Are Smartphone Users Impulsive? A Comparison of Delay Discounting of Real and Hypothetical Smartphone Access and Money

Mariah Willis

California State University, Chico

Abstract

Smartphone use is prevalent in our society, with daily interactions ranging from 2-5 hours per day. Recently, smartphone overuse has been described as a behavioral dependence and is becoming an increasing health risk for sleep disturbances, anxiety, and depression. College students are an at-risk population for smartphone overuse, with self-reported time spent on smartphones ranging from 8-10 hours per day. One possible explanation for smartphone overuse may be impulsivity. Other impulsive behaviors including drug use, pathological gambling and sexual risk-taking behavior are often described by delay discounting (DD), a behavioral measure that describes the manner in which the subjective value of an outcome decreases as the delay to receipt increases. Smartphone overuse has recently been conceptualized as an instance of DD; however, no task has been developed to measure DD of smartphone access. The present within-subjects study evaluated the novel Smartphone Delay Discounting Task (SDDT) in comparison with the existing Monetary Delay Discounting Task (MDDT); hypothetical and real outcomes were also compared between the tasks. A significant main effect of commodity type was observed (p=.004); however, contrary to prediction, money was discounted more steeply than smartphone access. This finding was surprising but may be explained by a magnitude effect (i.e., steeper DD of small-magnitude outcomes). Consistent with the DD literature, real outcomes were not discounted significantly differently from hypothetical outcomes (p =.34). Future studies wanting to expand upon these findings should investigate DD of larger magnitudes in hypothetical tasks.

Key words: Smartphone overuse, delay discounting, impulsivity, hypothetical outcomes, college student

Are Smartphone Users Impulsive? A Comparison of Delay Discounting of Real and Hypothetical Smartphone Access and Money

Smartphone use has gradually become more widespread and convenient, providing immediate and readily available access to the Internet, social media, social engagement (i.e., texting, calling) and copious amounts of other applications. Increasingly, applications provide "push" notifications including sounds or vibrations, which signal that reinforcement is available. Moreover, notifications and "feeds" are updated unpredictably, providing gambling-like or intermittent reinforcement that may be highly enticing. Finally, because smartphones are portable and readily accessible, smartphone-related reinforcement is easily obtainable.

Since 2012, smartphone ownership has risen from 34% to 77%, and is projected to rise yearly (Pew Research Center, 2018). With more users comes a greater risk of smartphone overuse, which studies have shown has increased in prevalence in recent years. For example, in the United States, daily duration of smartphone interactions ranges from 2-5 hours with phone-checking behavior occurring once every 15 minutes (Pew Research Center, 2018). Smartphone overuse is now being described as problematic and as a behavioral dependence (Billieux, Maurage, Lopez-Fernandez, Kuss, & Griffiths, 2015; Choliz, 2010; Al-Barashdi, Bouazza, & Jabur, 2015), with 20% of smartphone users in the United States indicating that they are dependent on their smartphones (i.e., couldn't live without their phones; Pew Research Center, 2018).

College students may be at risk for smartphone overuse. Within this population, 94% report owning a smartphone (Pew Research Center, 2018). Among college-aged smartphone owners, 77% of their time is spent using their smartphone to access social media and the Internet (Roberts, Yaya, & Manoils, 2014). Self-reported time spent on smartphones among those in this demographic ranges from 8-10 hours per day (Roberts, Yaya, & Manoils, 2014). With frequent use to such an extent among college students, it is therefore imperative to investigate how smartphone overuse may affect young adults and their psychological functioning.

Smartphone overuse has been extensively studied in the literature and is associated with increased risks for sleep disturbances, such as issues falling asleep and staying asleep (Demirci, Akgonul, & Akpinar, 2015); risk-taking behaviors, including texting while driving (Hayashi, Russo, & Wirth 2015; Caird, Johnston, Willness, Asbridge, & Steel, 2014); and increased risk for depression and anxiety (Demirci, Akgonul, & Akpinar, 2015; Kuss, Kanjo, Crook-Rumsey, Kibowski, Wang & Sumich, 2018). With these known risks, an understanding of the psychological motivations underlying smartphone overuse is needed.

Researchers have provided several reasons for smartphone use including social interactions, such as communicating through social media sites (Raacke & Bonds-Raacke, 2008); to gain information, such as Google™ searches (Sohn, Li, Griswold, & Hollan, 2008); to pass time (Hiniker, Patel, Kohno, & Kientz, 2016); for comfort in stressful times (Panova & Lleras, 2016); and for entertainment (Shin & Dey, 2013). However, little research has provided explanations for smartphone *over*use. Smartphone overuse may be motivated by fears of missing out (Elhai, Levine, Dvorak, & Hall, 2016); separation anxiety from smartphones (Cheever, Rosen, Carrier, & Chavez, 2014); or ease of access (Shin & Dey, 2013) and instant gratification sought by the user (Hiniker, Patel, Kohno, & Kientz, 2016). The latter reasons may be especially important when conceptualizing smartphone overuse as an instance of impulsivity.

Impulsivity

Impulsivity is often described as a multidimensional construct comprised of personality traits including sensation seeking, lack of urgency, lack of self-control, and lack of selfregulation; actions characterized by lack of inhibitory motor control; and choices favoring immediate, but smaller options over delayed, but larger options (MacKillop et al., 2016). Impulsivity is reliably associated with a variety of addictive and risky behaviors including drug use (Moody, Franck, Hatz, & Bickel, 2016; MacKillop et al., 2011), pathological gambling (Cosenza, Griffiths, Nigro, & Ciccarelli, 2017; Dixon, Marley, & Jacobs, 2003), and risky sexual behavior (Berry et al., 2019; Johnson & Bruner, 2012).

Recently, personality researchers have conceptualized smartphone overuse as an instance of impulsivity because users often describe that they cannot be away from their phones or feel dependent on their smartphones (Billieux, van der Linden, & Rochat, 2008; Kim et al., 2016). Billieux et al. compared smartphone overuse with personality traits using the UPPS Impulsive Behavior Scale (UPPS; Whiteside & Lynam, 2001), which measures indices of impulsive behavior including urgency, lack of premeditation, lack of perseverance, and sensation seeking. Interestingly, the strongest predictor of smartphone overuse in their sample was greater urgency (i.e., inability to wait). In a similar study, Kim et al. (2016) examined personality factors using the Behavioral Inhibition System/Behavioral Activation System Scale (BIS/BAS; Carver & White, 1994), the Dickman Dysfunctional Impulsivity Instrument (DDII), and the Brief Self-Control Scale (BSCS; Tangney, Baumeister, & Boone, 2004) in an effort to predict possible smartphone addiction predisposition. Kim et al. found that, in addition to more time spent on smartphones, higher scores on the BIS/BAS and DDII and lower scores on the BSCS were predictors for high smartphone addiction predisposition. In addition to impulsive personality traits being associated with smartphone overuse, researchers have examined smartphone overuse and impulsive actions. For example, Chen, Liang, Mai, Zhong, and Qu (2016) found that excessive smartphone users were less controlled in a Go/No-Go task (i.e., emitted more premature responses) compared to those who did not meet criteria for excessive smartphone use.

Researchers have also examined smartphone overuse and other technology-oriented behaviors such as social media and Internet overuse as instances of impulsive choice. Meshi, Elizarova, Bender, and Verdejo-Garcia (2019) examined excessive social media use and impulsive decision-making using the Iowa Gambling Task (IGT; Bechera et. al., 1994). Meshi et al. found that individuals who used social media excessively made riskier decisions during the IGT, suggesting they may be more impulsive than those who use social media less frequently. Saville, Gisbert, Kopp, and Telesco (2010) examined Internet overuse and impulsivity using a hypothetical monetary delay discounting task. They found that individuals who met criteria for “Internet addiction” discounted delayed money more steeply (i.e., made more choices for immediate, but smaller money amounts) than participants who did not meet criteria for Internet addiction. More recently, researchers have found that individuals who overuse smartphones also tend to discount delayed hypothetical monetary rewards more steeply (Wilmer & Chein, 2017). Given these findings, it may be advantageous to examine the relationship between smartphone overuse and impulsive decision-making within a delay discounting framework.

Delay Discounting

Delay discounting (DD) is a behavioral measure that describes the manner in which the subjective value of a future outcome decreases as the delay to its receipt increases (Madden & Johnson, 2010). In a typical DD task, individuals are asked to make choices between an immediate, but smaller option and a delayed, but larger option (e.g., “Would you like $50 now or $100 in 1 month?”). Individuals are said to be impulsive when they favor the “smaller-sooner” (SS) option over the “larger-later” (LL) option when the consequences are positive (i.e., rewarding); the opposite is true when consequences are negative (i.e., punishing). Across several trials in which the LL is held constant (e.g., $100 in 1 month), the amount of the SS is adjusted based on the individual's choices (Du, Green, & Myerson, 2002). In the Du et al. procedure, choosing the LL increases the SS amount (e.g., $50) by half of the SS amount on the next trial (e.g., $75); likewise, choosing the SS decreases the SS amount by half on the next trial ($25). This adjusting-amount procedure is used to find an indifference point (i.e., the present subjective value of the discounted LL) across a range of LL delays. Once indifference points are obtained for several LL delays, they are plotted to construct a DD curve, the steepness of which describes the rate at which the LL loses value as a function of time to its receipt.

Several factors affect DD rate, including the degree to which an outcome can be readily consumed (Holt, Newquist, Smits, & Tiry, 2013; Odum & Baumann, 2007; Odum & Rainaud, 2003). In general, consumable outcomes such as food (i.e., primary reinforcers) tend to be discounted more steeply than monetary outcomes (i.e., conditioned reinforcers; Odum, 2011). Specifically, Odum, Baumann, and Rimington (2006) compared DD of hypothetical money with DD of hypothetical food and found that food was discounted more steeply than money. Similarly, Estle, Green, Myerson, and Holt (2007) compared DD of hypothetical money with DD of three consumable but hypothetical outcomes (candy, soda, and beer). They found that hypothetical consumable outcomes were discounted more steeply than hypothetical monetary outcomes. Additionally, hypothetical cigarettes (Johnson, Herrmann, & Johnson, 2015; Odum & Baumann, 2007; Bickel, Odum, & Madden, 1999), drugs (Odum et al., 2000), alcohol (Odum & Rainaud, 2003), and entertainment (Charlton & Fantino, 2008) have been found to be discounted more steeply than hypothetical money. Importantly, studies in this area have focused on comparing directly consumable outcomes within the population it applies (e.g., cigarettes for cigarette smokers). Thus, if one is to examine DD of smartphone access, it may be advantageous to sample from a population of individuals who overuse smartphones. Although DD studies of this sort are valuable, one shortcoming appears to be their reliance on hypothetical outcomes.

DD of Hypothetical vs. Real Outcomes

Comparisons of DD of real and hypothetical outcomes have frequently been conducted (Johnson & Bickel, 2002; Lagorio & Madden, 2005; Locey, Jones, & Rachlin, 2011; Madden, Begotka, Raiff, & Kastern, 2003). Results of these studies suggest that DD rates of real and hypothetical outcomes do not differ significantly. In other words, DD rate does not appear to depend on reward type. However, evidence for this conclusion comes exclusively from studies that have compared DD of real and hypothetical monetary outcomes. Furthermore, rather than assessing DD of truly real money, studies have relied on *potentially* real money (i.e., participants are told that one of their choices will be experienced; Lawyer, Schoepflin, Green, & Jenks, 2011; Robertson & Rasmussen, 2018). Perhaps more problematic is that no study, to our knowledge, has compared DD of real and hypothetical outcomes when delays are experienced (i.e., involve opportunity costs), which Johnson et al. (2015) showed produced different DD rates compared when delays were not experienced (i.e., did not involve opportunity costs). Increasingly, it may be valuable to compare DD rates of hypothetical and real outcomes across commodities to determine if discounting genuinely differs upon whether outcomes are experienced or not.

Some studies have observed differences between hypothetical and real outcomes when real outcomes were directly consumable. Specifically, Jimura, Myerson, Hilgard, Braver, and Green (2009) examined DD of real (i.e., liquids) and hypothetical rewards (i.e., money), finding that experienced delays and choice outcomes for real liquids resulted in steeper discounting rates than hypothetical monetary outcomes; these findings were replicated in 2011 (Jimura et al., 2011) and suggest that there may be a difference across commodities when delays are experienced and directly consumable outcomes are real. However, one limitation of these two studies is the comparison of real outcomes that were directly experienced and consumable with hypothetical outcomes that were not directly experienced or consumable. A study design in which real and hypothetical outcomes are compared within the same commodity may yield different results. Furthermore, employing a within-subjects design in which participants complete all condition types may shed light on commodity differences.

The Present Study

The primary aim of the present study was to examine whether smartphone overuse is associated with steep DD in the novel Smartphone Delay Discounting Task, in which participants choose between immediate, but brief smartphone access (e.g., 5 s now) and delayed, but longer smartphone access (e.g., 10 s in 20 s). A second aim of the present study was to compare DD of smartphone access, a purportedly and directly consumable outcome, with DD of monetary outcomes (i.e., the "gold standard" in the DD literature). Finally, a third aim of the present study was to examine potential differences between DD of real and hypothetical versions of these DD tasks. We chose to evaluate these differences in one of the most at-risk populations for smartphone overuse: college students. Moreover, DD studies have tended to focus on comparisons of addicted individuals and control participants. We therefore restricted our recruitment in this exploratory study to smartphone-dependent individuals.

We predicted three main outcomes. First, we predicted that smartphone access in the Smartphone Delay Discounting Task would be discounted like other commodities. That is, the subjective value of delayed smartphone access would decrease as the delay to its receipt is increased. Second, based on DD studies showing that directly consumable outcomes are discounted steeper than monetary outcomes, smartphone access would be discounted more steeply than money, regardless of whether the outcome was real or hypothetical. Lastly, based on studies indicating that DD may be steeper when outcomes are real and experienced, we predicted that the real version of each outcome, regardless of whether the commodity was smartphone access or money, would be discounted more steeply than its hypothetical counterpart.

Methods

Participants

College students currently enrolled in psychology coursework at a large western university in the United States were recruited via classroom announcements, flyers posted to research-related bulletin boards, and an online research participant recruitment system (Sona Systems, Inc., Tallinn, Estonia).

Eligibility was assessed using an online screening questionnaire (Qualtrics, Inc., Provo, UT). Participants were eligible for the study if they: (1) were at least 18 years old, (2) owned a smartphone, (3) used their smartphone at least once per day, (4) were comfortable using their smartphone for 10 minutes during the study (i.e., using data), (5) and met criteria for mobile phone dependence (Fransson, Choliz, & Hakansson, 2018).

Participants received extra credit towards their coursework, in addition to monetary compensation (via Amazon eGift Card) during an in-person experimental session. Monetary compensation was determined by choices that the participant made in the Real Money Delay Discounting task (see below for a description) and ranged from $1.00-$15.84. All materials and procedures were approved by the Human Subjects Research Committee at California State University, Chico.

Materials

Demographic questionnaire. Participants answered demographic questions relating to age, sex, race, ethnicity, and educational status. In the screening questionnaire only, participants also answered questions pertaining to smartphone use, including a question about smartphone ownership (yes/no), a categorical question about frequency of use (ranging from once per week to more than 10 times per day), and a question about whether the participant was comfortable using 10 minutes worth of their own smartphone data during the in-person experimental session (yes/no). Additionally, questions relating to smartphone use including phone checking use (times per day), social media use (times per day), texting (times per day), and calling (times per day), were assessed. Participants were also asked a question relating to the perception of time when using their smartphones (“Time seems to slow down/speed up when I use my smartphone”).

Test of Mobile Phone Dependence (TMD). The Test of Mobile Phone Dependence is a 22-item questionnaire that assesses an individual’s mobile phone dependence (Fransson, Choliz, & Hakansson, 2018). Items include, “I spend more time than I would like to using my mobile phone”, and “When my mobile phone is in my hand, I can’t stop using it”. All items are rated on a 5-point Likert scale ranging from 0 to 4. The first ten questions are answered from 0 (never) to 4 (frequently); the last 12 are answered from 0 (completely disagree) to 4 (completely agree). Scores for the TMD range from 0 to 88, with a score of 58 or higher indicating mobile phone dependency. The internal consistency of the TMD in this study was good ($\alpha = .88$).

Social Media Engagement Questionnaires. Two novel measures relating to social media use were assessed during in-person sessions. First, questions relating to smartphone and social media were asked, including, “Over the course of an average day, about how many separate times do you use social media on your smartphone (e.g., Facebook, Instagram, Twitter, Snapchat) to interact with others?” Second, participants’ propensity to ‘like’ and ‘comment’ on social media images was assessed. For example, an image that read, “I’m looking for a job. Can someone share their resume with me so I have an idea of what to do?” was presented with, “How likely are you to comment on this post?” Data from the latter questionnaire are not reported here.

Fear of Missing Out scale (FoMO). The Fear of Missing Out scale, developed by Przbylski, Murayam, DeHann, and Gladwell (2013) measures fear of missing out with respect to smartphone and social media use. The 10-item questionnaire is rated on a 5-point Likert scale (0 = “Not at all true of me” to 4 = “Extremely true of me”). Questions included, “When I have a good time it is important for me to share the details online (e.g., updating status)”. The measure uses a raw scoring system, with higher scores indicating greater levels of FoMO. The scale typically has excellent reliability ($\alpha = .90$); however, it was questionable in this study ($\alpha = .67$).

Elicitation of monetary equivalence value for DD tasks. An elicitation procedure was used to determine the amount of money each participant deemed subjectively equivalent to 10 seconds of smartphone access. Participants made repeated choices between a fixed amount of smartphone access (10 seconds) and an adjusting amount of money (e.g., 50 cents). All outcomes were hypothetical, although participants were asked to pretend they would actually receive the consequence associated with their choices. Based on the participant’s choices, the monetary amount adjusted across five trials. If the participant preferred money on a trial, then the amount of money available on the next trial decreased by half of the previous adjustment amount (e.g., from $0.50 to $0.25). If the individual preferred smartphone access on a trial, then the amount of money available on the next trial increased by half of the previous adjustment amount (e.g., from $0.50 to $0.75). This adjusting procedure continued for four additional trials until a monetary equivalence amount was identified. This monetary amount was used as the LL option in the monetary DD tasks.

Monetary DD Tasks (MDDT). Two monetary tasks – one real, one hypothetical – were used to assess DD. For both tasks, participants made repeated choices between SS and LL amounts of money. For example, individuals were asked, "Would you rather have $X now or $Y in 5 seconds". Similar to the elicitation procedure described above, the SS was adjusted after each choice (Du et al., 2002). Specifically, if individuals preferred the SS over the LL on a trial, then the SS decreased on the next trial. However, if participants preferred the LL over the SS on a trial, then the SS would increase on the next trial. Choices were made across four trials; the adjusted amount of the SS following the fourth trial served as the indifference point.

Four delays to the LL were assessed in an ascending order (5, 10, 15, & 20 s). The hypothetical version of the MDDT was always presented before the real version of the MDDT. During the hypothetical MDDT, participants were asked to pretend that both the outcome of their choice (e.g., the delay to the LL) and the amount of money they chose to receive were real. The instructions displayed prior to the hypothetical MDDT were as follows:

> *In this section of the study, we will ask you to make choices between different amounts of hypothetical money. It is important to remember that the outcome of your choice is hypothetical (pretend). For example, if you choose to have money now, you should pretend that you will have money now. If you choose to wait for money, you should pretend that you will have money after some period of time.*

During the real MDDT, outcomes were real and experienced. The instructions displayed prior to the real MDT were as follows:

> *In this section of the study, we will ask you to make choices between different amounts of real money. It is important to remember that the outcome of your choice is real and will be experienced after you make your choice. For example, if you choose to*

have money now, you will actually have money now. If you choose to wait for money, you will actually have to wait for money.

If participants chose the SS on a trial, the research assistant (MW) would hand the participant the SS amount from a money till that contained quarters, dimes, nickels, and pennies. The participant would then place the change in a mason jar so they could see how much money they were earning during the real MDDT. If the participant chose the LL on a trial, they had to wait for the LL delay before the research assistant handed them the LL amount.

Smartphone DD Tasks (SDDT). Two novel Smartphone Delay Discounting Tasks were used to evaluate participants' choices regarding smartphone access. Like the MDDTs, during both the hypothetical and real SDDTs, individuals were asked to make choices between an immediate, but brief duration of smartphone access (SS) and a delayed, but longer duration of smartphone access (LL). We used the same adjusting-amount procedure as the MDDTs (Du et al., 2002). If participants chose the SS, then the SS duration decreased on the next trial. If they chose the LL, then the SS duration increased on the next trial. Four trials were administered with the adjusted SS duration after the fourth trial serving as the indifference point.

Four delays were examined identically to the MDDTs (5, 10, 15, & 20 s). For the hypothetical SDDT, individuals were asked to pretend that they would have access to their smartphone and, if they chose the LL, to pretend that the LL delay was real. During the real SDDT, individuals experienced both the delay and outcome of their choice. If the participant preferred the SS on a trial, then the research assistant would hand the participant their phone. If, however, they preferred the LL on a trial, then the participant had to wait for the LL delay before the research assistant would hand them their smartphone. With the exception of the commodity, the instructions for the SDDTs were identical to the MDDTs.

Procedure

Before completing a 90-minute, in-person experimental session, participants completed an online screening questionnaire. An informed consent form was provided, and informed consent was obtained. Participants then completed the online screening questionnaire to determine eligibility. If participants were deemed eligible, they were provided with an access code that allowed them to sign up for the 90-minute, in-person experimental session. Prior to the session, participants were sent a reminder e-mail 24 hours before the scheduled session.

Apparatus and Setting

All experimental sessions took place one-on-one with the research assistant (MW). Upon the arrival, the research assistant confirmed the participant’s appointment and verified their SONA identification number that was used to sign up for the experimental session. The research assistant then confirmed that the participant had brought their smartphone with them. Once the participant was verified, they were presented with a copy of the informed consent, told that it was identical to the one they read and agreed to online, and were asked if they had any questions.

Participants were asked to silence their smartphone and wait for 30 minutes in a windowless room (9’ x 6.5’ x 8') separated by a large partition. On one side of the partition was a desk, computer, and lamp; participants were asked to place their belongings here for the session. The other half of the room featured a recliner and a small table that held a coin counter and magazines; this side of the room served as the waiting area. After the 30-minute deprivation period, the research assistant collected the participant’s smartphone and placed it in a lock box for transportation to the second experimental location; this was to done so the participant could not look at their smartphone before starting the experimental session. The research assistant then escorted the participant to another laboratory setting to conduct the computerized tasks.

The second location for the experimental session was a private computer lab with 11 computer terminals. Participants were seated at the computer station closest to a window to optimize data network reception (i.e., smartphone Internet connection). The research assistant sat behind a partition at the computer station to the immediate right of the participant which featured a monitor that mirrored the participant's screen. The participant was informed of the second monitor, which was only used during the MDDTs and SDDTs so as to allow the research assistant to interact with the participant during the real DD tasks.

The experimental session began with the participant answering the demographic questionnaire, the social media engagement scales, and the FoMO scale. Between each of these assessments, a prompt appeared on the computer screen for the participant to notify the research assistant. Once the password was entered into the computer by the research assistant, the instructions for the next section were read aloud. After the FoMO scale, participants completed the elicitation procedure to determine the LL amount for the MDDTs. After the elicitation procedure, the second computer monitor was turned on and mirrored the participant's monitor. Additionally, participants were also assured prior to the experimental session that the research assistant would not look at their phone for any reason. During the real SDDT, the research assistant placed the participant's smartphone face down on the desk to ensure privacy.

Hypothetical DD tasks were always presented before the real DD tasks, with the order of money and smartphone DD tasks counterbalanced and randomized for each participant (i.e., participants first completed either the hypothetical MDDT or SDDT, followed by the real MDDT or SDDT). Before completing each of the DD tasks, participants completed and passed a brief quiz to confirm their understanding of the task instructions, this was done to ensure that the participant knew what task they were going to complete. For the real MDDT, participants were handed a mason jar to collect their earnings. Depending on their choices they were immediately handed the SS amount or had to wait before the research assistant handed them the LL amount. At the end of the real MDDT, the research assistant collected the jar. Once the in-person experimental session had ended, the research assistant counted the amount using a coin counter (Cassida, C 100 Electronic Coin counter, Cassida Inc., Portland, OR). Earnings were sent to the participant's e-mail address in the form of an Amazon eGift Card.

Similarly, during the real SDDT, participants had the option of using their smartphone for SS or LL durations. Based on their choices during the task, they were handed their smartphone immediately (SS) or had to wait before they were handed their smartphone (LL) and were instructed to do whatever they liked aside from taking pictures or making phone calls. After completing all four DD tasks, participants were debriefed, escorted back to the first laboratory room to collect their belongings, sent their Amazon eGift Card, and granted extra credit on SONA.

Data Analysis

Means and standard deviations for demographic characteristics (i.e., age, sex, ethnicity, and TMD scores) were calculated. Counts and percentages were calculated for questions pertaining to smartphone use. For DD tasks, indifference points were plotted as a function of LL delay using GraphPad Prism® (version 8.01 for Windows, GrahPad Software, La Jolla, CA). Area-under-the-curve (AUC) values were calculated to characterize the degree of DD for each task (Myerson, Green, & Warasuwitharana, 2001). AUC values represent the proportion of graphical space underneath the discounting curves with scores ranging from 0 to 1. Lower AUC values indicate steeper discounting. Cross-commodity (i.e., smartphone access vs. money) and within-commodity (i.e., real vs. hypothetical) comparisons were conducted using two-way repeated-measures analysis of variance (ANOVA).

Results

Three hundred and five participants completed the online screening questionnaire, of which 32 (9.5%) met criteria for eligibility. Sixteen participants (11 females, M_{age} = 22.1 years, SD_{age} = 3.1) participated in the in-person experimental session. Of these 16 participants, data from four participants were excluded due to programming errors during the experimental sessions. Specifically, each of the four participants preferred monetary outcomes exclusively during the elicitation procedure. As a result, the LL for the MDDTs was too small, further resulting in an SS amount ($0.02) that could not be properly adjusted in the MDDTs. In other words, we could not measure indifference points due to the small magnitude of the LL that resulted from the participant's preferences during the elicitation procedure. Demographic characteristics, including smartphone use characteristics, and TMD scores from the remaining participants are shown in Table 1.

Median group indifference points for the MDDTs and SDDTs were plotted. Results indicated that when the LL delay to both smartphone access and money increased, participants were less likely to wait for both commodities (Figure 1). A two-way repeated-measures ANOVA was used to compare AUC values across DD tasks. A significant main effect for commodity type was found, indicating that monetary outcomes were discounted more steeply than smartphone access, $F(1, 11) = 13.63$, p =.004 (Figure 1). No main effect of task type (real vs. hypothetical; p = .34) or interaction between commodity and task type were observed (p = .19).

Individual-subject median indifference points for the MDDTs and SDDTs were plotted, (Figure 2). The main effect of commodity type can be seen in data from Participants 3, 4, 6, 9, 10 and 11. Data from these individual subjects indicate that money was discounted more steeply than smartphone access. Interestingly, Participants 4 and 5 both had steeper discounting for hypothetical SDDTs. Participants 1, 2, 5, 7, and 12 showed very similar discounting for all four DD tasks. Only Participants 5 and 12 exhibited DD patterns as predicted.

Discussion

The present study compared delay discounting of real and hypothetical smartphone access and money in smartphone-dependent college students. Notably, we observed that smartphone access was discounted like other commodities. In other words, participants were less likely to wait for smartphone access as the delay to smartphone access increased. Consistent with the DD literature, we did not find a significant main effect for real vs. hypothetical DD within or between commodity types. We did, however, find a significant main effect for commodity type. Contrary to both the DD literature and our predictions, we found that money, regardless of condition type (real vs. hypothetical) was discounted more steeply than smartphone access, indicating that participants in our study were less likely to wait for monetary outcomes than smartphone access. This finding was surprising because previous research has found that directly consumable outcomes (i.e., smartphone access) are typically discounted more steeply than money. In addition, participants in the study were screened for smartphone dependence before completing the tasks. Theoretically, smartphone-dependent participants should have preferred immediate smartphone access if they were smartphone dependent. We also implemented a 30-minute deprivation period in addition to approximately 30 minutes’ worth of tasks before participants could access their smartphones. Similar logic would predict that spending an hour away from one’s smartphone should have resulted in steep discounting. It did not.

There may be several potential explanations for our significant yet contrary finding that money is discounted more steeply than smartphone access. First, it may be the case that during our elicitation procedure 10 s of smartphone access was not comparable to our monetary range. In other words, 10 s worth of smartphone access may not have been subjectively equivalent to the preferred monetary amount (i.e., 10 s of smartphone access cannot be comparably monetized). Increasing the amount of smartphone access in future studies may elicit different responses. Additionally, holding the monetary amount constant and adjusting the smartphone access duration during the elicitation procedure may yield different results.

Another possible explanation for our finding for steeper discounting of monetary outcomes may have resulted from the low monetary magnitudes. In particular, the largest possible reward magnitude in the MDDTs was 99 cents. Previous researchers have found a magnitude effect for discounting rates, in which smaller magnitude rewards are discounted steeper than larger magnitude rewards (e.g., $10 is discounted more steeply than $100; Baker, Johnson, & Bickel, 2004). This so-called “magnitude effect” may be especially true for real outcomes (i.e., smaller, real, and experienced outcomes may be discounted more steeply; Jimura et al., 2011).

Finally, yet another explanation for steeper discounting of monetary outcomes at the group level could be explained by the durations during the SDDT. Participants made choices between durations of smartphone access in seconds, which may not accurately characterize smartphone overuse. Alternatively, impulsive choices related to smartphone access could better be characterized not by use duration but by actions taken with respect to smartphones (e.g., social media use) and the resulting rewards (e.g., likes, comments). Another possibility may be that the delay options for smartphone access began at intervals (i.e., 5 s) that were too short to elicit impulsive choice making. There was, however, evidence at the largest delay (i.e., 20 s) that steeper discounting was observed. Increasing the delay amounts within the SDDTs should result in steeper discounting. However, there are practical limits when assessing real outcomes.

There were several limitations to the present study. The first limitation was our sample size. While several participants were eligible to participate in our study (32), only a limited sample (16) signed up to participate in the in-person study and (14) systematically completed all of the discounting tasks. This is especially evident when comparing individual-subject data (i.e., participant 12 showed steeper discounting for smartphone access compared to monetary compared to all other 11 participants). Another limitation to this study may have been the within-subjects design. Future studies may consider a between-subjects design in which DD of participants who are smartphone dependent are compared to DD of a control group. Another limitation may have been related to pre-session smartphone use. While we did implement a smartphone deprivation period, it is possible it was not sufficient to increase motivation for smartphone access. In addition, we did not ask participants how much time they had spent on their phones that day and did not control for time of day of data collection. Participants who completed the tasks in the afternoon vs. the morning may have spent less time on their smartphones that day. Future research may want to control for these time-related variables.

Despite these limitations, we did observe that smartphone access was discounted like other commodities. Future studies could use these results and the novel SDDT to further investigate DD of smartphone access and better understand why individuals make impulsive choices about smartphone use. Further, we found that DD of real vs. hypothetical outcomes did not differ, replicating previous findings. This finding may be meaningful as researchers plan similar studies, as future protocols would not necessarily need to involve real outcomes and would subsequently be less time-consuming and effortful for all involved. Future studies conducted outside of the laboratory may find possible solutions in the present data when attempting to treat smartphone-dependent individuals who wish to decrease smartphone overuse.

References

Al-Barashdi, B., Bouazza, A., & Jabur, N. (2015). Smartphone addiction among university undergraduates: A literature review. *Journal of Scientific Research & Reports, 4*(3), 210-225.

Baker, F., Johnson, M. W., & Bickel, W. K. (2003). Delay discounting in current and never-before cigarette smokers: Similarities and differences across commodity, sign, and magnitude. *Journal of Abnormal Psychology*, *112*(3), 382-392.

Billieux, J., Van der Linden, M., & Rochact, L., (2008). The Role of Impulsivity in Actual and Problematic Use of the Mobile Phone. *Applied Cognitive Psychological*, *22*, 1195-1210. doi: 10.1002/acp.1429

Billieux, J., Maurage, P., Lopez-Fernandez, O., Kuss D., & Griffiths, M. (2015). Can disordered mobile phone use be considered a behavioral addiction? An update on current evidence and a comprehensive model for future research. *Technology and Addiction*, *2*(2), 156-162.

Berry, M. S., Johnson, P. S., Collado, A., Loya, J. M., Yi, R., & Johnson, M. W. (2019). Sexual probability discounting: A mechanism for sexually transmitted infection among undergraduate students. *Archives of Sexual Behavior*, *48*(2), 495-505. doi10.1007/s10508-018-1155-1

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50*, 7-15.

Bickel, W. K., Odum, A. L., & Madden, G. J. (1999). Impulsivity and cigarette smoking: Delay discounting in current, never, and ex-smokers. *Psychopharmacology*, *146*(4), 447-454.

Caird, J. K., Johnston, K. A., Willness, C. R., Asbridge, M., & Steel, P. (2014). A meta-analysis of the effects of texting on driving. *Accident Analysis & Prevention*, *71*, 311-318.

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *Journal of Personality and Social Psychology, 67*, 319-333.

Charlton, S. R., Fantino, E., (2008). Commodity specific rates of temporal discounting: does metabolic function underlie differences in rates of discounting? *Behavioral Processes 77*(3), 334-42.

Chen, J., Liang, Y., Mai, C., Zhong, X., & Qu, C. (2016). General deficit in inhibitory control of excessive smartphone users: Evidence from an event-related potential study. *Frontiers in Psychology*, *7*, 511. doi:10.3389/fpsyg.2016.00511

Choliz, M. (2010). Mobile phone addiction: A point of issue. *Addiction, 105(2),* 373-375.

Cosenza, M., Griffiths, M. D., Nigro, G., & Ciccarelli, M. (2017). Risk-taking, delay discounting, and time perspective in adolescent gamblers: An experimental study. *Journal of Gambling Studies*, *33*(2), 383-395.

Demirci, K., Akgönül, M., & Akpinar, A. (2015). Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students. *Journal of Behavioral Addictions,4*(2), 85-92. doi:10.1556/2006.4.2015.010

Demographics of Mobile Device Ownership and Adoption in the United States. (2018, February 05). Retrieved from http://www.pewinternet.org/fact-sheet/mobile/

Dixon, M. R., Marley, J., & Jacobs, E. A. (2003). Delay discounting by pathological gamblers. *Journal of Applied Behavior Analysis*, *36*(4), 449-458.

Du, W., Green, L., & Myerson, J. (2002). Cross-cultural comparisons of discounting delayed and probabilistic rewards. *The Psychological Record*, *52*(4), 479-492.

Elhai, J. D., Levine, J. C., Dvorak, R. D., & Hall, B. J. (2016). Fear of missing out, need for touch, anxiety and depression are related to problematic smartphone use. *Computers in Human Behavior*, *63*, 509-516.

Estle, S. J., Green, L., Myerson, J., & Holt, D. D. (2007). Discounting of monetary and directly consumable rewards. *Psychological Science*, *18*(1), 58-63.

Fransson, A., Choliz, M., & Hakansson, A. (2018). Addiction-like mobile phone behavior-validation and association with problem gambling. *Frontiers in Psychology*, *4*(9), 655.

Hayashi, Y., Russo, C. T., & Wirth, O. (2015). Texting while driving as impulsive choice: A behavioral economic analysis. *Accident Analysis and Prevention*, *83*, 182-189.

Hiniker, A., Patel, S. N., Kohno, T., & Kientz, J. A. (2016). Why would you do that? Predicting the uses and gratifications behind smartphone-usage behaviors. In *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing - UbiComp '16* (pp. 634–645). Heidelberg, Germany: ACM Press.

Holt, D. D., Newquist, M. H., Smits, R. R., Tiry, A. M., (2014). Discounting of food, sex, and money. *Psychological Bulletin Review*, *21*(3), 794-802. doi: 10.3758/s13423-013-0557-2.

Jimura, K., Myerson, J., Hilgard, J., Keighley, J., Braver, T. S., & Green, L. (2009). Are people really more patient than other animals? Evidence from human discounting of real liquid rewards. *Behavioral Processes 16*(6),1071-1076.

Jimura, K., Myerson, J., Hilgard, J., Keighley, J., Braver, T. S., & Green, L. (2011). Domain independence and stability in young and older adults' discounting of delayed rewards. *Behavioural Processes*, *87*(3), 253-259.

Johnson, M. W., & Bruner, N. R. (2012). The Sexual Discounting Task: HIV risk behavior and the discounting of delayed sexual rewards in cocaine dependence. *Drug and Alcohol Dependence*, *123*(1-3), 15-21. doi: 10.1002/jeab.110

Johnson, P. S., Herman, E. S.,& Johson, M. W. (2015). Opportunity costs of reward delays and the discounting of hypothetical money and cigarettes. *Journal of the Experimental Analysis of Behavior 103,* 87-107.

Kim, Y., Jeong, J.-E., Cho, H., Jung, D.-J., Kwak, M., Rho, M. J., … Choi, I. Y. (2016). Personality factors predicting smartphone addiction predisposition: Behavioral inhibition and activation systems, impulsivity, and self-control. *PLoS One*, *11*(8), e0159788.

Kuss, D., Kanjo, E., Crook-Rumsey, M., Kibowski, F., Wang, M., & Sumich, A. (2018). Problematic mobile phone use and addiction across generations: The roles of psychological symptoms and smartphone use. *Journal of Technology in Behavioral Science. (3)*3, 141-149.

Lawyer, S. R., Schoepflin, F., Green, R., & Jenks, C. (2011). Discounting of hypothetical and potentially real outcomes in nicotine-dependent and nondependent samples. *Experimental and Clinical Psychopharmacology*, *19*(4), 263-274.

Locey, M. L., Jones, B. A., & Rachlin, H. (2011). Real and hypothetical rewards. *Judgment and Decision Making*, *6*(6), 552-564.

MacKillop, J., Amlung, M. T., Few, L. R., Ray, L. A., Sweet, L. H., & Munafò, M. R. (2011). Delayed reward discounting and addictive behavior: a meta-analysis. *Psychopharmacology*, *216*(3), 305-321.

MacKillop, J., Weafer, J., C. Gray, J., Oshri, A., Palmer, A., & de Wit, H. (2016). The latent structure of impulsivity: Impulsive choice, impulsive action, and impulsive personality traits. *Psychopharmacology*, *233*(18), 3361-3370.

Madden, G. J., Begotka, A. M., Raiff, B. R., & Kastern, L. L. (2003). Delay discounting of real and hypothetical rewards. *Experimental and Clinical Psychopharmacology*, *11*(2), 139-145.

Madden, G. J., Ewan, E. E., & Lagorio, C. H. (2007). Toward an animal model of gambling: Delay discounting and the allure of unpredictable outcomes. *Journal of Gambling Studies*, *23*(1), 63-83.

Madden, G. J. & Johnson, P. S. (2010). A discounting primer. In G. J., Madden, & W. K., Bickel (Eds.), Impulsivity: The Behavioral and Neurological Science of Discounting. (pp. 11-37). Washington, DC: American Psychological Association.

Madden, G. J., Francisco, M. T., Brewer, A. T., & Stein, J. S. (2011). Delay discounting and gambling. *Behavioural Processes*, *87*(1), 43-49.

Meshi, D., Elizarova, A., Bender, A., & Verdejo-Garcia, A. (2019). Excessive social media users demonstrate impaired decision making in the Iowa Gambling Task. *Journal of Behavioral Addictions*, 1-5.

Moody, L., Franck, C., Hatz, L., & Bickel, W. K. (2016). Impulsivity and polysubstance use: A systematic comparison of delay discounting in mono, dual, and tri-substance use. *Experimental and Clinical Psychopharmacology*, *24*(1), 30-37.

Myerson, J., & Green, L. (1995). Discounting of delayed rewards: Models of individual choice. *Journal of the Experimental Analysis of Behavior*, *64*(3), 263-276.

Myerson, J., Green, L., & Warusawitharana, M. (2001). Area under the curve as a measure of discounting. *Journal of the Experimental Analysis of Behavior*, *76*(2), 235-243.

Odum, A. L. (2011). Delay discounting: Trait variable? *Behavioural Processes*, *87*(1), 1-9.

Odum, A. L., & Baumann, A. A. (2007). Cigarette smokers show steeper discounting of both food and cigarettes than money. *Drug and Alcohol Dependence*, *91*(2-3), 293-296.

Odum, A. L., Baumann, A. A., Rimington, D. D. (2006). Discounting of delayed hypothetical money and food: effects of amount. *Behavioral Processes, 73*(3),278-84.

Odum, A. L., Madden, G. J., Badger, G. J., & Bickel, W. K. (2000). Needle sharing in opioid-dependent outpatients: Psychological processes underlying risk. *Drug and Alcohol Dependence*, *60*(3), 259-266

Odum, A.L., & Rainaud, C. P., (2003). Discounting of delayed hypothetical money, alcohol, and food. *BehavioralProcesses, 64*(3),3-5-313

Przybylski, A. K., Murayama, K., Dehaan, C. R., & Gladwell, V. (2013). Fear of Missing Out Scale. *PsycTESTS Dataset*. doi:10.1037/t23568-000

Raacke, J., & Bonds-Raacke, J. (2008). MySpace and Facebook: Applying the Uses and Gratifications Theory to exploring friend-networking sites. *CyberPsychology & Behavior*, *11*(2), 169-174.

Roberts, J., Yaya, L., & Manolis, C. (2014). The invisible addiction: Cell-phone activities and addiction among male and female college students. *Journal of Behavioral Addictions*,*3*(4), 254-265. doi:10.1556/jba.3.2014.015

Robertson, S. H., & Rasmussen, E. B. (2018). Comparison of potentially real versus hypothetical food outcomes in delay and probability discounting tasks. *Behavioural Processes, 149*, 8-15.

Saville, B., Gisbert, A., Kopp, J., & Telesco, C., (2010). Internet additcion and delay discounting in college students. *The Psychological Record*, *60*, 273-286.

Shin, C., & Dey, A. K. (2013). Automatically detecting problematic use of smartphones. In *Proceedings of the 2013 ACM international joint conference on Pervasive and ubiquitous computing - UbiComp '13* (p. 335). Zurich, Switzerland: ACM Press.

Sohn, T., Li, K. A., Griswold, W. G., & Hollan, J. D. (2008). A diary study of mobile information needs. In *Proceeding of the twenty-sixth annual CHI conference on Human factors in computing systems - CHI '08* (p. 433). Florence, Italy: ACM Press.

Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality*, *72*(2), 271-324.

Wilmer, H. H., & Chein, J. M. (2016). Mobile technology habits: patterns of association among device usage, intertemporal preference, impulse control, and reward sensitivity. *Psychonomic Bulletin & Review*, *23*(5), 1607-1614.

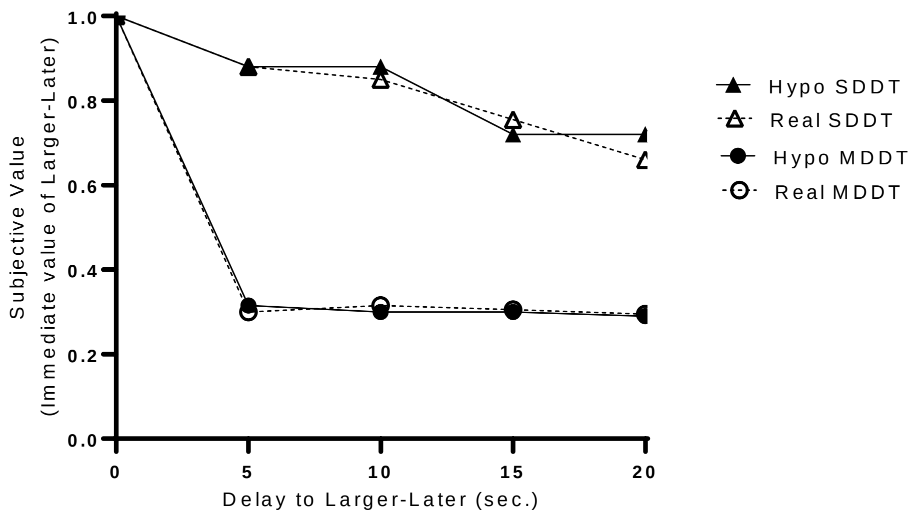

Figure 1: Group median delay discounting functions from the hypothetical and real SDDT (filled and open triangles, respectively) and hypothetical and real MDDT (filled and open circles, respectively).

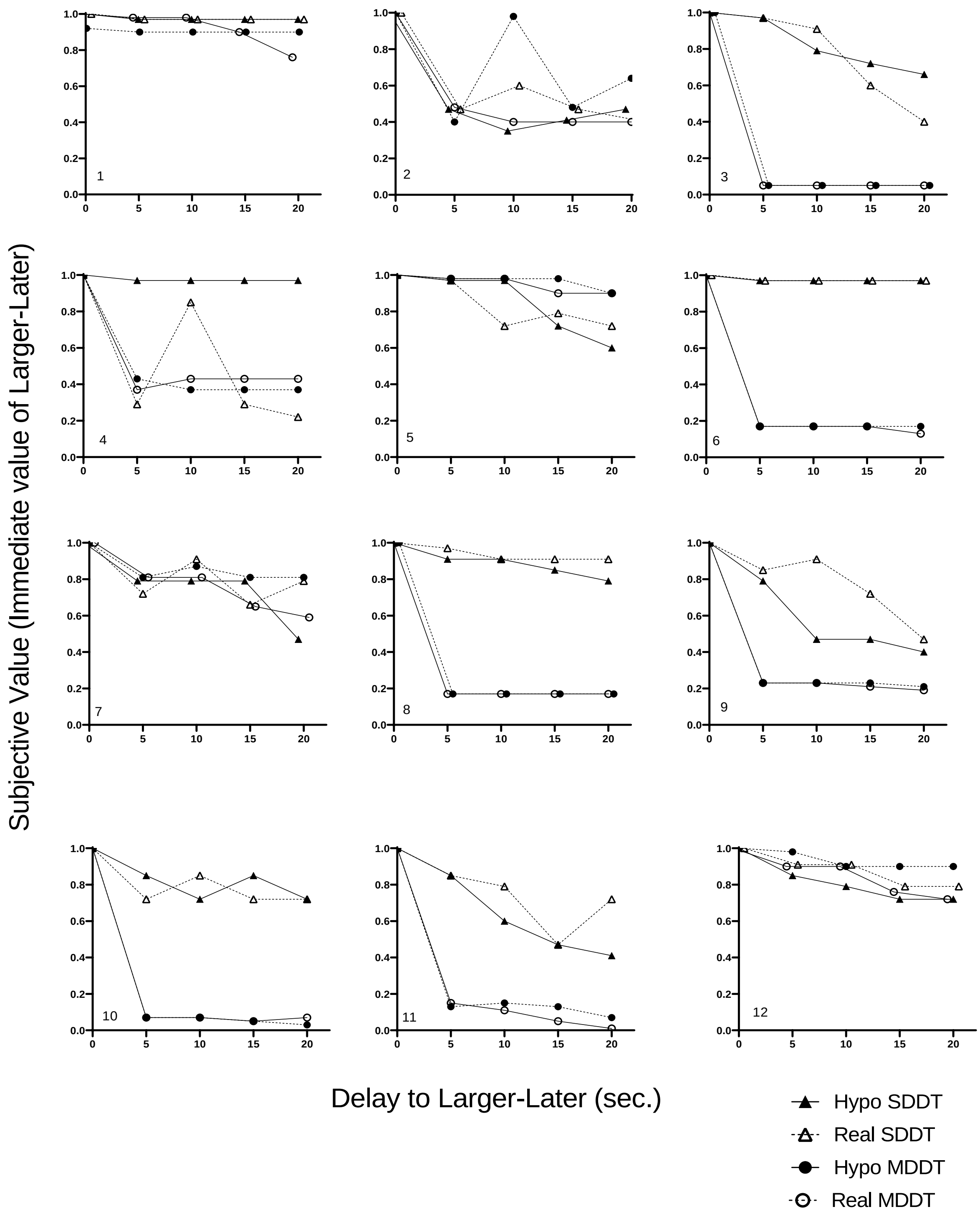

Figure 2: Individual-subject delay discounting functions from the hypothetical and real SDDT (filled and open triangles, respectively) and hypothetical and real MDDT (filled and open circles, respectively).

Table 1

Demographic characteristics

Characteristic	Mean (*SD*)	n (%)
Age, years	22.8 (3.2)	
Sex, female		10 (83)
Ethnicity		
Hispanic		6 (50)
Not Hispanic		6 (50)
Self-reported time spent on smartphones, hours		
More than 6 hours per day		5 (42)
5 – 6 hours per day		6 (50)
4-5 hours per day		3 (25)
Self-reported smartphones checking behavior, times per day		
More than 20 times		12 (100)
Self-reported social media use, times per day		
More than 20 times		9 (75)
10 to 20 times		1 (8)
3 to 5 times		2 (17)
Self-reported texting, times per day		
More than 20 times		6 (50)
10 to 20 times		5 (42)
6 to 10 times		1 (8)
Self-reported calling, times per day		
6 to 10 times		2 (17)
3 to 5 times		8 (67)
2 times		1 (8)
1 time		1 (8)
Test of Mobile Phone Dependence score[a]	67.6 (9.1)	
Fear of Missing Out (FoMO) Scale[b]	34.3 (8.7)	

[1a] Scores range from 0 to 88 with a cut-off score of 58 indicating mobile dependency. [1b] Scores range from 0 to 40 with higher scores indicating greater fear of missing out.