense of a parent), a negative value indicates individuals favor friends over parents, and a value of zero indicates no preference. Inclusion of the RewardRatio parameter is meaningful, because it (i) controls for lower level features of the task and (ii) can indicate whether individuals are generally paying attention to the task (i.e., greater RewardRatio should be related to decreased discounting behavior, consistent with previous work (Ludwig et al., 2019)). Notably, these parameters were allowed to vary randomly across participants (i.e., the level 2 units). Results in this modeling framework are from the population average solution with robust standard errors (modeled over dispersion).

We ran additional models that included between subject predictors, namely variables aimed at capturing underlying computational and motivational mechanisms of decision-making preferences. More information is described in the 'Analysis Plan' section.

Gambling.—Computational mechanisms of social decision-making were modeled from the gambling task data by fitting Sokol-Hessner and colleague's models derived from prospect theory (Sokol-Hessner et al., 2009, 2015, 2016; Tversky & Kahneman, 1992). The subjective utility ($u(x)$) of objective rewards during the task was calculated using the following piecewise functions.

$$u(x^+) = p(x^+) * (x^+)^\rho$$

$$u(x^-) = -\lambda * p(x^-) * (-x^-)^\rho$$

The two equations model the subjective utilities of gains and losses, respectively. The objective monetary amount is represented by x, $p(x)$ represents the probability of the objective monetary amount (1 for the guaranteed option, .5 for the gamble), ρ is the risk aversion parameter (1 indicates risk neutrality, < 1 indicates risk aversion for gains, risk seeking for losses, > 1 indicates risk seeking for losses, risk aversion for gains), and λ is the loss aversion parameter (1 indicates gain-loss neutrality, < 1 indicates gain seeking, > 1 indicates loss aversion). Subjective utility values were translated into choice probabilities using the SoftMax function.

$$p(\text{gamble}) = \left(1 + e^{-\mu * [u(\text{gamble}) - u(\text{guaranteed})]}\right)^{-1}$$

Where e is Euler's number and μ is a choice consistency parameter. The latter term describes whether the relationship between subjective value results choice behavior is stochastic or deterministic (greater parameter values indicate more deterministic decision-making). This equation was adapted into a likelihood function in order to perform maximum likelihood estimation. The optim()function in R was used to perform constrained optimization (Byrd, Lu, Nocedal, & Zhu, 1995) on the likelihood function using starting parameters obtained via grid search. Loss and risk aversion values were constrained between 0 and 10, whereas choice consistency parameters were constrained to fall between 0 and 35.

Results

Analysis Plan

Every step of the analysis plan was decided *a priori* unless noted otherwise (i.e., 'post-hoc'). We first ran four random coefficient regression models on the discounting data to conceptually replicate prior work demonstrating that young adults prioritize parents over friends. Specifically, because prior work only examined decision-making with monetary consequences, we sought to test in the present study whether young adults would also prioritize parents over friends when social outcomes were at stake. Afterwards, we examined possible computational mechanisms underlying these social preferences. To do this, we tested whether loss and risk aversion parameters, as well as gambling decisions (post-hoc), differed when playing for a parent or a close friend. We then examined socioemotional motivational mechanisms underlying social decision-making preferences by testing whether relationship quality was greater for a parent or friend. For our exploratory aims, we tested whether individual differences in loss and risk aversion parameters (and number of gambling decisions, a post-hoc analysis), in addition to individual differences in relationship quality, could predict decision-making preferences. Finally, we also conducted a post-hoc test that formally compared discounting preferences between social and monetary outcomes.

Results Related to H1: Social Decision-making Preferences for Monetary and Social Consequences during Decision-making.—The condition parameter (variable describing who was affected by a discounting decision, see methods; π_{1i}) was positive and significant for the probabilistic and delay discounting runs involving monetary rewards, indicating that participants were more likely to favor their parent over a friend. Table 1 lists the coefficient values and associated standard errors for each discounting condition's random coefficient regression model. Participants were 34.6% more likely to discount (versus not discounting) when a parent benefited from the relatively certain monetary option and a friend benefited from the relatively uncertain monetary option compared to the opposite; participants were 35.5% more likely to discount (versus not discounting) when a parent benefited from the relatively immediate monetary option and a friend benefited from the relatively delayed monetary option compared to the opposite. The condition parameter was marginally significant for the probabilistic discounting run with social rewards (17.0% effect size), and was not significant for the delay discounting run with social

rewards (13.7% effect size). These results showed that individuals were on average more likely to favor parents over friends, and these trends were significant for the probabilistic and delay discounting runs with monetary rewards, and marginally significant with the probabilistic discounting run with social rewards. Figure 2 visualizes these coefficients and their respective standard errors. These results conceptually replicate prior work indicating that young adults prioritize parents over friends in monetary decisions and partially support hypothesis *H1*. Specifically, they support *H1* as related to decisions involving monetary outcomes, but not necessarily when they involve social outcomes.

Results Related to H2: Computational Underpinnings of Social Decision-making Preferences.—Participants were more likely to choose to gamble when playing for their friend than when playing on behalf of a parent (Parent *M*(SD): 55.32 (25.94), Friend *M*(SD): 60.06 (27.43); $t(221) = -3.319$, $p = .001$, Cohen's $d = 0.223$, Pearson's $r = 0.684$). In terms of risk aversion (intolerance of risk arising due to diminishing sensitivity to marginal rewards), participants exhibited comparable levels of risk aversion when playing for parents and friends (Parent *M*(SD): 1.34 (1.38), Friend *M*(SD): 1.44 (1.65); $t(221) = -0.849$, $p > .250$, Cohen's $d = 0.053$, Pearson's $r = 0.223$). By contrast, participants tended to be more loss averse (overweighting of losses relative to gains) when their decisions affected a parent compared to when their decisions affected a friend (Parent *M*(SD): 2.64 (2.51), Friend *M*(SD): 2.40 (2.35); $t(221) = 1.798$, $p = .074$, Cohen's $d = 0.117$, Pearson's $r = .646$). These results garner partial, modest support for hypothesis *H2* in that they suggest a difference in loss aversion, but not risk aversion, explains parent-over-friend preferences in decision-making.

Results Related to H3: Motivational Underpinnings of Social Decision-Making Preferences.: Though self-reported relationship quality with parents and friends was high overall, participants reported relatively higher relationship quality with their nominated friend (*M*(SD): 4.32 (0.44)) compared to their nominated parent (*M*(SD): 3.92 (0.66); $t(371) = 11.488$, $p < .001$, Cohen's $d = .596$, Pearson's $r = 0.318$). These results strongly support hypothesis *H3*, since *H3* predicted a difference in relationship quality between parents and friends. However, we note the direction of the effect is the opposite of the direction the significant effects related to *H1* and *H2* (and is consistent with prior related work (Guassi Moreira et al., 2018)).

Results Related to Exploratory A1: Individual Differences in Computational Biases Shape Decision-making with Monetary Outcomes.—As shown in Table 2A, we observed that a greater propensity to gamble with hypothetical rewards for friends was related to an increased propensity to favor *parents* during both discounting conditions for monetary, but not social rewards (aim *A1*). Effects in a similar direction emerged for parents, but did not exceed our threshold for statistical significance. Afterwards, we found that individuals who were less risk averse for parents (for gains) tended to be more likely to favor them in the monetary discounting conditions. A similar trend emerged for friends (less risk aversion for friends was related to a greater propensity to favor them) during probabilistic discounting for monetary rewards. There was no relationship between metrics

of loss aversion and social decision-making preferences (see supplement). Supplementary Figure 1 (top) visualizes these results.

Results Related to Exploratory A2: Individual Differences in Motivational Biases Decision-making with Social Outcomes.—Parent and friend relationship quality scores from the IPPA were used as between-person predictors in random coefficient regression models of discounting (grand mean centered, aim *A2*). Parent relationship quality predicted trial-by-trial decision-making behavior for the discounting runs involving social rewards – participants with greater relationship quality with their parents were even more likely to favor a parent over a friend, and those with reduced relationship quality were less relatively less likely to favor a parent over a friend (Table 3). A similar pattern was present across all discounting tasks with friend relationship quality. However, despite non-trivial effect sizes, these friend relationship quality results did not reach statistical significance. Supplementary Figure 1 (bottom) visualizes these results.

Post-Hoc Analysis: Directly Comparing Behavior when Monetary vs Social Outcomes are at Stake.—After observing the results described above, we opted to directly comparing social decision preferences between parents and friends when different types of outcomes were at stake. A supplementary, follow-up analysis employing traditional computational models of discounting (i.e., hyperbolic discounting rates; Burns et al., 2020; Seaman et al., 2018) found some evidence to indicate that parent-over-friend discounting preferences were modestly stronger when monetary, compared to social rewards, were at stake for delay discounting decisions (Cohen's $d = .12$). No such effect was observed for probabilistic discounting decisions (Cohen's $d = .06$). Analytic details and full statistical output is provided in the Supplement.

Discussion

Every day humans make decisions that affect close others. The present study examined how individuals make these decisions and characterized the mechanisms that drive social decisions about close others. Consistent with prior work (Guassi Moreira et al., 2018, 2019), the present study found that young adults favor their parents over friends when decisions have financial consequences. However, these same participants were more equivocal when deciding whether to prioritize parents or friends when making decisions with social consequences. In evaluating potential mechanisms, computational models revealed that individuals exhibited more loss aversion for parents compared to friends. Individuals who demonstrated greater risk aversion for their parent, however, were more likely to prioritize parents in decisions with monetary consequences, suggesting value-based computations drive social decisions about financial resources. Conversely, participants reported greater relationship quality with friends than parents when social motivations were assessed, and the magnitude of this motivational bias tracked with one's likelihood of prioritizing a friend in decisions with social outcomes. Importantly, computational biases did not track with preferences when social outcomes were at stake and vice versa, underscoring the specificity of each mechanism.

The present findings suggest that value-based computations and socioemotional motivations guide different types of social decisions. This pattern of results suggests social goals are context-dependent and can dynamically shift decision-making cognitions and behaviors. Parents and friends serve different functions in the lives of young adults (Hopmeyer & Medovoy, 2017; Roisman, Masten, Coatsworth, & Tellegen, 2004) and social obligations are likely to vary as a result. Preferences for parents in situations with financial outcomes may thus be driven by a need to contribute or reciprocate (Fuligni, 2018). By contrast, the apparent lack of a parent or friend preference in decisions with social outcomes (i.e., time spent with close other) may be due to the fact that some individuals prefer spending time with their parent and others with their friend, leading to a net zero preference at the group level. It is also important to consider that time spent with a close other is not necessarily synonymous with the concept of a social preference. It is possible that stronger social preferences would emerge if different social rewards were considered (i.e., engaging in specific social activities with different close others), or if social preferences were evaluated at different stages of development (e.g., children or middle-aged adults).

A post-hoc and preliminary statistical comparison provides some evidence to suggest that observed differences between reward types were not due to chance—that parent-oriented preferences with monetary rewards are indeed stronger than parent-oriented preferences with social rewards when making delay discounting decisions (but not probabilistic discounting). This could be due to a number of reasons, ranging from the salience of the social rewards we offered, to task demands related to computing value for money compared to social rewards (it may be more difficult to compute value calculations for ‘time spent’ than dollars), and to the ease with which individuals implicitly compute probabilities when making discounting decisions (potentially explaining the null finding when contrasting decision preferences for monetary and social outcomes in probabilistic discounting). Additional manipulations in future studies can help unpack these effects, perhaps with the help of cross-model reward decisions (e.g., asking individuals to assign a monetary value to social outcomes). If these differences are replicated, future work may wish to identify why they exist in the first place. We have speculated that obligation to parent and friend relationships most likely plays a large role (authors, 2018), but were unable to find compelling evidence (and no study measures collected here can speak to this notion). Additional work in this vein will need to carefully consider what obligation means in the context of parent and friend relationships, and thoughtfully select (or even devise) methods to sensibly equate the two for quantitative analyses. This difficulty highlights the possibility that qualitative analysis may be useful in resolving this issue while the field attempts to find an appropriate quantitative articulation. Finally, given prior work demonstrating the role that culture plays in feelings of familial obligation (Fuligni & Pedersen, 2002; Tsai, Telzer, Gonzales, & Fuligni, 2015), future work ought to formally examine how cultural differences shape social decision making for parents and friends.

Group-level results suggest that young adults exhibit value-based computational biases for their parents and social motivational biases for their friends, indicating at least two mechanistic pathways by which social decisions are generated. Exploratory analyses indicated that individual differences in computational and motivational variables predict

decision-making preferences, thereby revealing the plausibility and subsequent significance of each mechanism.

In terms of computational mechanisms, individuals on average exhibited slightly greater loss aversion for parents versus friends and individual differences in risk aversion predicted parent-over-friend preferences for monetary rewards. This shows that an individual could be presented with a choice containing the *same* objective return and uncertainty for a parent and friend, yet subjectively value the choice differently. As such, this indicates higher-order social preferences are built upon basic psychological computations, such as risk assessment, that vary as a function of social context (Tamir & Thornton, 2018). That individual differences in patterns of subjective valuation were systematically related to social decision-making preferences suggests that social goals act as a prism—the same input (i.e., contextual decision features) may shine in, and multiple actionable value judgments emerge (i.e., computed subjective value), each driving a different pattern of behavior. Crucially, this implies that a *nested* and *unified* framework for social decision-making may exist, where behavior is motivated by the arbitration of several systems that are differentially weighted depending on numerous features of the situation (Sims, 2018). Indeed, this may partially explain why we observed a main effect of loss aversion while risk aversion was systematically related to individual differences in decision preferences (the decision-making context in the discounting tasks emphasized features salient to risk aversion, whereas other scenarios might have underscored individual differences in loss aversion). While we cannot yet formalize such a framework, these results suggest that context-dependent loss and risk calculations underlie social decision making.

With regard to motivational mechanisms, we found that individuals on average reported greater relationship quality with friends compared to parents, while individual differences in relationship quality predicted decision-making preferences when social, but not monetary, outcomes were at stake. The pattern of preferences observed in decisions with social outcomes is a departure from what we observed in this study and others with monetary outcomes (Guassi Moreira et al., 2019). That decision preferences were sensitive to contextual features indicates that social goals do not manifest uniformly across all contexts. An apparent need to contribute or reciprocate may manifest as favoring a parent over a friend when monetary, but not social, rewards are at stake. Prior work indicates that friendships are predicated upon the need to feel understood by someone or having someone with whom to share thoughts (Arnett, 2000; Hopmeyer & Medovoy, 2017; Kaniušonytė & Žukauskienė, 2018). As such, choosing to prioritize a friend over a parent during decisions involving social rewards may represent the pursuit of these social goals. This possibility is further supported by our individual differences finding that relationship quality with one's friend moderated decision-making behavior regarding social rewards. Together, these results show that decision-making involving social outcomes is swayed by motivational, but not computational, biases, and possibly a different set of social goals than decisions with monetary outcomes. Given that a vast range of social rewards exist in the real world, it is possible – and ought to be addressed in future work – that a different pattern might have emerged with different kinds of social rewards (e.g., social capital).

Limitations and Future Directions.

The present study illustrates how social preferences are shaped by contextual features of decision-making scenarios, as well as individual differences in computational and motivational biases. Though these notions represent exciting avenues for future social decision-making research, direct and conceptual replications are needed to further enhance confidence in these conclusions. To fully test the boundary conditions of our findings, future work ought to examine decisions about different close others (e.g., romantic partners), using other decision-making tasks, and in different developmental and cultural populations. These efforts would help identify the generalizability of the present results and flesh out how social goals influence lower level psychological processes to influence decision-making behavior. In further considering generalizability, it is worth noting that our sample demographics (mostly white and Asian-American, mostly female, mostly late adolescent/young adult) is certainly not representative of all adults in the United States, let alone the world. Future work should strive to examine these effects in other populations, and we caution readers to bear these constraints on generalizability in mind when evaluating our results. This is particularly important to consider given prior work linking gender to differences in value-based decision making (Cardoos et al., 2017; Fancis, Hasan, Park, & Wu, 2015; Zachry, Johnson, & Calipari, 2019), though we observed no such gender differences in the present study. Additional follow-up work could also focus on directly replicating our individual differences findings with larger sample sizes. While we note that our individual difference analyses were well-powered on the strength of having nearly 100 decision-level (level 1) observations (Astivia, Gadermann, & Guhn, 2019; Mathieu, Aguinis, Culpepper, & Chen, 2012), future work with larger sample sizes would lend increased confidence in the present results by further reducing noise in estimates of random slopes and effect sizes and potentially improving power. Replication in larger samples would lend increased confidence to the current individual differences results by reducing the likelihood that factors tangentially related to sample size (e.g., variability of random slopes, skew of level 2 variables, etc.) were driving the results here.

Concluding Remarks.

The present results showed that social decision preferences are not necessarily conserved when different types of outcomes (monetary versus social) are at stake. This was highlighted by the facts that parent relationships tended to be favored over friend relationships when monetary outcomes were involved, whereas decision preferences were more equivocal when social outcomes are at stake. The present results also shed light on the computational and socioemotional underpinnings of social decision preferences, with the former influencing individual differences when monetary outcomes were involved and the latter influencing individual differences when social outcomes were at stake. These results emphasize the importance of delineating social decision behavior across multiple contexts, reinforcing the notion that there is no ‘one-size-fits-all’ heuristic for social decision preferences while hopefully paving the way for unifying theories of decision-making behavior.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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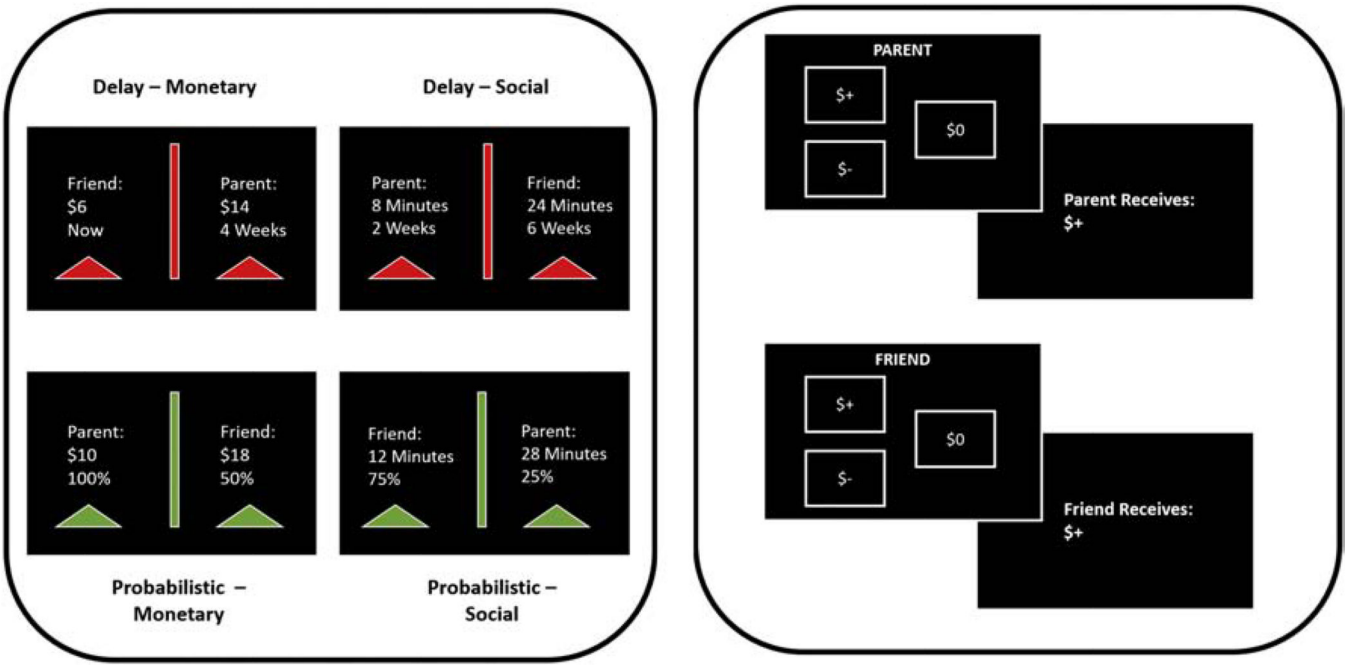

Figure 1.

Schematic overviews of the discounting (left) and gambling tasks (right).

Note. All rewards were hypothetical. Outcomes for the gambling task depended on participant choices (e.g., gamble or safe). Reward values in figure above are blank, but varied across trials. The risky option on some trials contained a gain and zero, whereas others contained a gain and loss (depicted above). See the methods for more details. The discounting tasks sought to model social decision-making preferences between parents and friends; the gambling tasks involved completing separate runs for parent and friend, respectively, and helped model computational processes that might support social decision-making preferences.

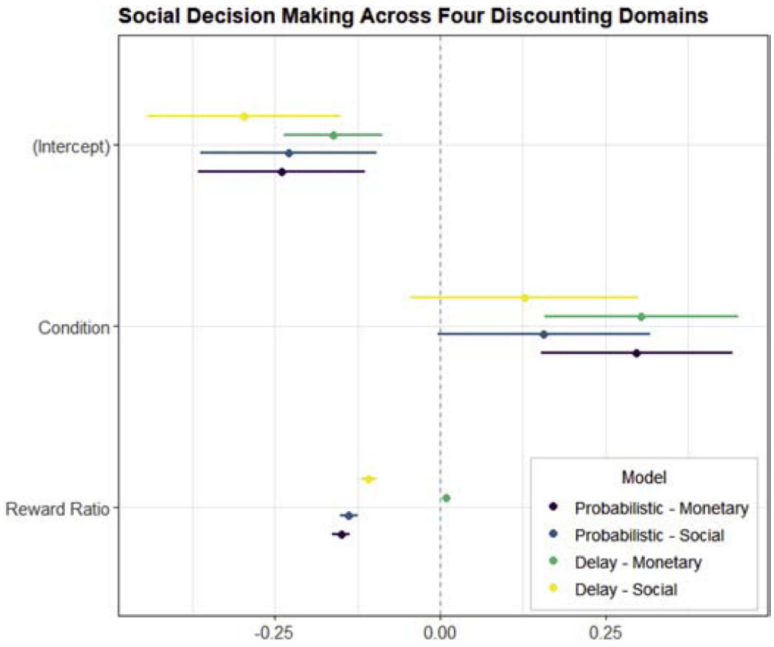

Figure 2.

Visualizing Social Decision-making Preferences (positive Condition values indicate preference toward parents)

Note. Coefficients are on a logit scale. Intercept represents the log likelihood of discounting when condition = 0 (Friend benefits from discounting option, parent benefits from non-discounting option) and reward ratio (defined below) is at its grand mean. Condition was coded such that 1 = discounting benefits parent, 0 = discounting benefits friend. Reward ratio reflects the division of the non-discounting option over the discounting option (grand mean centered), such that larger values indicate greater reward magnitude for the non-discounting option over the discounted option. 95% confidence intervals are depicted, computed using robust standard errors from the population-average solution.

Table 1.

Social Decision-making Preferences Across Four Discounting Conditions

Predictor	Probabilistic—Monetary	Probabilistic—Social	Delay—Monetary	Delay—Social
Intercept	−0.240 (.064) ***	−0.230 (.068) **	−0.162 (.038) ***	−0.297 (.074) ***
Condition	0.297 (.074) ***	0.157 (.082) °°	0.304 (.075) ***	0.128 (.088) °
Reward Ratio	−0.150 (.007) ***	−0.138 (.007) ***	0.008 (.005) °°	−0.108 (.006) ***

Note.

*** $p < .001$,

** $p < .01$,

* $p < .05$,

°° $p < .10$,

° $p < .250$.

Coefficients are on a logit scale. Intercept represents the log likelihood of discounting when condition = 0 and reward ratio is at its grand mean. Condition was coded such that 1 = discounting benefits parent, 0 = discounting benefits friend (positive values indicate a parent-over-friend preference, negative values indicate a friend-over-parent preference). Reward ratio reflects the division of the non-discounting option over the discounting option (grand mean centered), thus negative values indicate individuals were less likely to discount when the discounting reward was relatively smaller than the nondiscounting reward. Results reflect robust standard errors from the population-average solution.

Table 2

A. Social decision-making preferences across four discounting conditions, moderated by number of gamble decisions during the gambling task

B. Social decision-making preferences across four discounting conditions, moderated by risk aversion parameters from the gambling task

Predictor	Probabilistic—Monetary	Probabilistic—Social	Delay—Monetary	Delay—Social
Intercept				
Sex	0.041 (0.297)	−0.121 (0.265)	−1.495 (0.208)***	−1.160 (0.278)***
Parent GD	−0.055 (0.326)	0.001 (0.301)	0.596 (0.244)*	0.567 (0.313) °°
Friend GD	0.006 (0.007)	−0.013(0.006)*	−0.004 (0.005)	−0.003 (0.006)
	−0.014 (0.006)*	0.001 (0.006)	0.003 (0.004)	0.002 (0.005)
Condition				
Sex	−0.010 (0.366)	0.172 (0.230)	0.259 (0.138) °°	0.307 (0.319)
Parent GD	0.223 (0.390)	−0.249 (0.279)	−0.106 (0.212)	−0.523 (0.364) °
Friend GD	−0.012 (0.007) °	0.008 (0.006) °	−0.009 (0.008)	0.004 (0.007)
Reward	0.016 (0.006)*	0.004 (0.228)	0.014 (0.006)*	0.004 (0.006)
	−0.200 (0.036)***	−0.164 (0.024)***	−0.105 (0.032)**	−0.099 (0.023)***
Reward Ratio				
Sex	0.058 (0.038) °	0.018 (0.027)	−0.006 (0.034)	−0.008 (0.027)
Parent GD	−0.001 (0.001) °	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.000)*
Friend GD	0.001 (0.001) °	0.001 (0.001) °	−0.001 (0.000) °	0.000 (0.000)
Predictor	**Probabilistic—Monetary**	**Probabilistic—Social**	**Delay—Monetary**	**Delay—Social**
Intercept				
Sex	0.074 (0.310)	−0.049 (0.260)	−1.436 (0.220)***	−1.140 (0.285)***
Parent ρ	−0.102 (0.337)	0.088 (0.294)	0.523 (0.253)*	0.540 (0.318) °°
Friend ρ	−0.046 (0.066)	−0.027 (0.066)	−0.066 (0.069)	−0.074 (0.041)
	−0.073 (0.042) °°	−0.051 (0.070)	−0.029 (0.062)	0.020 (0.082)
Condition				
Sex	0.083 (0.379)	0.145 (0.259)	0.287 (0.139)*	0.361 (0.227)
Parent ρ	0.118(0.403)	−0.215(0.293)	−0.145 (0.199)	−0.595 (0.244) °
Friend ρ	−0.183 (0.087)*	−0.007 (0.056)	−0.149 (0.078) °°	−0.002 (0.091)
Reward	0.079 (0.038)*	0.034 (0.025) °	0.105 (0.078) °	−0.132 (0.077) °°
	−0.158 (0.018)***	−0.152 (0.024)***	−0.101 (0.033)**	−0.092 (0.024)**
Reward Ratio				
Sex	0.009 (0.019)	0.004 (0.027)	−0.011 (0.035)	−0.018 (0.028)
Parent ρ	−0.011 (0.010)	−0.012(0.005)*	0.008 (0.007)	−0.009 (0.008)
Friend ρ	−0.002 (0.016)	−0.005 (0.008)	−0.011 (0.006) °°	−0.003 (0.006)

Note.

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***
$p < .001$,

**
$p < .01$,

*
$p < .05$,

°°
$p < .10$,

°
$p < .250$.

Coefficients are on a logit scale. Condition was coded such that 1 = discounting benefits parent, 0 = discounting benefits friend (positive values indicate a parent-over-friend preference, negative values indicate a friend-over-parent preference). Sex was coded such that 0 = Male, 1 = Female. Reward ratio reflects the division of the non-discounting option over the discounting option (grand mean centered), thus negative values indicate individuals were less likely to discount when the discounting reward was relatively smaller than the non-discounting reward. Results reflect robust standard errors from the population-average solution. GD refers to the number of‘gamble' decisions made when completing the task for a parent and for a friend, p refers to risk aversion (a potential computational mechanism) when completing the task for a parent and for a friend.

Table 3

Social decision-making preferences across four discounting conditions, moderated by relationship quality.

Predictor	Probabilistic—Monetary	Probabilistic—Social	Delay—Monetary	Delay—Social
Intercept				
Sex	−0.218 (0.064)$^{\circ}$	−0.300 (0.182)$^{\circ}$	−0.130 (0.104)$^{\circ}$	−0.520 (0.187)**
Parent RQ	−0.022 (0.182)	0.083 (0.196)	−0.040 (0.112)	0.255 (0.203)$^{\circ}$
Friend RQ	−0.025 (0.121)	−0.291 (0.132)*	−0.040 (0.056)	−0.431 (0.130)**
	0.017 (0.176)	0.081 (0.172)	0.175 (0.107)$^{\circ}$	−0.071 (0.186)
Condition				
Sex	0.068 (0.239)	0.222 (0.218)	0.317 (0.191)$^{\circ\circ}$	0.141 (0.227)
Parent RQ	0.274 (0.252)	−0.080 (0.232)	−0.009 (0.208)	−0.011 (0.244)
Friend RQ	0.143 (0.112)$^{\circ}$	0.815 (0.168)***	0.065 (0.108)	0.825 (0.180)***
Reward	−0.373 (0.240)$^{\circ}$	−0.364 (0.228)$^{\circ}$	−0.341 (0.210)$^{\circ}$	−0.295 (0.228)$^{\circ}$
	−0.158 (0.018)***	−0.143 (0.014)***	0.005 (0.004)	−0.099 (0.013)***
Reward Ratio				
Sex	0.009 (0.019)	0.006 (0.016)	0.005 (0.005)	−0.010 (0.015)
Parent RQ	−0.011 (0.010)	−0.040 (0.010)***	0.005 (0.004)	−0.031 (0.009)**
Friend RQ	−0.002 (0.016)	−0.006 (0.017)	−0.002 (0.005)	0.019 (0.016)$^{\circ}$

Note.

$^{***}p < .001$,

$^{**}p < .01$,

$^{*}p < .05$,

$^{\circ\circ}p < .10$,

$^{\circ}p < .250$.

Coefficients are on a logit scale. Condition was coded such that 1 = discounting benefits parent, 0 = discounting benefits friend (positive values indicate a parent-over-friend preference, negative values indicate a friend-over-parent preference). Sex was coded such 0 = Male, 1 = Female. Reward ratio reflects the division of the non-discounting option over the discounting option (grand mean centered), thus negative values indicate individuals were less likely to discount when the discounting reward was relatively smaller than the non-discounting reward. Results reflect robust standard errors from the population-average solution. RQ refers to relationship quality for parent and friend, respectively.