

## A better praise or a bigger raise?

Exploring the contrast between delay discounting of real monetary and social rewards.

by

Harshil Vyas

Supervised by:

1. Alan Sanfey

2. Bernd Figner

Radboud University Nijmegen

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## ABSTRACT

Delay discounting refers to an individual's subjective value decreasing with an increase in the delay of receiving that reward. People, when asked to make such choices in which they must choose either the immediate or the delayed reward, have been shown to exhibit behavior that has been linked to impulsivity and patience. Such choices that are delayed across time are known as intertemporal choices. What was first experimented using marshmallows has now been widely studied using the classic reward of money, and though there have been many a nontraditional task that have utilized alternate rewards, they have often relied on hypothetical choices. This research therefore employed a real positive social reward to investigate how participants discount receiving social rewards via the social networking platform of Instagram, where it is typical to delay sharing content in order to maximize outreach and admiration. Furthermore, in order to compare discounting for social rewards with money, they were asked to provide monetary equivalents for how much they value receiving social rewards. Against a fixed immediate reward, participants were then confronted with choices that included four different reward magnitudes across four different delays. Mixed effects modeling was thereby used to analyze the data which showed significance of magnitude and delay, but not for the different conditions, nor for any interactions. A secondary analysis was performed to calculate hyperbolic discount rates, which too did not show significance for the reward type contrast. Potential explanations of these results including how compelling the choice was, participants' perception of social reward, advantages and constraints of using Instagram in researching delay discounting, as well as motivational confounds are discussed.

*Keywords:* Monetary Reward, Social Reward, Instagram, Hyperbolic Delay Discounting, Mixed Effects Modeling

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## Introduction

Imagine planning a party for someone whose birthday is two weeks away. Would you want to tell them today itself, or wait without a word for them to be surprised two weeks later? If you're inclined to say, 'tell them right this instant', you have discounted the value of the social reward you choose to receive. That reward being appreciation and recognition for what you are doing for someone. In making one happy and excited for their birthday (i.e. giving them a social reward), you are receiving a smaller sooner (SS) or larger later (LL) social reward from them in return. Herein, delay discounting (DD) refers to reduction in subjective value of a reward with the increase in duration of reception of that reward (Scheres, De Water, & Mies, 2013). Thence, any decision that is delayed across time, wherein one must choose between either immediate or a delayed reward is known as intertemporal choice (IC) (Tayler, Arantes, & Grace, 2009).

Humans in their everyday lives are faced with such decisions in which they must choose between alternatives that differ in either their probability of occurrence, or their subjective value (Moreira, et al., 2016). At the same time, many an important choice, such as in the domains of health, environment, and financial security requires the decision-maker to step into the future and visualize their potential impending gains; that is, predicting outcomes and assessing expected rewards bearing in mind temporal delays (Frost & McNaughton, 2017). Even leisure decisions such as deciding between spending money now or to save money for a trip to Paris in two months (Peters & Büchel, 2010). Many have thereby associated an inability to wait for a larger but delayed reward to impulsivity, and on a clinical level, to behavioral disorders like gambling, overeating, and overspending (Smith, et al., 2018). Hence, decision scientists have sought to understand how people discount future rewards and to what degree they favor an immediately available option. To this end, there have been numerous studies investigating IC, specifically examining the DD behavior exhibited by participants.

However, since Walter Mischel and his colleagues first asked children to choose between one marshmallow now, or two in twenty minutes, the primary experimental variable for quantifying DD in research has been money (Bar, 2010). Though researchers have examined DD in a variety of social domains, such as studying how emotional arousal increases impulsivity during IC tasks (Sohn et al., 2015), and demonstrating increased patience when participants made an IC for someone else (Albrecht et al., 2010), the currency of choice and outcome in these studies have still relied on the standard monetary measures.

Nevertheless, there have been some notable nontraditional IC tasks that have utilized alternate rewards. Juice, food, and even erotic pictures for instance (Scheres, De Water, & Mies, 2013). Most other non-traditional IC tasks have involved comparing valuation of monetary rewards against drugs of abuse (Peters & Büchel, 2011), such as food and alcohol (Odum & Rainaud, 2003), cigarettes, though smokers and non-smokers discounted money similarly (Johnson, Herrmann, & Johnson, 2015), and marijuana, in comparison to controls and ex-users (Johnson, et al., 2010). All the aforementioned studies reported that in contrast to money, participants discounted the 'vice' more steeply (Odum, 2011; O'Hara, Carey, Kervick, Crowley, & Dabrowski, 2016). A study on gamers also showed there to be a positive correlation between their self-reported frequency of gaming and their respective discount

rates of game-time and money (Buono, et al., 2017). Although, it is important to note that all the aforementioned studies relied on hypoethical rewards.

As the variability in such choices suggests, inherently, an IC relies on an individual's subjective value of the potential rewards (Peters & Büchel, 2011). However, despite the large number of publications on DD and IC in the past two decades (Smith, et al., 2018), very few to date have considered how social rewards might be impacted by IC, or if they are discounted in the same way as primary rewards. A social reward can be defined as the hedonic reward obtained through the pleasurable and motivational aspects of social interaction (Foulkes, McCrory, Neumann, & Viding, 2014). For instance, in our day to day life, it is rewarding to be admired by your friends, or being invited to join a party or a club. Students may discount future rewards of getting good grades on essays and instead prefer the immediate reward of socializing (Zhang, Liu, & Feng, 2019), whereas employees may put in extra effort to be recognized in their jobs, and work towards a delayed positive appraisal.

Social rewards often involve episodic future thinking of delayed rewards, which has been previously shown to be modulated by a functional coupling of ACC with hippocampus and amygdala (Peters & Büchel, 2010). The authors of this study also concluded that because of the robust imagery of the imagined future reward, participants become less impulsive in their choices. Although, despite there being ample research on social rewards, when investigated together in the context of DD, scientists have typically operationalised the reward as social feedback, wherein social rewards have been used as an outcome of the main (often monetary) task, to be paid out on the basis of the participants' performance. Lin, Adolphs, and Rangel (2011), Kohls, et al. (2013), Flores, Münte, and Doñamayor (2015), and Distefano, et al. (2018) for instance, examined the anticipation and delivery of both monetary and social rewards. However, in utilizing Monetary and Social Incentive Delay tasks, they mention a major limitation of not being able to adjust and match the magnitude of the social rewards in comparison to the monetary rewards.

Categorizing and quantifying social rewards is indeed a difficult task, and Foulkes, Viding, McCrory, and Neumann (2014) did just that with a novel Social Reward Questionnaire (SRQ). They identified six significant categories of social rewards – admiration, sociability, prosocial interactions, negative social potency, passivity, and sexual relationships. The same group of researchers further validated their findings by conducting a study that focused on individuals with high psychopathic traits using a probabilistic reward anticipation task wherein subjects either received money or Facebook likes as feedback. The following year, Foulkes, Bird, Gökçen, McCrory, & Viding (2015) also conducted a similar study on individuals with autistic traits and alexithymia. The authors observed across both studies that individuals with psychopathic and autistic traits disliked sociability and prosocial interactions, and rather enjoyed negative social potency (being cruel to others and using them for personal gain). Negative social potency has also since been linked to problematic social media use (Meshi, Turel, & Henley, 2020).

Nonetheless, a few interesting paradigms that observed varied DD effects have been utilized to study DD of social rewards in humans where participants could choose between a SS or LL social reward. Tayler et al. (2009) for instance, found that in comparison to DD of monetary reward, subjects sometimes had negative discount rates when deciding about relationship fulfilment and outcomes. A relationship starting today which lasts 4 years for example, was equated similarly to a relationship

starting in 1 year and lasting 3 years. Moreover, Charlton et al. (2012) asked participants to first rate their friends on a scale of social proximity, 1 being the closest and 10 being an acquaintance. They then asked the participants, for each proximity level, if they would like to interact with them now for number of minutes they would specify, or for 25min after varied delays. They observed a decrease in discounting (increased willingness to wait for a conversation) with increase in social distance. However, these studies too, relied upon measures using hypothetical rewards.

Although, one research that did utilize real social reward and not hypothetical was that of Mühlhoff, Stevens, and Reader (2011) who conducted a study with guppies (*Poecilia reticulata*). The fish therein were trained to make spatial choices rather than temporal. They were asked to choose between swimming towards food or same-sex shoaling partners with a manipulation of the distances such that two pieces of food, or two shoaling partners awaited at a 20cm distance. Further down the tank, six pieces of food or six shoaling partners were placed at varying distances (from 40cm to 120cm). The researchers observed that the guppies travelled faster towards food than social rewards, suggesting that they spatially (and temporally) discounted food more steeply than social rewards.

Chester, et al. (2019) on the other hand, have been the only researchers to utilize real rather than hypothetical social rewards in a human-based study. They designed an aggression paradigm based on the negative social potency of inflicting a small amount of pain now (in terms of a noise blast) or a large amount of pain later. This study actually delivered the noise blast to their participants and their counterparts wherein they observed that a significant number of participants chose the immediate reward. This was perhaps to inflict a lesser amount of pain without there being sufficient motivation to be overtly aggressive. This thesis thence focused on the positive social rewards, those of admiration and sociability. For this purpose, a novel social reward was designed using the rewarding aspects of the social media platform, Instagram, to be contrasted with the classic IC task of choosing between an immediate or delayed monetary reward.

Nearly a decade after its conceptualization, Instagram has amassed upwards of a billion users (Statista, 2020), with at least 500 million active users engaging with the app daily (Facebook, 2020). Here, online, in the realm of sharing and viewing digital user-created content, the feature of 'like' has become the new currency, one that is "explicitly social in nature" (Sherman, Hernandez, Greenfield, & Dapretto, 2018). Linked to, and virtually representing an innate human need of making and maintaining complex social relations, giving and receiving likes has been shown to be equally rewarding as money in the short term, if not more (Sherman, et al., 2018). Social networking sites (SNS) capitalize on these needs (Meshi, Tamir, & Heekeren, 2015) and provide incentives for users to keep returning to the app. This constant reinforcement has thus been studied in the context of mental health issues in users including addiction and depression as a result of Instagram use (Lup, Trub, & Rosenthal, 2015). Regardless, this impulsivity to receive admiration from friends and strangers alike has been shown not just in clinical population, but also in teenagers who strive to be famous (De Veirman, et al., 2020), and the industry as a whole that revolves around users monetizing sexualized content to receive attention (Drenten, Gurrieri, & Tyler, 2020).

Therefore, for brands wishing to advertise and individual users wishing to gain 'likes', the first question that comes to mind for anyone posting on Instagram is, 'at what time should I post?'. In order to



maximize the outreach, and to ensure maximum number of people view the content, users often delay posting online to the extent of scheduling their posts to match the patterns of Instagram activity of their audience (Kanuri, Chen, & Sridhar, 2018). In addition to Instagram being primarily used to match the subjective value of reward across both monetary and social, and be paid out for real, considering the aforementioned user behavior on the app, it also makes a great platform to be tested in an experimental setting for observing participants' willingness to delay sharing content in order to capitalize on their admiration gained from their viewers.

Additionally, since results in terms of DD social reward have been few and varied, more so for studies that offer a choice of a SS or LL social reward rather than rewarding participants with a happy or angry face as social feedback, the aim of this study was to investigate how DD across the aforementioned conditions differ within participants using a real social and monetary rewards. For the same, this research hypothesizes participants to more steeply discount social rewards in comparison to money. Alongside, this study also aimed to further explore if participants' levels of social media usage and valuation of these particular categories of social rewards impact their discount rates.

## Methods

### Participants

Participants were recruited via Prolific ([www.prolific.co](http://www.prolific.co)) with predefined pre-screening factors of nationality (Dutch), languages (Dutch and English), and social media (active Instagram use). 50 participants (female:male = 18:32) were recruited for the study and all of them were included in the analyses (Table. 1). They were paid based on their duration of participation. Additionally, they were also given either a monetary or social reward based on a random trial as their bonus. Exclusion criteria consisted of a failed attention check before starting the task. This is because the participants' responses to an initial questionnaire of entering their indifference points determined their subsequent decisions in the monetary condition of the IC task.

**Table. 1** Participant demographics

|     | Mean  | SD   | Min | Max | Range |
|-----|-------|------|-----|-----|-------|
| Age | 25.86 | 7.84 | 18  | 55  | 37    |

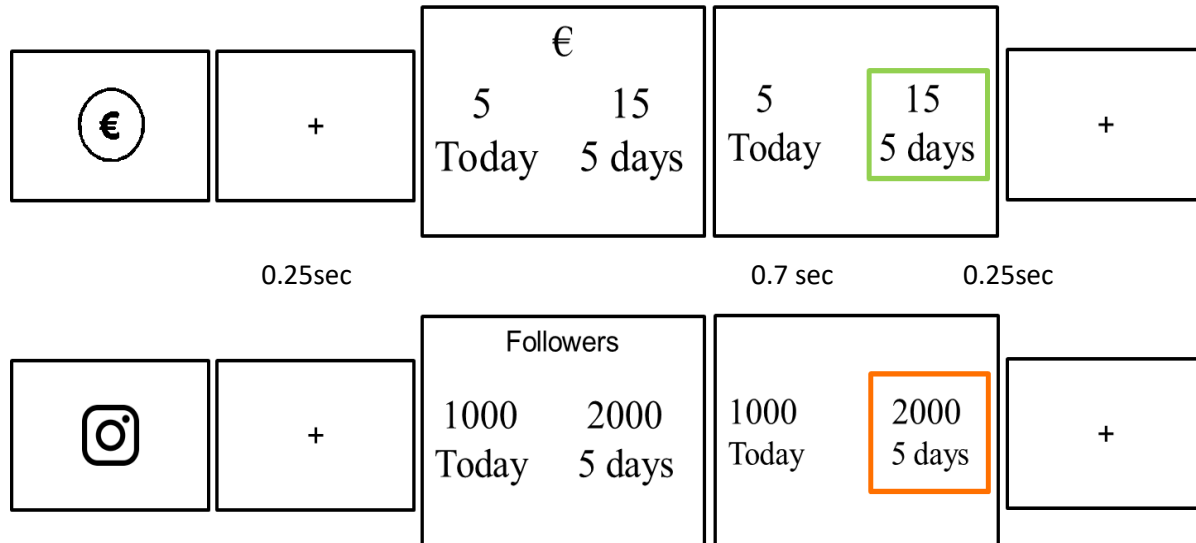
### Design

#### Intertemporal Choice (IC) Task

Participants were asked to choose between an immediate (SS) or delayed (LL) reward across two counterbalanced conditions contrasted in reward type, monetary and social reward. Each condition consisted of 16 decisions (repeated twice), varying in four levels of delay as well as magnitude (Table. 2).

Additionally, to further incentivize the selection of choices and record their preference, participants were informed that one of their choices (either from the monetary or social condition) will be chosen at random to be paid out for real following the experiment. i.e. if one of their trials was €5 today or €15 in

14 days and they chose the delayed option, then 14 days after completion of the task, they were given a bonus of €15.



**Fig. 1** IC task conditions and trial types.

### *Social Condition*

#### *Instagram*

Via the framework of SRQ, a prominent reward of admiration was chosen to be tested for contrasting DD social rewards against money. In order to operationalize this, a real-life behavior wherein people actively seek admiration and delay gaining reward was identified, that being sharing content and receiving reward through social media. Specifically, taking inspiration from studies conducted by (Sherman, et al., 2016; 2018), the platform Instagram was chosen.

Instagram ([www.instagram.com](http://www.instagram.com)) is a popular social networking app, owned by Facebook. This app is centered around users being able to share pictures and videos on their profile, similar to users being able to send out 'tweets' on Twitter ([www.twitter.com](http://www.twitter.com)). Instagram allows users to do this in multiple ways, via their features such as IGTV, feed, stories, and Reel. Relevant for this research are the features of feed and stories. Feed refers to pictures and videos shared on one's profile that remain on the page permanently (unless manually archived or deleted), whereas stories are short slideshow-format moments (in form of pictures and max 10sec videos) that users can share for a limited period (stories are automatically archived in 24h). Feed relies on the metric of the number of likes received by each post, while stories are measured using the metric of the number of 'views' that each story gained within a day. Moreover, if user A 'tags' or mentions user B in A's story, then user B can 're-share' the story on B's profile. Alternatively, user B can navigate to user A's profile, and from user A's feed, 'share' user A's post (picture or video) on user B's story (Fig. 2).

Furthermore, Instagram allows users to nonreciprocally follow users on the app (Lup, Trub, & Rosenthal, 2015). When a lot of people follow a popular account, brands may start approaching them to advertise products (De Veirman, Cauberghe, & Hudders, 2017). At the same time, 'regular' users 'tag' popular accounts on their own posts in hope that their post will be shared by the popular account, whereby in

Figure 1 displays four mockups of the Instagram app interface, labeled A, B, C, and D. Each mockup represents a different screen within the app, showing the layout and content elements.

- A: Profile Page** - Shows the user's profile information, including the profile picture, name, bio, and statistics (posts, followers, following). It also includes a grid of posts.
- B: Post Page** - Shows a post with a large image placeholder, caption, and engagement metrics (likes, comments). It includes a 'View Insights' button and a 'Create Ad' button.
- C: Story Page** - Shows a story with a large image placeholder and a 'POST SHARED ON STORY' overlay. It includes a 'Share to' button and a 'More' button.
- D: Story Page** - Shows a story with a large image placeholder and a 'STORY' overlay. It includes a 'Share to' button and a 'More' button.

The figure displays three screenshots of the Instagram analytics interface for the account 'brittanyvanbeek'.

- Screenshot A (Left):** Shows the 'Insights' tab with the 'AUDIENCE' sub-tab selected. It displays 1,415 followers (a 6% increase from August 2nd to August 8th). The 'Growth' section shows 5 overall new followers, with 8 unfollowed and 13 followed. The 'Top Locations' bar chart shows Zeevaar as the top location. The 'Age Range' bar chart shows the 18-24 age group as the primary audience. The 'Gender' pie chart indicates 42% women and 58% men. The 'Followers' bar chart shows a peak in followers during the 12a-3a time slot on Saturdays.
- Screenshot B (Middle):** Shows the 'Insights' tab with the 'ACTIVITY' sub-tab selected. It displays 931 accounts reached from August 9th to August 15th. The 'Top Locations' bar chart shows Zeevaar as the top location. The 'Age Range' bar chart shows the 18-24 age group as the primary audience. The 'Gender' pie chart indicates 42% women and 58% men. The 'Followers' bar chart shows a peak in followers during the 12a-3a time slot on Saturdays.
- Screenshot C (Right):** Shows the 'Insights' tab with the 'CONTENT' sub-tab selected. It displays 931 accounts reached from August 9th to August 15th. The 'Top Locations' bar chart shows Zeevaar as the top location. The 'Age Range' bar chart shows the 18-24 age group as the primary audience. The 'Gender' pie chart indicates 42% women and 58% men. The 'Followers' bar chart shows a peak in followers during the 12a-3a time slot on Saturdays.

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impressions - the total number of times users engaged with her content; b) information on growth of audience; c) demographics of her audience, showing gender and time of the week (by day and hour) of audience using the app; d) age range and locations of audience.

Thus, taking this feature into consideration, following participants' consent at multiple stages as elaborated below, influencers will receive five pictures from consenting participants, from which they will choose one that they would share on their story. The chosen picture and the influencer's identity is then revealed to the participants, who then consent once again to having their picture shared by the influencer matched to them (based on similarities in type of content). Four such influencers were recruited for this study who shared participants' pictures as a payout of social reward.

Therefore, in summation, in this condition, participants found the decisions socially rewarding because of two aspects. First, it is socially rewarding to see that someone has shared your picture on their profile. Secondly and indirectly, the number of views that the story (on the influencer's profile) will receive is also rewarding, which can potentially lead to more followers and viewers being directed to the participant's profile. Therefore, the main manipulation here is the number of followers of the accounts that will share the participants' pictures, since the number of views is proportional to the outreach of those accounts (De Veirman, Cauberghe, & Hudders, 2017).

During the trials, participants were confronted with a choice asking them to choose between having their picture shared today (on the story of an influencer with 1000 followers), or after a delay (on the story of an influencer with 2500/5000/10K/30K followers).

**Table. 2** Reward levels and Delays. Each cell represents the total number of choices made by 50 participants for each follower level-delay combination. SS was fixed at 1000 followers for all trials.

| <b>LL (followers on Instagram) / Delay (Days)</b> | <b>5</b> | <b>14</b> | <b>30</b> | <b>60</b> |
|---------------------------------------------------|----------|-----------|-----------|-----------|
| <b>2500</b>                                       | 100      | 100       | 100       | 100       |
| <b>5000</b>                                       | 100      | 100       | 100       | 100       |
| <b>10,000 (10K)</b>                               | 100      | 100       | 100       | 100       |
| <b>30,000 (30K)</b>                               | 100      | 100       | 100       | 100       |

#### Indifference Points

Indifference points are generally used to identify the magnitude or delay at which an individual perceives the subjective value of receiving the smaller sooner reward and larger later reward the same. In this study, indifference points refer to monetary amounts collected before the start of the task in order to standardize the subjective reward values of social and monetary rewards across participants. A question about the monetary amount that would make them feel equally happy as obtaining the social reward was presented to them on screen wherein they had to enter values for each reward level one after another, while being able to view their responses to the earlier levels as they progress (Fig. 4). The monetary values obtained through this process prior to testing were utilized as unique choices for each participant in the monetary reward condition (Odum & Rainaud, 2003).

### Monetary Condition

Subsequently, in this condition, participants were asked to choose between their subjective monetary equivalents for the social reward's SS and four levels of LL at the aforementioned delays. Based on the indifference points provided by them prior to commencing the task, the amounts that were shown for SS and LL were unique to each participant. For instance, if a participant entered €10 for 1000 followers, and €50 for 30,000 followers, then on eight of their trials (since each condition is repeated twice in a counterbalanced order), they will be asked to choose between €10 today or €50 in 5/14/30/60 days.

An influencer with these follower levels just shared **your** post on **their** story.

How much money would make you feel **just as happy**?

- Please enter an amount between **€1** and **€50** (no decimals).
- **DO NOT** use the same amount twice.

**1000** followers

**2500** followers

**5000** followers

**10K** followers

**30K** followers

Press enter to continue.

**Fig. 4** Indifference points data collection screen. Participants were asked to serially enter monetary equivalents for the five different levels of social reward.

### Questionnaires

#### Social Reward Questionnaire (SRQ)

SRQ is a 23-item questionnaire developed and validated by Foulkes, Viding, McCrory, and Neumann (2014). It was used to measure the subjective differences in valuation of giving and receiving social rewards. The hedonic aspects of the questionnaire items have been emphasized using “I enjoy” at the beginning of each sentence followed by a description of the type of social interaction in question. Participants responded on a scale of 1 to 7 (1 = strongly disagree, 7 = strongly agree). Of the six subscales or categories that have been identified, relevant categories of admiration, sociability, and prosocial interactions were used to see how participants value social rewards (Appendix 1).

#### Instagram Survey

Adapted to the research questions for this study, participants were asked to answer a short mixed qualitative and quantitative survey about their use and experience of the app (Appendix 2). This will range from questions asking about their frequency of use (1 = low, about once a month or less; 5 = high,

multiple times a day) of the app and sharing content, the size of their social network (number of followers on Instagram), and the extent to which, and how they value likes and views on their posts (Sherman, Hernandez, Greenfield, & Dapretto, 2018).

## Procedure

### Platform

Recruited participants were redirected to Gorilla ([gorilla.sc](https://gorilla.sc)) where the entire experiment was programmed and was being hosted.

### Pre-task

Participants were given instructions and asked for consent to participate in this experiment. They then answered the relevant questions of the SRQ. Following this, participants were reminded of the instructions and given an attention check before being asked to visualize the five pictures that they would like to share if given an opportunity. Finally, they submit their indifference points for each social reward level (5 followers levels including 1 SS and for 4 LL). Thereafter, they began the IC task.

### Post-task

Upon finishing the IC task, participants were asked to complete a short Instagram survey to enter their indifference points once again to test the variability in valuation of receiving a social reward before and after the task. Lastly, they were debriefed about the aim of the experiment and redirected to Prolific where they were paid for their time.

### Bonus

Participants were contacted via Prolific upon review of their responses. They were randomly assigned either a monetary or social reward. If they were assigned a monetary reward, they were given their bonus based on their chosen trial. If they were assigned a social reward, participants who had a public profile (and not private) were contacted to ask them to send in the five pictures that they would like to have shared. If participants agreed to send in pictures, they were forwarded to an influencer who closely matched the category of participants' pictures. They were informed that one from their set of five pictures will be chosen to be actually shared by an influencer.

To avoid biases, until the task was complete, and a subsequent reward chosen for them, only the number of followers of the influencers was known to the participant and not the account name. Participants could choose not to have their picture shared once the identity of the influencer was known. By doing so, they were informed that they were foregoing the bonus. On the other hand, if they do consent to have a picture shared by the influencer matched to them, after the delay of their chosen trial, the influencer shared the participants' pictures on their story for 24h. The username of the participant was mentioned along with the shared post (also post consent), thereby notifying the participant and bringing to their attention the account that shared it.

## Behavioral Data Analysis

The main goal of this research was to investigate the differences in DD of social and monetary rewards. In order to test this sole hypothesis, two Bayesian methods were employed to statistically analyze the contrast at hand. Furthermore, indifference points and interactions between SRQ and Instagram factors

were descriptively analyzed. Though neither were statistically tested to answer any hypotheses, SRQ and Instagram factors were input into a correlation matrix to visualize relationships between the predictors. Due to the results obtained from the correlation, the factors were not included in mixed-models analysis to avoid multicollinearity issues.

### Indifference Points

Indifference points were plotted to descriptively analyze the variability in indifference points before and after the IC task. This was done using GraphPad Prism 8. Only the indifference points before the task were taken into consideration for the experiment as well as statistical analyses.

### IC task

#### *Mixed-effects models*

The primary analysis in this thesis was mixed effects modeling, which was utilized to investigate the interactions between reward levels and delays across both conditions. This was done using the using brms package in R 3.6.1 (Bürkner, 2018) which allows for analysis of nonlinear multilevel models within the computation framework of Stan (Carpenter, et al., 2017). The DV was Choice (0 = SS; 1 = LL), with the two categorical variables that comprised of four levels of Delay and LL reward added as monotonic predictors (Bürkner & Charpentier, 2018). All 50 participants were included as factors in the analysis, as well as the condition differing in reward type (coded for sum-to-zero contrast). Thereafter, using the ‘bernoulli’ family, 6 chains, and 4000 iterations (2000 warm up), the following model was executed:

Choice ~ f\_Condition \* mo(o\_LL) \* mo(o\_Delay) + (1 + f\_Condition \* mo(o\_LL) \* mo(o\_Delay) | f\_pp\_ID)

The results obtained were tested for significance with the BayestestR package to calculate the 95% highest density intervals, to reaffirm the values of the lower and upper bounds of the 95% credible interval that are automatically generated as part of the brms model summary. Moreover, the analysis’ coefficients’ values were generated, and marginal effects were thereby plotted. Two and three-way interactions (Delay, LL, Condition) were also plotted, followed by conducting diagnostic tests for homoscedasticity and normality. Variance decomposition was then conducted to check for posterior prediction distributions of the analysis’ parameters. Post-hoc test however, with the emmeans package, was not carried out since it is not compatible with monotonic predictors (Bürkner & Charpentier, 2018).

#### *Hyperbolic discounting rates ( k values)*

In addition to the mixed effects models, a secondary analysis of estimating hyperbolic estimation of the discount rate (k) was carried out using the hBayesDM package in R, specifically using the dd\_hyperbolic function (Woo-Young, et al., 2020). This function computes, using a standard hyperbolic discounting model (Mazur, 1987), the discounting rate per participant as well as  $\beta$  (inverse temperature rate). The k value is found using the function:

$$V = \frac{A}{1 + k D} \quad (1)$$

where  $V$  is the subjective value of the objective reward  $A$  that is discounted across a delay,  $D$ . Starting from 0, an increasing  $k$  value suggests higher impulsivity for the immediate reward, i.e steeper discounting rate of the delayed reward. The significance of the  $k$  values obtained per participant per

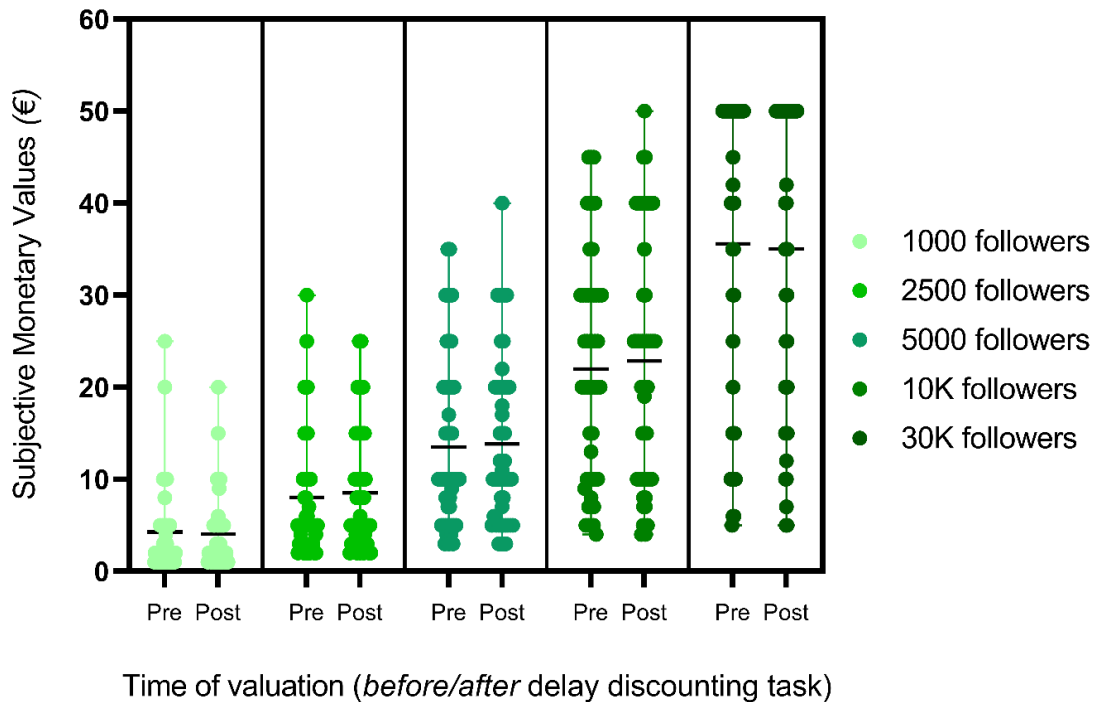
condition was assessed using the measure of 95% highest density interval via the aforementioned package's plotHDI function.

### Instagram Survey and Social Reward Questionnaire

The three categories of SRQ (Admiration, Sociability, and Prosocial Interaction) along with Instagram factors (Frequency of app use and number of followers) were tested for correlation and significance thereof using the corplot package in R (<https://github.com/taiyun/corplot>).

## Results

### Indifference Points



**Fig. 5** Variability in indifference points for each reward level before (pre) and after (post) IC task.

A descriptive analysis of indifference points before and after IC task showed stable means across the two time points across all participants. The descriptive statistics of the pre-task indifference points used as values for the IC task monetary reward trials are detailed in Table. 3 below.

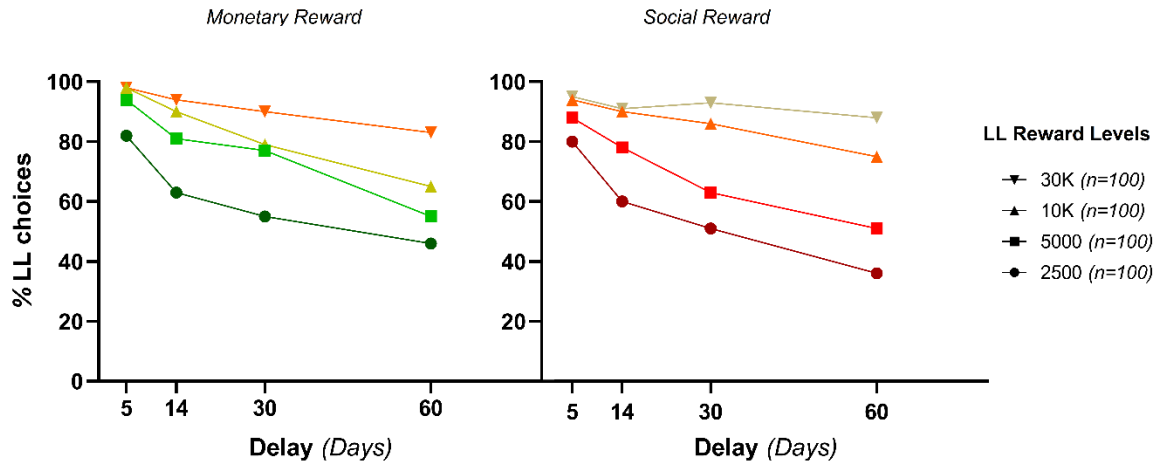
**Table. 3** Pre-task indifference points for each reward level.

| LL reward levels | 1000 | 2500 | 5000  | 10,000 | 30,000 |
|------------------|------|------|-------|--------|--------|
| Minimum          | 1    | 2    | 3     | 4      | 5      |
| Maximum          | 25   | 30   | 35    | 45     | 50     |
| Median           | 2.5  | 5    | 10    | 20     | 41     |
| Range            | 24   | 28   | 32    | 41     | 45     |
| Mean             | 4.26 | 8.04 | 13.52 | 22     | 35.58  |



## IC Task

### Descriptive Statistics



**Fig. 6** %LL choices across monetary and social reward conditions in the IC task.

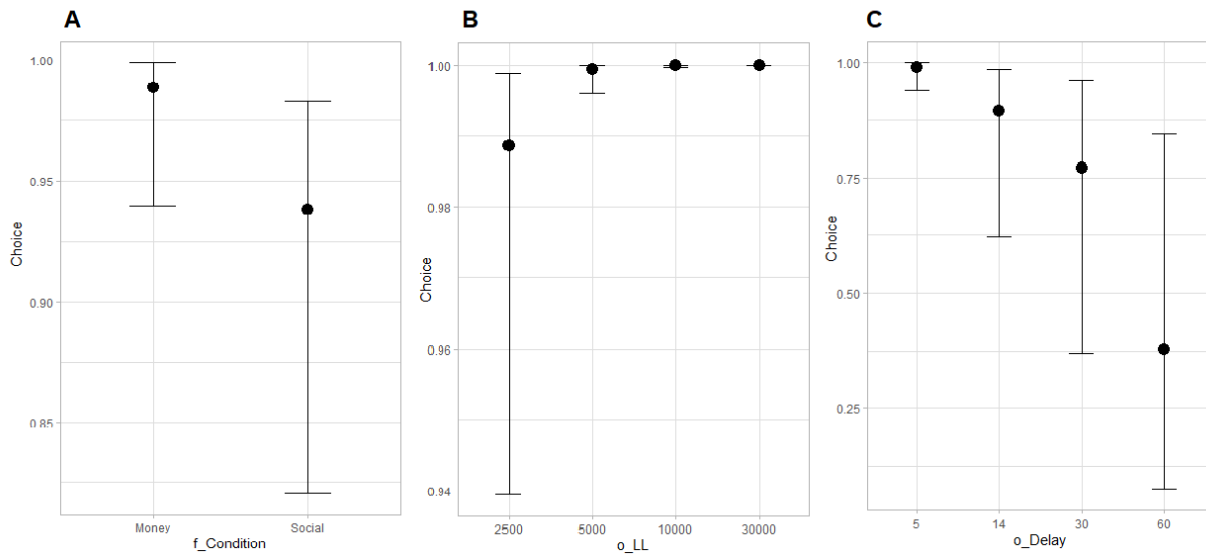
Participants overall chose LL reward for Monetary condition more than in the Social condition. However, there are differences across reward levels and delays. For the first two reward levels and delays (5, 14 days; 2500, 5000 followers) participants discounted social rewards more steeply whereas for the last two reward levels and delays (30, 60 days; 10K, 30K followers) participants discounted monetary reward more steeply.

#### Choice Analysis

Keeping in mind that this is a Bayesian method, statistical significance was inferred using 95% credible intervals. Having said that, the mixed effects model did not show a main effect of condition on DD ( $\beta = 0.89$ , CI = -0.05, 1.94). The main effect of Delay was significant ( $\beta = -1.55$ , CI = -1.99, -1.13), suggesting that participants carefully considered the durations of the delays when making choices. Furthermore, the model also found a significant main effect of LL reward levels ( $\beta = 3.13$ , CI = 1.77, 4.70), which suggests that participants were sensitive to the differing reward levels when choosing SS or LL reward across both conditions. The conditional effects plots for Condition, Delay, and LL are shown in Fig. 7. Lastly, none of the two-way or the three-way interaction between Condition, LL, and Delay were found to be significant (Table. 4).

**Table. 4**  $\beta$  estimates for fixed and random effects.

| Parameter                         | $\beta$ | Estimate Error | Lower-95% | Upper-95% | Rhat | 95% highest density intervals |       |
|-----------------------------------|---------|----------------|-----------|-----------|------|-------------------------------|-------|
| Intercept                         | 3.64    | 0.69           | 2.39      | 5.10      | 1.00 | 2.35                          | 5.05  |
| f_Condition1                      | 0.89    | 0.50           | -0.05     | 1.94      | 1.00 | -0.14                         | 1.84  |
| mo(o_LL)                          | 3.13    | 0.73           | 1.77      | 4.70      | 1.00 | 1.68                          | 4.55  |
| mo(o_Delay)                       | -1.55   | 0.22           | -1.99     | -1.13     | 1.00 | -1.98                         | -1.12 |
| mo(o_LL): f_Condition1            | 0.48    | 0.46           | -0.67     | 1.35      | 1.00 | -0.55                         | 1.45  |
| mo(o_Delay): f_Condition1         | -0.12   | 0.18           | -0.47     | 0.25      | 1.00 | -0.48                         | 0.25  |
| mo(o_LL): mo(o_Delay)             | -0.25   | 0.17           | -0.57     | 0.15      | 1.00 | -0.58                         | 0.14  |
| mo(o_LL):mo(o_Delay):f_Condition1 | -0.10   | 0.19           | -0.47     | 0.31      | 1.00 | -0.44                         | 0.32  |



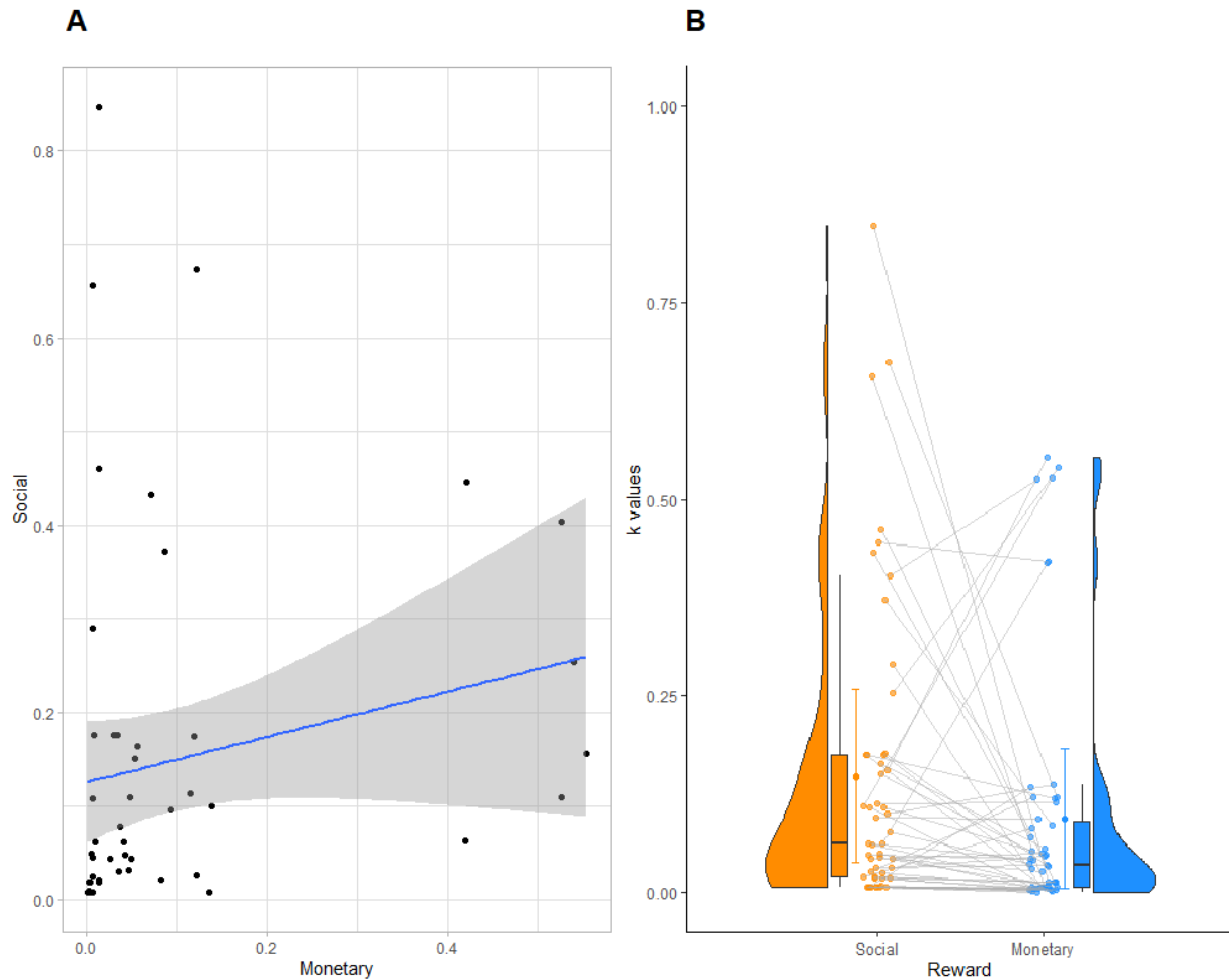
**Fig. 7** Conditional effects plots for a) Condition, b) LL, c) Delay.

#### Hyperbolic discounting rates (k values)

Of the 50 participants in the sample, 37 had a higher discounting rate for social compared to monetary reward. The modeled discount rates were found to be significant for social reward (CI: 0.0075, 0.6559) as well as for monetary reward (CI: 0.0014, 0.5265) individually (Fig. 8). The contrast between the two rewards (Social – Monetary) was however, not significant (95% HDI: -0.52, 0.61).

**Table. 5** Descriptive statistics of hyperbolic discount rates modeled using R.

| Reward Type | Social | Monetary |
|-------------|--------|----------|
| Minimum     | 0.0075 | 0.0014   |
| Maximum     | 0.8475 | 0.5534   |
| Median      | 0.0630 | 0.0345   |
| Range       | 0.8399 | 0.5521   |
| Mean        | 0.1484 | 0.0944   |
| SD (Mean)   | 0.0275 | 0.0222   |



**Fig. 8** a) Scatterplot with regression line and b) Raincloud plot of discounting rates (k values) per participant across both conditions of the IC task.

### Instagram Survey and Social Reward Questionnaire

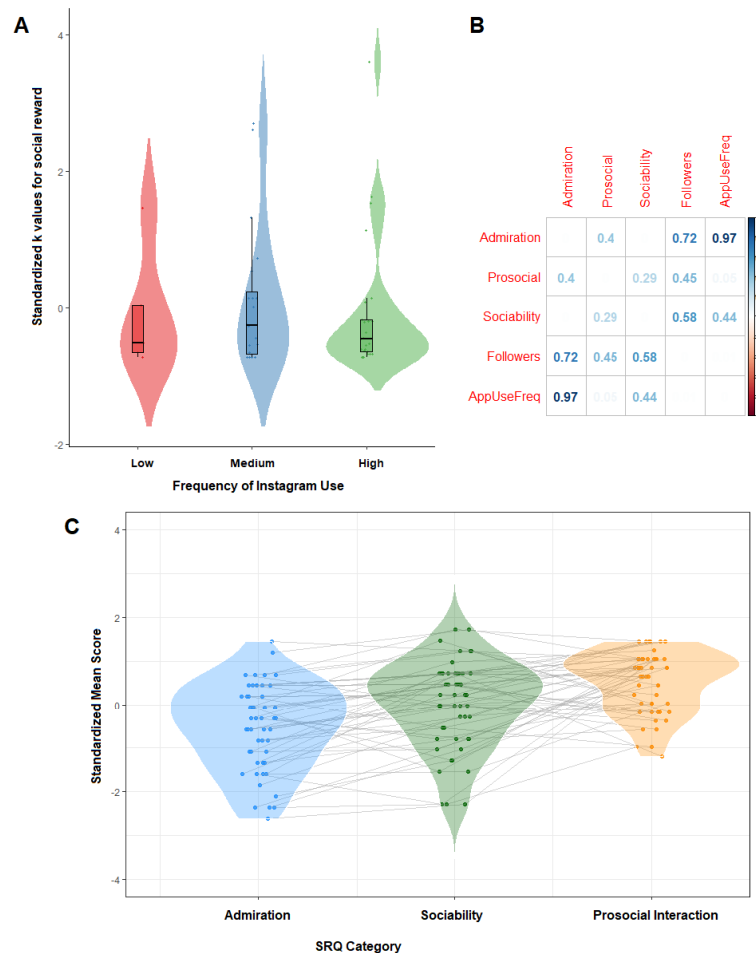
Mean scores for each category of SRQ were calculated (Table. 6) and from the Instagram survey, two factors, namely frequency of use of the app, and the number of followers each participant has were taken into consideration to be correlated with SRQ.

**Table. 6** Descriptive statistics of questionnaire responses

|                     | Mean | SD   | Min | Max  | Range |
|---------------------|------|------|-----|------|-------|
| <b>Instagram</b>    |      |      |     |      |       |
| Frequency of Use    | 4.06 | 1.10 | 1   | 5    | 4     |
| Number of Followers | 243  | 231  | 0   | 1250 | 1250  |

| SRQ         |      |      |      |   |      |
|-------------|------|------|------|---|------|
| Admiration  | 5.06 | 0.98 | 3    | 7 | 4    |
| Sociability | 4.71 | 1.33 | 1.67 | 7 | 5.33 |
| Prosocial   | 6.08 | 0.69 | 4.4  | 7 | 2.6  |
| Interaction |      |      |      |   |      |

Furthermore, there was a high correlation observed for the SRQ category of Admiration with Frequency of Instagram Use ( $p < 0.01$ ). Though no such relationship could be established with their corresponding discounting rates (Fig. 9).



**Fig. 9** a) Raincloud plot illustrating the relationship between standardized discount rates for social reward and frequency of Instagram use, b) Correlation between SRQ and Instagram factors, and c) Participants' standardized mean scores across SRQ categories

## Discussion

The main aim of this study was to distinguish the DD behavior in individuals when confronted with IC for social as well as monetary rewards. This was done so using the classic IC paradigm wherein monetary choices depended on unique subjective values for each participant varied across fixed delays. The social

reward utilized in this research was novel and designed specifically for this project. The main hypothesis of this study was that participants would discount social rewards more steeply than they would discount monetary rewards. Furthermore, to the best of author's knowledge, this is the first study to match subjective value of monetary rewards with social rewards that are adjustable in magnitude. This is in contrast to prior studies that have utilized social feedback (happy, sad, or angry faces) as a social reward which does not allow for adjusting the magnitude across delays (Lin, Adolphs, and Rangel, 2011; Kohls, et al., 2013; Flores, Münte, and Doñamayor, 2015; Distefano, et al., 2018). In addition to this, following the study by Chester, et al. (2019), this is the second study to use real social rewards in the experiment rather than hypothetical, wherein the paradigm allows for participants to deliberately choose between an immediate and delayed social reward to investigate how they value seeking and delaying social rewards in real life.

To this end, the primary analysis using a mixed effects model did not show significance for an effect of the differing conditions. None of the interactions between condition, reward levels, and delays were significant either. Noting here that the effects of LL reward levels and delay are not different across conditions. Since there is no evidence to suggest otherwise, it implies therefore that decisions made by the participants were reasonable choices, who took the magnitude of the differing amounts and durations of the delay into account when deciding but not the type of reward. The results of the secondary analysis too, did not show a significant difference between the discount rates for the two types of rewards.

Prior studies that have attempted to contrast with money have often done so using a drug of abuse. Odum and Rainaud (2003), Johnson, et al. (2010), Odum (2011), and O'Hara, et al. (2016) all reported participants to discount the non-monetary reward more steeply than money. Such steeper discounting has also been observed by Buono, et al. (2017) who designed a paradigm to compare DD time spent on gaming in contrast to discounting money. Though they found participants to discount game time more, the researchers of this study assume the choice for game time to be that compelling, considering they may not necessarily forego the immediate reward of a smaller game time as they could simply play it again later, more so made less valid by the paradigm being hypothetical. Nonetheless, the aforementioned results imply that across all domains investigated, money remains the strongest motivator to delay rewards, as it may be more lucrative and concrete in the long term in comparison any non-monetary rewards, whose subjective values reduce faster than it does for money.

Nevertheless, the results did show there to be a significant effect of magnitude as well as delay, wherein participants made more SS choices for social reward when the follower level was up to 5000 and when the delay was up to 14 days, but made more LL choices when the delay was 30 days or more, and when the follower level exceed 10,000. This observation is in accordance to Johnson, Herrmann, and Johnson (2015), who investigated DD of cigarettes compared to money and also found cigarettes to be steeply discounted in comparison to money, but at larger magnitudes of cigarettes, the cigarettes were discounted less steeply. Tayler et al. (2009) too found a similar magnitude effect among their participants in discounting duration and intensity of close-relationship fulfillment and outcomes.

At the same time, in the realm of Instagram, it is definitely worth investigating further how people are impatient in receiving social rewards and intentionally delay sharing content to maximize their social

reward online. Considering the observation of there being a high correlation between the SRQ category of Admiration and the frequency of Instagram use, why people choose to spend so much time and effort to be this calculative on Instagram remains to be fully understood. Especially, the behavior of steeply discounting rewards to be gained in the near future but having the opposite DD behavior for social rewards to be received in a distant future - so much so that they value the distant social rewards more than money. Such research could also potentially help explain and predict problematic social media use and its implications on offline social interactions. This aspect of social reward DD behavior is in line with the research of Meshi, Turel, and Henley (2020) who recently observed participants who used multiple social media platforms (here Snapchat and Facebook) to struggle with problematic use and multiple failed attempts at quitting a platform. They suggested this may be because of gamification of messaging feature by Snapchat wherein participants gain immediate rewards for messaging their friends and replying as soon as possible to increase rewards gained in the form of a 'streak'.

However, as has been previously critiqued by Paglieri et al. (2015), there may have been motivational confounds during the IC task for social rewards. Participants in this study showed a wide range in number of followers they have, as well as their frequency of use. Though discount rates did not show a relationship with frequency of use, Instagram activity is fluctuating dynamically and the current sample did not have largely influential people or those who actively seek rewards through the platform. Future studies should thence consider having users with business accounts as participants, since they consciously track the analytics involved in engagement and interaction of their content with their audience so as to maintain and improve their status online as an influencer. They then, this research hypothesizes, would show a more robust and steeper DD for social rewards on Instagram. More so, if the future study compares discounting for admiration on Instagram among business and personal accounts, they should observe that those with a reputation care whereas others will not.

Although, having business accounts would also mean having to increase the reward levels from a maximum of 30,000 followers to up to 100,000. This may lead to the social reward being operationalized as hypothetical, unless enough money is invested in this research to pay influencers to be a part of the study as influencers to the participants who are also influencers but on a relatively low level. Alternatively, the reward could be operationalized as business accounts getting more or less views depending on their unique content and peak hours of audience activity on the app, which would also be hypothetical. Therein, one potential explanation of the results of participants in this study being mostly patient for LL reward could also be because of the SS reward level not being enticing enough as an immediate option. Subsequently, this in turn may have led participants to equate extremely low indifference points, thereby making the monetary SS reward just as non-lucrative. Furthermore, if influencers only have up to 5000 followers, it may matter who the person is that would share the participants' posts, though for influencers above 10,000 followers, the magnitude is large enough for it to not be as important for the influencer to be of one's liking, leading participants to wait for the large payout regardless of the influencer.

In addition to this, another factor that may have impacted participants' decisions in the social reward condition could be that the choice may have been perceived, to an extent, as hypothetical. This is since

the participants were not aware of the influencer that would share their post at the time of performing the IC task. Even after having an influencer assigned to them, it was still not an influencer of their choice. Therefore, combining users with business accounts as subjects with hypothetical choice wherein participants could predetermine the influencer of their choice before the task would make for a much more compelling choice. This could be because, as Peters and Büchel (2010) observed, participants were less impulsive when they had a more vivid imagery of the future reward. So if participants, having in mind the exact posts and the influencers who would share their content at the time of making ICs, are still patient, then Peters' and Büchel's (2010) findings can be challenged in the context of impulsivity on rewards gained through social media.

Lastly, some of the design limitations of this research were the methods of indifference points collection. Rather than participants equating a monetary amount to having their content shared by influencers with differing follower levels (which restricts the range of monetary amounts especially if it is to be paid out for real), participants should be asked to enter the follower amounts that they would equate with fixed amounts of money. Another limitation could also be that the entire Social Reward Questionnaire was not used or statistically analysed. Previous research by Meshi, Turel, and Henley (2020) found a surprising correlation between problematic social media use with the category of negative social potency. Future research into impulsivity and DD in the context of social media should utilize all SRQ categories and see if there are any significant correlations of those with individuals' DD and social reward seeking behavior.

In conclusion, this research found that though participants had a varying discounting rates across the two types of rewards, when taking into consideration the multilevel model comprising of each condition, reward level, as well as delay, the effect of condition is not so significant, but rather, DD for both rewards is done so similarly with magnitude and delay durations in mind. These results therefore suggest a common mechanism for discounting both social and monetary rewards and should in the future be combined with neural data using fMRI and analyze data using conjunction analysis, to investigate the similarities in brain networks involved in delaying social in comparison to monetary rewards. Furthermore, Instagram was found to be a great way to investigate DD of social rewards, with advantages of customization of paradigm, the possibility of hypothetical as well as real rewards, as well as the validity of the task for DD considering user behavior on the app in the world today. Future studies that wish to employ Instagram can use it for investigation of many such behaviors that are simulated online on social networking sites, with potential implications for impulsivity, anxiety, depression, and impact on offline social interactions as well as decision-making in social contexts.

## References

- Albrecht, K., Volz, K. G., Sutter, M., Laibson, D. I., & Von Cramon, D. Y. (2010). What is for me is not for you: brain correlates of intertemporal choice for self and other. *Social cognitive and affective neuroscience*, 6(2), 218-225.
- Bar, M. (2010). Wait for the second marshmallow? Future-oriented thinking and delayed reward discounting in the brain. *Neuron*, 66(1), 4-5.
- Benoit, R. G., Gilbert, S. J., & Burgess, P. W. (2011). A neural mechanism mediating the impact of episodic prospection on farsighted decisions. *Journal of Neuroscience*, 31(18), 6771-6779.
- Buono, F. D., Sprong, M. E., Lloyd, D. P., Cutter, C. J., Printz, D. M., Sullivan, R. M., & Moore, B. A. (2017). Delay Discounting of Video Game Players: Comparison of Time Duration Among Gamers. *Cyberpsychology, Behavior, and Social Networking*, 20(2), 104-108.
- Bürkner, P. C. (2018). An R Package for Bayesian Multilevel Models Using Stan. *Journal of Statistical Software*, 80(1), 1-28.
- Bürkner, P. C., & Charpentier, E. (2018). Modeling monotonic effects of ordinal predictors in regression models.
- Carpenter, B., Gelman, A., Hoffman, M., Lee, D., Goodrich, B., Betancourt, M., . . . Riddell, A. (2017). tan: A probabilistic programming language. *Journal of Statistical Software*, 76(1).
- Casaló, L. V., & Ibáñez-Sánchez, S. (2018). Influencers on Instagram: Antecedents and consequences of opinion leadership. *Journal of Business Research*, 117, 510-519.
- Charlton, S. R., Gossett, B. D., & Charlton, V. A. (2012). Effect of delay and social distance on the perceived value of social interaction. *Behavioural processes*, 89(1), 23-26.
- Chester, D. S., Bell, S. B., DeWall, C. N., West, S. J., Romero-Lopez, M., & Craig, A. W. (2019). Neural correlates of intertemporal choice in aggressive behavior. *Aggressive behavior*, 45, 507-516.
- De Veirman, M., Cauberghe, V., & Hudders, L. (2017). Marketing through Instagram influencers: the impact of number of followers and product divergence on brand attitude. *International Journal of Advertising*, 36(5), 798-828.
- De Veirman, M., De Jans, S., Van den Abeele, E., & Hudders, L. (2020). Unravelling the power of social media influencers: a qualitative study on teenage influencers as commercial content creators on social media. In C. & Goanta, *The Regulation of Social Media Influencers* (pp. 126-166). Edward Elgar Publishing.
- Distefano, A., Jackson, F., Levinson, A. R., Infantolino, Z. P., Jarcho, J. M., & Nelson, B. D. (2018). A comparison of the electrocortical response to monetary and social reward. *Social cognitive and affective neuroscience*, 13(3), 247-255.
- Drenten, J., Gurrieri, L., & Tyler, M. (2020). Sexualized labour in digital culture: Instagram influencers, porn chic and the monetization of attention. *Gender, Work & Organization*, 27(1), 41-66.



- Facebook. (2020, 08). *Facebook for Business: Get started with marketing on Instagram*. Retrieved from Facebook: <https://www.facebook.com/business/marketing/instagram#>
- Flores, A., Münte, T. F., & Doñamayor, N. (2015). Event-related EEG responses to anticipation and delivery of monetary and social reward. *Biological psychology*, 109, 10-19.
- Foulkes, L., Bird, G., Gökçen, E., McCrory, E., & Viding, E. (2015). Common and distinct impacts of autistic traits and alexithymia on social reward. *PloS one*, 10(4), 1-12.
- Foulkes, L., McCrory, E. J., Neumann, C. S., & Viding, E. (2014). Inverted social reward: Associations between psychopathic traits and self-report and experimental measures of social reward. *PloS one*, 9(8), 1-10.
- Foulkes, L., Viding, E., McCrory, E. J., & Neumann, C. S. (2014). Social Reward Questionnaire (SRQ): development and validation. *Frontiers in psychology*, 5(201), 1-8.
- Frost, R., & McNaughton, N. (2017). The neural basis of delay discounting: A review and preliminary model. *Neuroscience & Biobehavioral Reviews*, 79, 48-65.
- Johnson, M. W., Bickel, W. K., Baker, F., Moore, B. A., Badger, G. J., & Budney, A. J. (2010). Delay discounting in current and former marijuana-dependent individuals. *Experimental and clinical psychopharmacology*, 18(1), 99-107.
- Johnson, P. S., Herrmann, E. S., & Johnson, M. W. (2015). Opportunity costs of reward delays and the discounting of hypothetical money and cigarettes. *Journal of the Experimental Analysis of Behavior*, 103(1), 87-107.
- Kanuri, V. K., Chen, Y., & Sridhar, S. (2018). Scheduling content on social media: Theory, evidence, and application. *Journal of Marketing*, 82(6), 89-108.
- Kircaburun, K., & Griffiths, M. D. (2018). Instagram addiction and the Big Five of personality: The mediating role of self-liking. *Journal of behavioral addictions*, 7(1), 158-170.
- Kohls, G., Perino, M., Taylor, J., Madva, E., Cayless, S., Troiani, V., . . . Schultz, R. (2013). The nucleus accumbens is involved in both the pursuit of social reward and the avoidance of social punishment. *Neuropsychologia*, 51(11), 2062-2069.
- Lin, A., Adolphs, R., & Rangel, A. (2011). Social and monetary reward learning engage overlapping neural substrates. *Social cognitive and affective neuroscience*, 7(3), 274-281.
- Lup, K., Trub, L., & Rosenthal, L. (2015). Instagram# instasad?: exploring associations among instagram use, depressive symptoms, negative social comparison, and strangers followed. *Cyberpsychology, Behavior, and Social Networking*, 18(5), 247-252.
- Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In M. L. Commons, J. E. Mazur, J. A. Nevin, & H. E. Rachlin, *Quantitative Analysis of Behavior Volume 5: The effect of delay and of intervening events on reinforcement value* (pp. 55-73). Psychology Press.
- Meshi, D., Tamir, D. I., & Heekeren, H. R. (2015). The emerging neuroscience of social media. *Trends in cognitive sciences*, 19(12), 771-782.

- Meshi, D., Turel, O., & Henley, D. (2020). Snapchat vs. Facebook: Differences in problematic use, behavior change attempts, and trait social reward preferences. *Addictive Behaviors Reports*, 12(100294), 1-5.
- Moreira, D., Pinto, M., Almeida, F., Barros, S., & Barbosa, F. (2016). Neurobiological bases of intertemporal choices: A comprehensive review. *Aggression and violent behavior*, 26, 1-8.
- Mühlhoff, N., Stevens, J. R., & Reader, S. M. (2011). Spatial discounting of food and social rewards in guppies (*Poecilia reticulata*). *Frontiers in psychology*, 2(68), 1-11.
- O'Hora, D., Carey, R., Kervick, A., Crowley, D., & Dabrowski, M. (2016). Decisions in motion: Decision dynamics during intertemporal choice reflect subjective evaluation of delayed rewards. *Scientific reports*, 6(20740), 1-17.
- Odum, A. L. (2011). Delay discounting: trait variable? *Behavioural processes*, 87(1), 1-9.
- Odum, A. L., & Rainaud, C. P. (2003). Discounting of delayed hypothetical money, alcohol, and food. *Behavioural processes*, 64(3), 305-313.
- Paglieri, F., Addessi, E., Sbaffi, A., Tasselli, M. I., & Delfino, A. (2015). Is it patience or motivation? On motivational confounds in intertemporal choice tasks. *Journal of the Experimental Analysis of Behavior*, 103(1), 196-217.
- Peters, J., & Büchel, C. (2010). Episodic future thinking reduces reward delay discounting through an enhancement of prefrontal-mediotemporal interactions. *Neuron*, 66(1), 138-148.
- Peters, J., & Büchel, C. (2011). The neural mechanisms of inter-temporal decision-making: understanding variability. *Trends in Cognitive Sciences*, 15(5), 227-239.
- Scheres, A., De Water, E., & Mies, G. W. (2013). The neural correlates of temporal reward discounting. *Wiley Interdisciplinary Reviews: Cognitive Science*, 4(5), 523-545.
- Sherman, L. E., Greenfield, P. M., Hernandez, L. M., & Dapretto, M. (2018). Peer influence via instagram: effects on brain and behavior in adolescence and young adulthood. *Child development*, 89(1), 37-47.
- Sherman, L. E., Hernandez, L. M., Greenfield, P. M., & Dapretto, M. (2018). What the brain 'Likes': neural correlates of providing feedback on social media. *Social cognitive and affective neuroscience*, 13(7), 699-707.
- Sherman, L. E., Payton, A. A., Hernandez, L. M., Greenfield, P. M., & Dapretto, M. (2016). The power of the like in adolescence: effects of peer influence on neural and behavioral responses to social media. *Psychological science*, 27(7), 1027-1035.
- Smith, B. J., Monterosso, J. R., Waksak, C. J., Bechara, A., & Read, S. J. (2018). A meta-analytical review of brain activity associated with intertemporal decisions: Evidence for an anterior-posterior tangibility axis. *Neuroscience & Biobehavioral Reviews*, 86, 85-98.
- Sohn, J. H., Kim, H. E., Sohn, S., Seok, J. W., Choi, D., & Watanuki, S. (2015). Effect of emotional arousal on inter-temporal decision-making: an fMRI study. *Journal of physiological anthropology*, 34, 1-8.

- Statista. (2020, 07). *Most popular social networks worldwide as of July 2020, ranked by number of active users*. Retrieved from Statista: <https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/>
- Taylor, S., Arantes, J., & Grace, R. C. (2009). Temporal discounting for monetary and close relationship outcomes. *Personal Relationships*, 16(3), 385-400.
- van Driel, L., & Dumitrica, D. (2020). Selling brands while staying “Authentic”: The professionalization of Instagram influencers. *Convergence: : The International Journal of Research into New Media Technologies*, 1-19.
- Woo-Young, A., Hairong, G., Yitong, S., Haines, N., Hahn, H., Teater, J., . . . Pitt, M. (2020). Rapid, precise, and reliable measurement of delay discounting using a Bayesian learning algorithm. *Scientific Reports (Nature Publisher Group)*, 10(1), 1-27.
- Zhang, S., Liu, P., & Feng, T. (2019). To do it now or later: The cognitive mechanisms and neural substrates underlying procrastination. *Wiley Interdisciplinary Reviews: Cognitive Science*, 10(e1492), 1-20.

## Appendices

### Appendix 1: Social Reward Questionnaire

**Admiration:** Q1, Q7, Q11, Q18; **Prosocial Interactions:** Q2, Q6, Q16, Q19, Q22; **Sociability:** Q4, Q10, Q15

Mean score for each category is calculated using the scale: strongly disagree = 1; strongly agree = 7

|                                                                               | Strongly Disagree | Disagree | Slightly disagree | Neither agree nor disagree | Slightly agree | Agree | Strongly Agree |
|-------------------------------------------------------------------------------|-------------------|----------|-------------------|----------------------------|----------------|-------|----------------|
| 1. I enjoy being around people who think I am an important, exciting person   |                   |          |                   |                            |                |       |                |
| 2. I enjoy treating others fairly                                             |                   |          |                   |                            |                |       |                |
|                                                                               |                   |          |                   |                            |                |       |                |
| 4. I enjoy going to parties                                                   |                   |          |                   |                            |                |       |                |
|                                                                               |                   |          |                   |                            |                |       |                |
| 6. I enjoy feeling emotionally connected to someone                           |                   |          |                   |                            |                |       |                |
| 7. I enjoy it if others look up to me                                         |                   |          |                   |                            |                |       |                |
|                                                                               |                   |          |                   |                            |                |       |                |
|                                                                               |                   |          |                   |                            |                |       |                |
| 10. I enjoy being a member of a group/club                                    |                   |          |                   |                            |                |       |                |
| 11. I enjoy being around people who are impressed with who I am and what I do |                   |          |                   |                            |                |       |                |
|                                                                               |                   |          |                   |                            |                |       |                |
|                                                                               |                   |          |                   |                            |                |       |                |
|                                                                               |                   |          |                   |                            |                |       |                |
| 15. I enjoy many people wanting to invite me to their social events           |                   |          |                   |                            |                |       |                |
| 16. I enjoy keeping promises I make to others                                 |                   |          |                   |                            |                |       |                |
|                                                                               |                   |          |                   |                            |                |       |                |
| 18. I enjoy achieving recognition from others                                 |                   |          |                   |                            |                |       |                |
| 19. I enjoy it if someone accepts me as I am, no matter what                  |                   |          |                   |                            |                |       |                |
|                                                                               |                   |          |                   |                            |                |       |                |
|                                                                               |                   |          |                   |                            |                |       |                |
| 22. I enjoy making someone feel happy                                         |                   |          |                   |                            |                |       |                |
|                                                                               |                   |          |                   |                            |                |       |                |

## Appendix 2: Instagram Survey

### Part 1

*Please open Instagram on your phone or on the computer to answer the following questions.*

1. How many people are you following? \_\_\_\_\_
2. How many followers do you have? \_\_\_\_\_
3. How many photos have you posted? \_\_\_\_\_
4. Is your account public or private? \_\_\_\_\_
5. Is your account regular or business? \_\_\_\_\_
6. How often do you use Instagram? *(please choose one)*
  - a) Multiple times a day
  - b) About once a day
  - c) A few times a week
  - d) A few times a month
  - e) About once a month or less
7. How often do you post stories? *(please choose one)*
  - a) Multiple times a day
  - b) About once a day
  - c) A few times a week
  - d) A few times a month
  - e) About once a month or less
8. How often do you post pictures onto your feed? *(please choose one)*
  - a) Multiple times a day
  - b) About once a day
  - c) A few times a week
  - d) A few times a month
  - e) About once a month or less
9. How often do you check the views on your stories? *(please choose one)*
  - a) After the story has expired
  - b) Every few hours

c) Every hour

d) Other (please specify) \_\_\_\_\_

10. When did you join Instagram? (answer as month/year) \_\_\_\_\_

11. Other than Instagram, which social networking sites, apps, or blogging platforms do you use regularly?

(please check all that apply.)

☐ Facebook

☐ Twitter

☐ Tumblr

☐ Pinterest

☐ Snapchat

☐ Reddit

☐ Foursquare / Swarm

☐ Other \_\_\_\_\_

☐ Other \_\_\_\_\_

12. Why do you use Instagram? What do you like about the app and what do you dislike? \_\_\_\_\_

## Part 2

1. For posts, I would consider more than \_\_\_\_\_ likes to be “a lot” of likes.

2. *Please circle as many as apply:* I would feel \_\_\_\_\_ when my pictures get a LOT of likes.

Happy | Excited | Proud | Surprised | Amused | Unhappy | Hurt | Sad | Angry

3. For posts, I would consider fewer than \_\_\_\_\_ likes to be “very few” likes.

4. *Please circle as many as apply:* I would feel \_\_\_\_\_ when my pictures get only A FEW likes.

Happy | Excited | Proud | Surprised | Amused | Unhappy | Hurt | Sad | Angry

## Part 3

1. For stories, I would consider more than \_\_\_\_\_ views to be “a lot” of views.

2. *Please circle as many as apply:* I would feel \_\_\_\_\_ when my stories get a LOT of views.

Happy | Excited | Proud | Surprised | Amused | Unhappy | Hurt | Sad | Angry

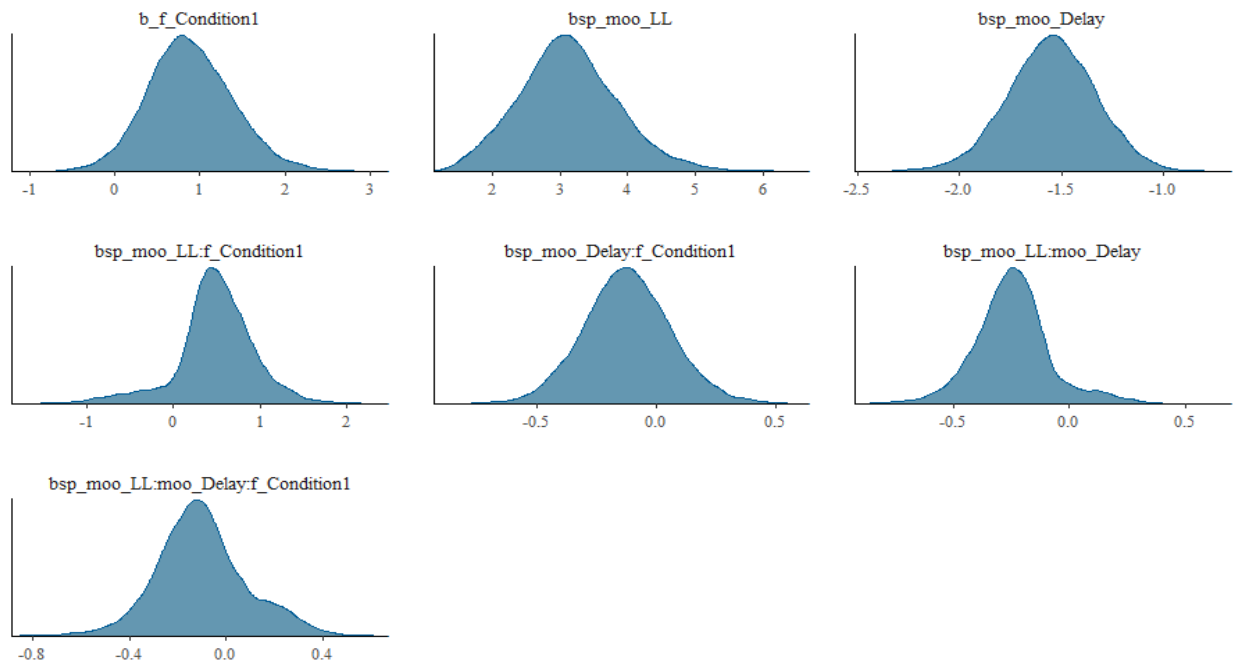
3. For stories, I would consider fewer than \_\_\_\_\_ views to be “few” views.

4. *Please circle as many as apply:* I would feel \_\_\_\_\_ when my pictures get only A FEW views.

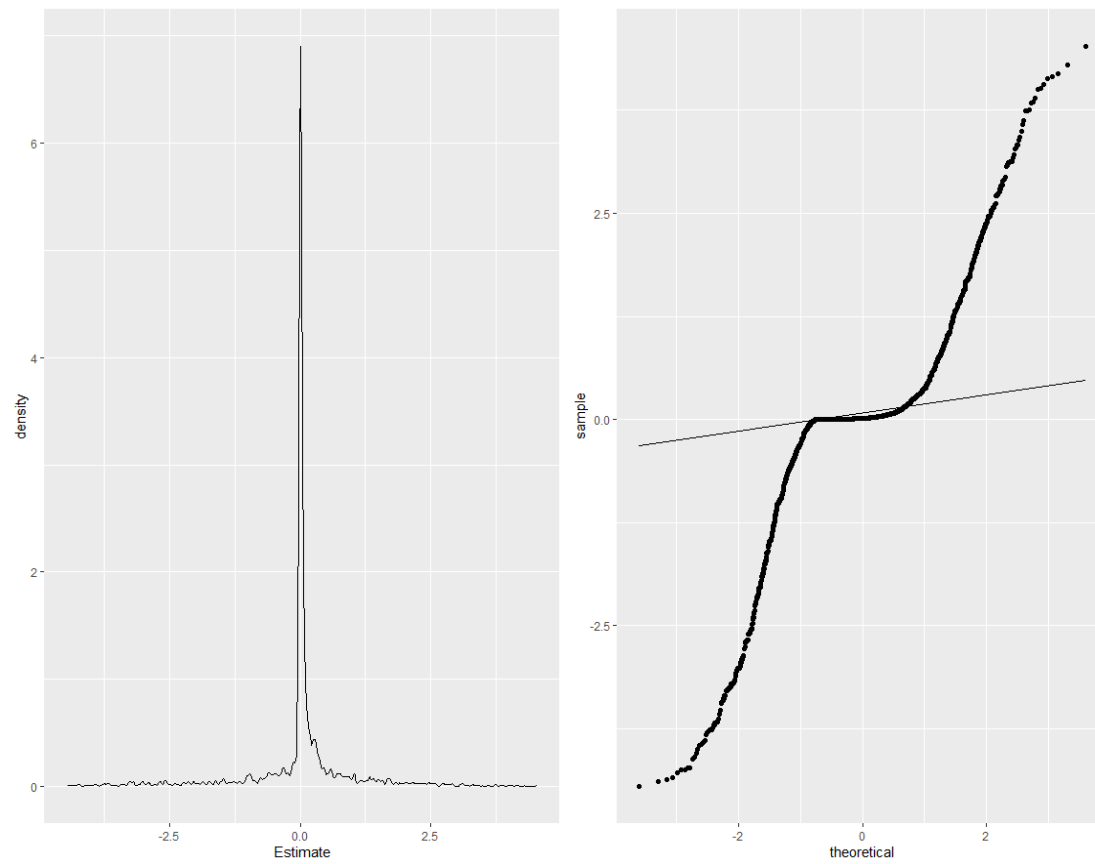
Happy | Excited | Proud | Surprised | Amused | Unhappy | Hurt | Sad | Angry

### Appendix 3: Mixed effects model

Posterior distributions of the main model



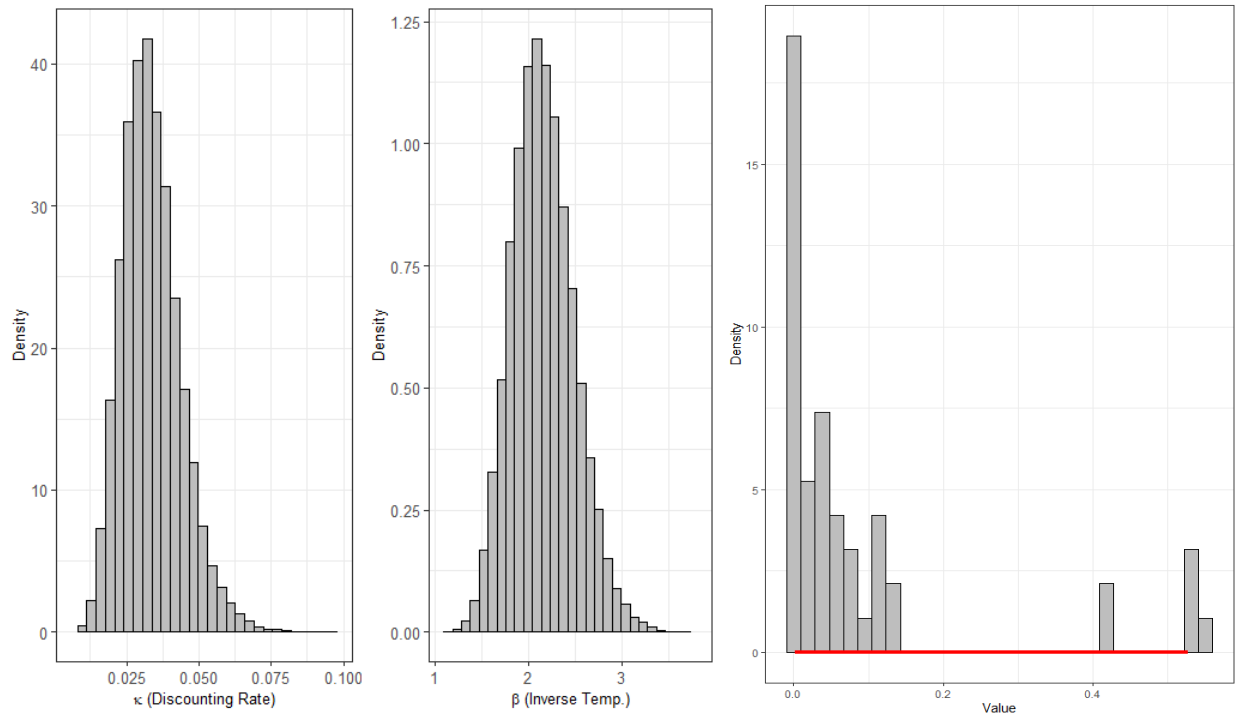
## Normality: model residuals density and QQ plots



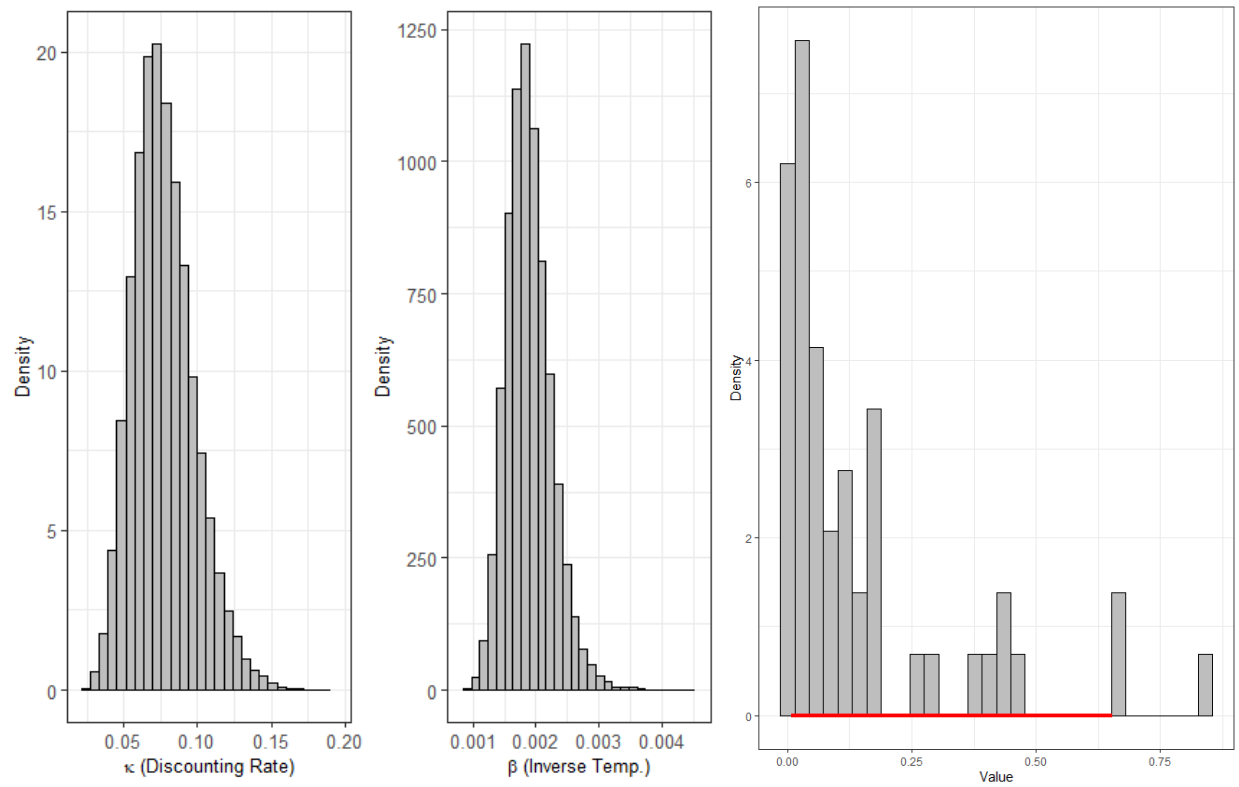


## Appendix 4: Hyperbolic discounting rate $k$

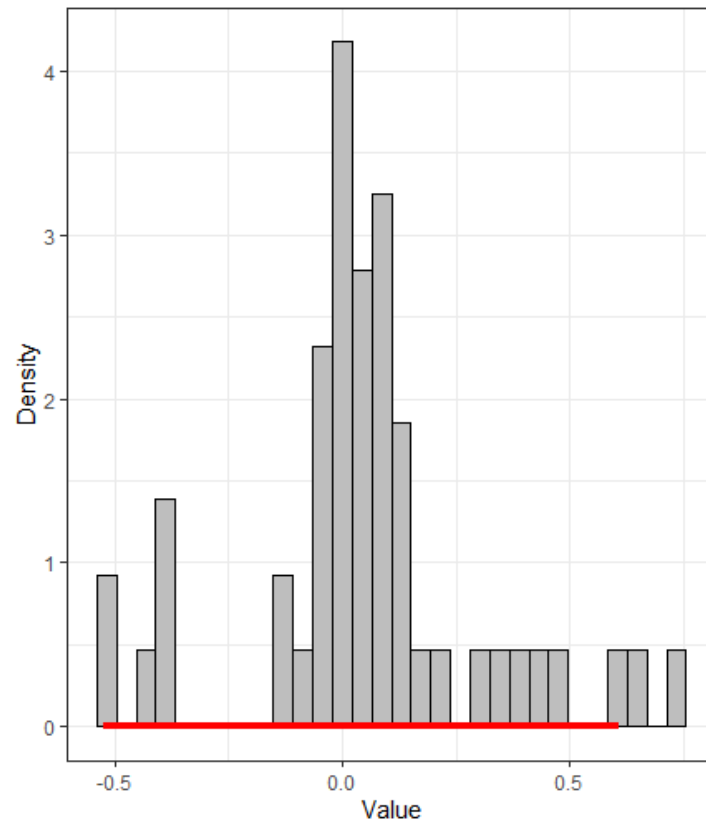
Monetary reward discount rates,  $\beta$  temperature, and HDI histograms.



Social reward discount rates,  $\beta$  temperature, and HDI histograms.



Difference in contrast (Social – Money) MCMC HDI plot.



#### Appendix 5: Instagram and SRQ factors correlation matrix

|                    | <b>Admiration</b> | <b>Prosocial</b> | <b>Sociability</b> | <b>Followers</b> | <b>AppUseFreq</b> |
|--------------------|-------------------|------------------|--------------------|------------------|-------------------|
| <b>Admiration</b>  | 1.000000000       | 0.1226435        | 0.6656241          | -0.05242748      | 0.006114126       |
| <b>Prosocial</b>   | 0.122643494       | 1.0000000        | 0.1514559          | -0.10837320      | 0.277964837       |
| <b>Sociability</b> | 0.665624098       | 0.1514559        | 1.0000000          | 0.07985430       | 0.110559538       |
| <b>Followers</b>   | -0.052427477      | -0.1083732       | 0.0798543          | 1.00000000       | 0.364632925       |
| <b>AppUseFreq</b>  | 0.006114126       | 0.2779648        | 0.1105595          | 0.36463292       | 1.000000000       |