Abstract

Would you rather have $100 now or $300 in one year? The temporal discounting phenomenon predicts that most people would prefer the $100; that is, people tend to prefer immediate rewards over future rewards, even when the future rewards will be considerably larger in size. The general tendency for people to discount future resources can become problematic, because such tendency is associated with a vast array of risky and short-sighted behaviours. The current study attempted to diminish temporal discounting by exposing participants to age-progressed digital renderings of their futures selves. These digital renderings, also known as doppelgangers, did not effectively reduce temporal discounting of either future monetary resources or future non-monetary resources. Follow-up analyses suggest that (1) participants did not consider their digital doppelgangers to be realistic and vivid; (2) participants did not identify with the age-progressed renderings of their future selves. Future improvements and applications of digital doppelgangers were discussed.

Key words: temporal discounting, future self-Continuity, doppelganger

Age-progressed doppelgangers and temporal discounting: An experimental study within the future self-continuity framework

Would you rather have \$100 now or \$300 in two years? The temporal discounting phenomenon predicts that most people would prefer the \$100; that is, people tend to prefer immediate rewards over future rewards, even when the future rewards will be considerably larger in size. The question remains, nonetheless, whether people would discount future *monetary rewards* in the same way that they would discount future *non-monetary rewards*. Consider the scenario: would you rather have 100 days of good luck starting now, or 300 days of good luck starting in two years? An accumulating body of evidence suggests that people would discount non-monetary rewards somewhat differently than they would discount the corresponding amount of monetary rewards. For instance, people tend to devaluate future food in a much steeper fashion than they would for future money (Odum, Baumann, & Rimington, 2006).

The general tendency for people to depreciate both monetary and non-monetary future welfare can become problematic, because such tendency is associated with a vast array of risky or short-sighted behaviours, including gambling, smoking, alcoholism, illicit drug abuse, and unsafe sexual acts (Bickel, Odum, & Madden, 1999; Hoerger, Quirk, & Weed, 2011; Kirby, Petry, & Bickel, 1999). Researchers have therefore become increasingly interested to identify the underlying mechanisms of temporal discounting, and in so doing, mitigate the extent of discounting. According to the future self-continuity hypothesis (Ersner-Hershfield, Wimmer, & Knutson, 2009), people engage in temporal discounting because they feel psychologically disconnected with their future selves, and hence they also feel unobligated to care for their future selves. Putting the hypothesis to practice, one recent study (Hershfield et al., 2011) successfully reduced temporal discounting of retirement funds by exposing participants to age-progressed digital renderings of their future selves. These digital renderings, also known as doppelgangers (Bailenson, 2012), effectively enhanced the psychological connectedness between the participants and their future identities. No existing study, however, seeks to reduce temporal discounting of monetary and non-monetary resources in general using similar technology.

The current study aims to validate and expand on the future self-continuity account of temporal discounting. The present study will aims to employ age-progressed doppelgangers to: (1) enhance psychological connectedness and reduce temporal discounting of *monetary gains*; (2) enhance psychological connectedness and reduce temporal discounting of *non-monetary gains*.

Temporal Discounting

Temporal discounting and its implications are becoming a popular investigation among economists, philosophers, and psychologists. The term temporal discounting has often been used interchangeably with “delayed discounting” (Odum et al., 2006), “time preference” (Frederick, 2006), or “inability to delay gratification” (Hoerger et al., 2011) across different disciplines. Although differ in terminology, researchers from various fields conceptualize temporal discounting similarly as “the tendency for people to devalue future gains as a function of temporal distance from present” (Ersner-Hershfield et al., 2009). The temporal discounting phenomenon can be mathematically codified using the following formula[1] (Bartels & Rips, 2010):

$$\delta = \left[\frac{V}{A}\right]^{\frac{1}{(t_2 - t_1)}}$$

where *V* represents the value of a more immediate reward at time t_1, and *A* represents the value of a more distant reward at time t_2. When individuals are asked to make intertemporal choices that involve a specific set of immediate rewards (V) (e.g. $100 in 1 year), future rewards (A) (e.g. $300 in 3 years), and time delays (D) (e.g. 3 years minus 1 year), those who consistently produce a *small* discount factor (δ) (e.g. 0.58) are considered to have engaged in steeper rate of temporal discounting.

The rate of discounting tends to vary across resource domains. Gretchen Chapman (1996) proposed the domain independence notion of temporal discounting. She explained that “although participants were fairly reliable in their discount rates within a domain, there was a very low correlation in discount rates between domains” (Chapman, 1996). Specifically, individuals tend to discount non-monetary rewards at a somewhat different rate than they would discount monetary rewards. For example, smokers discounted cigarettes more steeply than money (Bickel et al., 1999). Similarly, individuals with dependencies on alcohol,

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[1] The temporal discounting phenomenon is perhaps more conventionally codified using the hyperbolic discounting function (Kirby & Maraković, 1995), such that: $V = A/1 + kD$, where *V* represents the value of an immediate reward, *A* represents the value of a future reward, *D* represents the amount of time between the immediate reward and future reward (usually in years), and *k* represents a discount parameter that varies across individuals. When individuals are asked to make intertemporal choices that involve a specific set of current rewards (V) (e.g. $100), future rewards (A) (e.g. $300), and time delay (D) (e.g. 3 years), those who consistently produce a *larger* discount parameter (*k*) (e.g. 0.67) are considered to have engaged in steeper rate of temporal discounting. The discount parameter (*k*) can be formally converted into discount rate (*r*) using the formula: $\mathrm{r} = (1 + kD)^{(1/D)} - 1$. The hyperbolic discount rate (*r*) can be transformed into Bartels and Rips’ discount factor (δ) using the formula: $r = (1/\delta) - 1$. For a detailed explanation of the relationships among these equations, see Bartels & Rips, 2010.

cocaine, or heroin, discounted their drug of abuse more steeply than cash (Coffey, Gudleski, Saladin, & Brady, 2003; Madden, Petry, Badger, & Bickel, 1997; Petry, 2001). These differences cannot be explained by addiction or the perishable nature of consumable goods alone, because people who are not alcohol-dependent also discounted alcohol more steeply than money (Odum et al., 2006; Petry, 2001). Estle and colleagues (2007) offered an alternative explanation by demonstrating that college students discounted *directly consumable* goods such as beer, candy, and soda more steeply than money. The researchers further pointed out that people do not need to discount money as steeply as consumable goods, because money is a generalized reinforcer that can be exchanged for whatever people desire at a given point in time. This alternative explanation is supported by Odum and colleagues (2006), who observed that individuals discounted directly consumable food such as macaroni more steeply than money, regardless of the size of the treat.

Elevated level of temporal discounting is associated with a host of societal problems. For instance, individuals who engage in steep temporal discounting also tend to suffer from health problems such as obesity, alcoholism, drug addiction, anger, aggression, depression, and sexually transmitted diseases (Baumeister, Vohs, & Tice, 2007; Gottdiener, Murawski, & Kucharski, 2008; Hoerger et al., 2011; Kirby et al., 1999; Petry, 2001; Seeyave et al., 2009; Wulfert, Safren, Brown, & Wan, 1999). Individuals who discount future rewards steeply are also linked to financial debts, criminal offenses, and unsatisfactory academic performance (Bembenutty & Karabenick, 1998; Hoerger et al., 2011; Kirby, Winston, & Santiesteban, 2005). Conversely, people who can generally delay gratification are associated with better diet, increased exercise, improved physical health, and improved psychological well-being, comparing to individuals who often fail to delay gratification (Hoerger et al., 2011). Given the potential consequences of temporal discounting, researchers are becoming increasingly motivated to understand temporal discounting, and more recently, manipulate temporal discounting. An inter-disciplinary effort (Hershfield et al., 2011) involving economists, psychologists, and computer scientists successfully reduced temporal discounting of retirement funds by exposing individuals to age-progressed renderings of future selves. These researchers capitalized on an underlying mechanism of temporal discounting known as future self-continuity.

Future Self-Continuity

The future self-continuity hypothesis (Ersner-Hershfield et al., 2009; Hershfield, 2011) proposes that people who engage in temporal discounting also tend to feel psychologically disconnected with their future selves. In the original words of the authors, "the degree to which an individual feels disconnected from his or her future self should correlate with the degree to which that individual discounts future rewards" (Ersner-Hershfield et al., 2009). In extreme cases of psychological disconnectedness, people may consider their distant future selves as complete strangers. Asking people to make intertemporal choices may then be like asking them to choose "between spending money today or giving it to a stranger years from now" (Hershfield et al., 2011). When future selves are sufficiently estranged, people are not rationally required to care about future welfare.

The future self-continuity hypothesis implies that temporal discounting can be a rational act rather than an irrational one. Traditionally, temporal discounting is believed to be irrational; engaging in temporal discounting is believed to be a sign of weak will (Bartels &

Rips, 2010; Frederick, 2006; Hershfield, 2011). According to this view, people are acting irrationally when they “prefer a smaller immediate pleasure over a greater future pleasure, because now and later are equally parts of one life” (Frederick, 2006). Individuals become rational only when they maintain an impartial concern for all parts of their lives. In other words, rationality demands temporal impartiality. This traditional view is challenged by contemporary philosophers who argue that people are not required to treat all parts of their future equally (Bartels & Rips, 2010; Frederick, 2006). For instance, Derek Parfit (1971; as cited in Frederick, 2006) proposes that “a person is a succession of overlapping selves related to varying degrees by memories, physical continuities, and similarities of character and interests”. The psychological connections between the current self and future selves tend to erode naturally as a function of temporal distance. When the distinction between different stages of one’s life is as great as the distinction between different human beings, individuals can have sane and rational grounds to engage in temporal discounting. Building on Parfit’s proposition, the future self-continuity framework seeks to “provide a normative foundation for discounting rather than branding it as impulsiveness or failure of self-control” (Bartels & Rips, 2010).

Despite its theoretical claims, the future self-continuity account of temporal discounting was not initially supported by empirical data. Shane Federick (2003) from Yale University surveyed 228 participants from a convenient population, and found no significant relationship between discount rate and how much people identify with their future selves. Nonetheless, this initial observation was later challenged by Bartels and Rips (2010), who revisited Federick’s data with a different statistic procedure, and revealed a striking –.91 correlation between temporal discounting and psychological connectedness with future selves. A parallel study using event-related fMRI also yielded encouraging results. Ersner-Hershfield, Wimmer, and Knutson (2009) monitored activation in the rostral anterior cingulate cortex (rACC) while participants rated the similarity between their current selves and future selves. Hershfield and colleagues found that individual differences in rACC activation reliably predict temporal discount rate that was assessed one week later.

Emerging success in establishing a relationship between psychological connectedness and temporal discounting has prompted researchers to expand on the future self-continuity hypothesis. The next objective has been set to demonstrate that changes in psychological connectedness with the future selves can *cause* changes in temporal discounting. To date, only one existing study (Hershfield et al., 2011) successfully reduced temporal discounting of retirement funds by enhancing psychological connectedness. The study derived its success by exposing participants to age-progressed doppelgangers of their future selves.

Digital Doppelgangers

Jeremy Bailenson (2012) of Stanford University employed the term “doppelgangers” to describe virtual representations of the self that are controlled by a computer algorithm. According to Bailenson (2012), doppelgangers are to be distinguished from avatars in terms of user control. If avatars are virtual representations of the self that human users have real time control over, then doppelgangers are virtual representations of the self that human users have absolutely no control over. In a sense, avatars become doppelgangers when autonomous algorithms replace human users to assume direct control. Doppelgangers do not necessarily entail complex technology. Doppelgangers do not always have to be sophisticated manifestation in a highly immersive virtual reality; they can simply take the form of a morphed photograph on an ordinary piece of paper (Ahn & Bailenson, 2011).

Exposing individuals to their digital doppelgangers have been used as an advertisement tool to influence consumer behaviour (Ahn & Bailenson, 2011), and as an advocacy tool to influence dietary behaviour (Fox, Bailenson, & Binney, 2009), exercise behaviour (Fox & Bailenson, 2009), and energy use (Ahn, 2011). Correspondingly, doppelgangers have also been deployed as an intervention procedure to diminish temporal discounting of financial welfare. Hershfield and colleagues (2011) recruited fifty university students, and generated an elderly representation of each participant using the age-progression algorithm from the FaceGen Modeller software. Participants were then randomly assigned to two conditions: half of the participants were introduced to the 70-year-old version of “themselves” in a virtual reality, the other half of the participants were introduced to the 70-year-old representation of a total stranger. The researchers found that participants who interacted with their age-progressed doppelgangers became more future-oriented and set aside more current income for distant retirement, comparing to their control group counterpart. Follow-up analysis also suggested that psychological connectedness with the future selves mediated the relationship between experimental condition and retirement fund allocation.

Hershfield and colleagues (2011) believe that psychological connectedness tend to naturally decay as a function of temporal distance, because people often find it difficult or unpractical to envision a distant and vivid future self. Connecting to the future selves becomes less challenging when individuals are presented with a compelling projection of their future appearances. Hershfield further proposed in a separate paper (2011) that, in order for the age-progressed doppelgangers to be effective, the digital renderings must: (1) look physically similar to the participants; (2) look vivid and realistic to the participants; (3) liked and cared for by the participants.

Although Hershfield and colleagues demonstrated that age-progressed doppelgangers can reduce temporal discounting of retirement funds, no existing study has applied similar technology to manipulate temporal discounting of monetary and non-monetary rewards in general. Despite an accumulating body of evidence suggests that steep discounting is associated with a host of risky behaviours, very limited research has been done to identify effective interventions that can mitigate the normative tendency for people to discount both monetary and non-monetary resources. The current study aims to address this gap in the literature.

The Current Study

The current study aims to determine whether exposure to age-progressed doppelgangers can enhance psychology connectedness with the future selves, and in turn, reduce temporal discounting of both monetary and non-monetary rewards. Building on the procedure used by Hershfield and colleagues (2011), participants were exposed to either: (1) their age-progressed dopppelgangers (aged-self condition), (2) the age-progressed rendering of a stranger (aged-other condition), or to (3) the unmodified profile photo of their current selves (current-self condition). The current study hypothesizes that:

H1: participants who were exposed to their age-progressed doppelgangers would become more psychologically connected with their future selves, comparing to their control group counterparts.

H2: participants who were exposed to their age-progressed doppelgangers would discount *monetary* rewards less steeply than would their control group counterparts.

H3: participants who were exposed to their age-progressed doppelgangers would discount *non-monetary* rewards less steeply than would their control group counterpart.

Participants

Participants in this study were approximately 117 Introductory Psychology students from the University of Winnipeg undergraduate subject pool (45 males; 72 females; M_{age} = 20.37, SD = 6.73). There were no specific requirements for participating in the study. Participants received one research credit toward their Introduction to Psychology course requirement.

Approximately ten additional student volunteers were recruited and photographed to generate visual stimuli for the “aged-other” condition. Volunteers received one research participation credit in exchange for being photographed. Each volunteer was asked to read and sign an Image Release Form that describe the purpose of the photo shoot, and the procedures by which the confidentiality of the photograph would be maintained.

Materials

Age Progression. Participants were invited to collaborate on a profile photo shoot as they came into the laboratory. Participants were specifically asked to smile naturally as they were being photographed. Using the profile photos as input, the experimenter generated a 70-year-old doppelganger for each participant using the age-progress algorithm from AgingBooth (PiVi & Co, 2012). For the “aged-other” condition, the identical aging algorithm was used to create a 70-year-old version of a stranger to the participants. Agingbooth was chosen over Facegen, APRIL, Poser, and other industrial-grade modeling programs, because

Agingbooth represents a free-to-use age progression technology that is more readily accessible to the general public. Appendix B illustrates an example of the aged-progressed output generated by Agingbooth.

Psychological Connectedness Rating Task. Psychological connectedness with the future selves was measured by using an adaption of the continuous Psychological Connectedness Rating Task (Bartels & Rips, 2010). Participants were asked to manipulate the overlaps within six pairs of Euler circles to indicate the degree of connectedness between their current selves and the person they would become in 1, 5, 10, 20, 30, and 40 years respectively. The psychological connectedness rating task was administered to each participant on a computer interface. Appendix D provides a screenshot of the rating task.

Temporal Discounting Task for Monetary Gains. Adapting from the free-response procedure used by Bartels and Rips (2010), participants were asked to complete three types of intertemporal choices, as follows:

Delays:
It would be equally attractive[2] for me to receive $100 tomorrow or $_____ in 5 years.

Intervals Postponement:
It would be equally attractive for me to receive $500 in 5 years or $_____ in 10 years.

Intervals Preponement:
It would be equally attractive for me to receive $_____ in one year or $500 in 5 years.

[2] Original wording of the temporal discounting task was "it would be indifferent for me to receive $100 tomorrow or $_____ in 5 years" (Bartels & Rips, 2010). Hardisty and Weber (2009) argued that such phrasing can be confusing and difficult to understand. The current study aligned with Hardisty and Weber's recommendations, changing the wording to "it would be equally attractive for me to receive $100 tomorrow or $_____ in 5 years".

Participants were asked to complete 17 intertemporal choices in total (Appendix E). The presenting order of these 17 items was randomized for each participant. Participants received the task in a booklet and completed each item using pencils.

Temporal Discounting Task for Non-monetary Gains. Consistent with the scenario used by Bartels and Rips (2010), participants were given the following scenario:

> Imagine that you will have the same job for the rest of your life. At this job, you get to spend about half of the days doing something that you love (good days). The other half of the days, you must spend doing something that you hate (bad days). Suppose that you were given a chance to choose between having some extra good days (and, thus, fewer bad days) this year, or in a future year.

Participants were then asked to fill in the blanks for three types of intertemporal decisions, as follows:

> Delays:
> It would be equally attractive for me to
> receive 20 extra good days tomorrow or _____ extra good days in 5 years.
>
> Intervals Postponement:
> It would be equally attractive for me to
> receive 38 extra good days in 5 years or _____ extra good days in 10 years.
>
> Intervals Preponement:
> It would be equally attractive for me to
> receive _____ extra good days in 1 year or 38 extra good days in 5 years.

Participants received 17 intertemporal decisions to complete (Appendix F). The presenting order of these 17 items was randomized for each participant. Participants received the task in a booklet and completed each item using pencils.

The Positive and Negative Affect Schedule (PANAS). The PANAS (Watson, Clark, & Tellegen, 1988) is a 20-item measurement that evaluates both positive affects (PA) (α = .847) and negative affects (NA) (α = .812). Participants indicated whether their psychological states correspond to various emotional terms (e.g. scared, attentive, enthusiastic). Participants responded to a 5-point Likert scale, anchored with 1 being “not at all”, and 5 being “extremely”. The PANAS was included to determine whether participants would react negatively toward their age-progressed renderings. The PANAS was administered to each participant in paper format (Appendix G).

Sensation Seeking. Sensation seeking was measured using the 12-item Sensation Seeking Subset ($\alpha = .883$) of the UPPS-P Impulsive Behavior Scale (Whiteside & Lynam, 2001). Participants indicated whether their attitudes or behaviours correspond to various statements (e.g. I would enjoy parachute jumping). Participants responded to a 5-point Likert scale, anchored with 1 being “strongly disagree”, and 5 being “strongly agree”. Sensation seeking was measured to account for the potential relationship between impulsivity and temporal discounting. The Sensation Seeking subset was administered to each participant in paper format (Appendix G).

Importance of Social Image. Importance of social image was evaluated using an adaptation of the 3-item Face subset ($\alpha = .765$) from the Portrait of Values Questionnaire Revised (PVQ-R) (Schwartz et al., 2012), as well as the 5-item Image subset ($\alpha = .861$) from the Aspiration Index (AI) (Grouzet et al., 2005). Participants indicated whether it is important for them to achieve certain goals in the future (e.g. to successfully hide the signs of aging). Participants responded to a 5-point Likert scale, anchored with 1 being “not important at all”, and 5 being “very important”. This measurement was included to account for the potential relationship between importance of social image and exposure to age progression. The Face subset and the Image subset were administered to the participants in paper format (Appendix

G). Scores from both scales were aggregated to produce an overall importance of social image score for each participant.

Reactions to Digital Renderings. Reactions to the digital renderings were evaluated using a 3-item questionnaire. Participants indicated whether or not: (1) the figure in the image looks like them; (2) the figure in the image looks realistic and vivid to them; as well as (3) they like the figure in the image. Participants responded to a 5-point Likert scale, anchored with 1 being “strongly disagree”, and 5 being “strongly agree”. This brief questionnaire was administered to each participant in paper format (Appendix G).

Demographics. Participants were asked to indicate their age and sex using pencil and paper (Appendix G). This demographics questionnaire was included to account for any potential age effects or sex differences in the current study.

Procedure

All participants attended the study session individually in person. As participants came into the laboratory, they were asked to carefully read and sign a consent form (Appendix A). Participants were briefly told that the current research is about decision making and rewards. Participants were given an opportunity to ask the experimenter any questions before proceeding to the study session.

As the study session began, participants were photographed by the experimenter. Using the profile photos as input, the experimenter generated a 70-year-old doppelganger for each participant using the age-progress algorithm from AgingBooth (PiVi & Co, 2012). Depending on the experimental conditions, participants were randomly exposed to either: (1) their age-progressed dopppelgangers (aged-self condition), (2) the age-progressed rendering of a same-sex stranger (aged-other condition), or to (3) the unmodified profile photo of their current selves (current-self condition). These static digital renderings were presented to the participants on a computer interface.

Following the exposure, participants from all three conditions were asked to complete a series of experimental tasks. Participants received: the psychological connectedness rating task (Bartels & Rips, 2010), the temporal discounting task for monetary rewards (Bartels & Rips, 2010), as well as the temporal discounting task for non-monetary rewards (Bartels & Rips, 2010). To control for potential confounding variables, participants were also given a series of questionnaires to complete. Participants were given: the Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988), the Sensation Seeking subset of the UPPS-P Impulsive Behavior Scale (Whiteside & Lynam, 2001), the Face subset of the Portrait of Values Questionnaire Revised (Schwartz et al., 2012), the Image subscale of the Aspiration Index (Grouzet et al., 2005), a 3-item questionnaire that assesses reactions to the digital renderings, as well as a demographic questionnaire that inquires age and sex. Table 1 provides an overview of the study procedure.

Upon completing the experiment, participants were given a debriefing form (Appendix H) that explains the purpose and rationale of the study. Participants were fully debriefed and thanked for contributing to the current research.

Results

Psychological Connectedness with the Future Selves. As shown in Figure 1, participants who were exposed to age-progressed doppelgangers did not report feeling more psychologically connected with their future selves in 1, 5, 10, 20, 30, and 40 years respectively, comparing to their control group counterparts. One-way analysis of variance (ANOVA) indicated that there is no main effect of condition across all six periods of time delay, thereby invalidating hypothesis H1.

Temporal Discounting of Monetary Gains. A discount factor (δ) was generated for each of the 17 intertemporal decisions that participants made. Each participant was therefore associated with 17 discount factors. The discount factors (δ) were calculated using the following formula:

$$\delta = \left[\frac{dollars\ at\ t_1}{dollars\ at\ t_2}\right]^{\frac{1}{(t_2 - t_1)}}$$

where *dollars at* t_1 and *dollars at* t_2 are the two values that participants were asked to equate, with the first value being at an earlier time t_1, and the second value being at a later time t_2. Participants are considered to have engaged in less discounting as δ increases from 0 to 1. Discount factors greater than 1 imply negative time preference –preferring a future reward over an immediate reward (Bartels & Rips, 2010). There were 91 of such responses (4.47% of data). These values were replaced by 1.0 to indicate temporal impartiality, or no temporal discounting.

As shown in Figure 2, Figure 3, and Figure 4, participants who were exposed to age-progressed doppelgangers did not discount monetary gains less steeply comparing to their control group counterparts. One-way ANOVA indicated that there is no main effect of condition both when the monetary gains were postponed (e.g. receive $500 in 5 years or $_____ in 10 years), and when the monetary gains were preponed (e.g. receive $_____ in one year or $500 in 5 years). There was also no main effect of condition both when the passage of time was conceptualized in terms of time delays (e.g. 1, 5, 10, 20, 30 and 40 years delay), as well as in terms of time intervals (e.g. 0-1, 1-5, 5-10, 10-20, 20-30, and 30-40 years intervals). There was insufficient evidence to validate hypothesis H2.

Temporal Discounting of Non-monetary Gains. Each participant was associated with 17 discount factors. The discount factors (δ) were calculated using the following formula:

$$\delta = \left[\frac{days\ at\ t_1}{days\ at\ t_2}\right]^{\frac{1}{(t_2 - t_1)}}$$

where *days at* t_1 and *days at* t_2 are the two values that participants were asked to equate, with the first value being at an earlier time t_1, and the second value being at a later time t_2. Participants are believed to have engaged in less discounting as δ increases from 0 to 1. Discount factors greater than 1 imply negative time preference – a preference of future rewards over immediate rewards (Bartels & Rips, 2010). There were 141 of such responses (6.70% of data). These values were replaced by 1.0 to indicate temporal impartiality, or no temporal discounting.

As indicated by Figure 5, Figure 6, and Figure 7, participants who were exposed to age-progressed doppelgangers did not discount non-monetary gains less steeply comparing to their control group counterparts. One-way ANOVA indicated that there is no main effect of condition both when the non-monetary gains were postponed (e.g. receive 38 extra good days in 5 years or _____ extra good days in 10 years), and when the non-monetary gains were preponed (e.g. receive _____ extra good days in 1 year or 38 extra good days in 5 years). Moreover, there was no main effect of condition both when the passage of time was conceptualized in terms of time delays (e.g. 1, 5, 10, 20, 30 and 40 years delay), as well as in terms of time intervals (e.g. 0-1, 1-5, 5-10, 10-20, 20-30, and 30-40 years intervals). There was insufficient evidence to validate hypothesis H3.

Positive and Negative Affects. One-way ANOVA indicated that there is significant main effect of condition for negative affects, $F(2, 114) = 5.69$, $p = .004$, but not for positive affects, $F(2, 114) = 1.507$, $p = .226$. Tukey post-hoc comparisons revealed that participants in the aged-self condition ($M = 16.56$, $SD = 5.82$) reported feeling more negative emotions comparing to participants in the current-self condition ($M = 13.03$, $SD = 2.99$), $p = .006$. Similarly, participants in the aged-other condition ($M = 15.97$, $SD = 5.58$) also reported feeling more negative emotions comparing to participants in the current-self condition, $p = .027$. Nonetheless, the comparison between participants in the aged-self condition and participants in the aged-other condition was not statistically significant, $p = .859$. Participants did not seem to have enjoyed seeing themselves age, or seeing another individual age.

Sensation Seeking. As shown in Table 2, participants across the three experimental conditions did not differ significantly in terms of sensation seeking. One-way ANOVA indicated that there is no main effect of condition for sensation seeking, $F(2, 114) = 0.48$, $p = .618$.

Importance of Social Image. As indicated by Table 2, participants across the three experimental conditions did not differ significantly in terms of how much they care for their social image. One-way ANOVA suggested that there is no main effect of condition for importance of social image, $F(2, 114) = 0.72$, $p = .49$.

Reactions to Digital Renderings. As shown in Table 2, participants across the three experimental conditions differed substantially in terms of how they reacted to the digital renderings. One-way ANOVA indicated that there is significant main effect of condition for similarity ratings, $F(2, 114) = 49.71$, $p = .000$. Specifically, many participants in the current-self condition did indeed find the images to look very similar to them ($M = 4.31$, $SD = 0.95$). In contrast, many participants in the aged-other condition did not find the digital renderings to look similar to them ($M = 2.05$, $SD = 0.99$). Participants in the aged-self condition considered their age-progressed doppelgangers to look somewhat similar to them ($M = 3.44$, $SD = 1.07$). All pair-wise Tukey post-hoc comparisons were statistically significant at $p <0.05$ for similarity ratings.

One-way ANOVA indicated that there is significant main effect of condition for realism ratings, $F(2, 114) = 24.4$, $p = .000$. Specifically, participants in the current-self condition rated their unmodified digital portraits to be very realistic ($M = 4.18$, $SD = 0.94$). In comparison, participants in the aged-self condition ($M = 2.74$, $SD = 1.12$) and participants in the aged- other condition ($M = 2.95$, $SD = 0.89$) both rated the digital renderings to be only somewhat realistic. All pair-wise Tukey post-hoc comparisons were statistically significant at $p <0.001$ for realism ratings, with one exception being the comparison between the aged-self condition and the aged-other condition, $p = .63$.

One-way ANOVA also indicated that there is significant main effect of condition for identification ratings, $F(2, 114) = 19.55$, $p = .000$. Specifically, participants in the current-self condition rated their unmodified digital portraits to be quite likeable ($M = 3.62$, $SD = 1.31$). Correspondingly, participants in the aged-self condition ($M = 2.05$, $SD = 1.12$) and participants in the aged- other condition ($M = 2.51$, $SD = 0.94$) both rated the digital renderings to be only somewhat likeable. All pair-wise Tukey post-hoc comparisons were statistically significant at $p < 0.001$ for identification ratings, with one exception again being the comparison between the aged-self condition and the aged-other condition, $p = .176$.

Demographics.

Age Effects. Most participants in the present study were in their early twenties ($M = 20.37$, $SD = 6.73$). There was no statistically significant age effect across all parts of the current study.

Sex Differences. Female participants did not respond differently than did male participants in almost all parts of the current study. The only exception is that female participants ($M = 1.78$, $SD = 0.95$) rated their age-progressed doppelgangers to be less likeable than did their male counterparts ($M = 2.44$, $SD = 1.26$), $t = -1.848$, $p = .037$, $d = -.665$.

General Discussion

The current study attempted to reduce temporal discounting by enhancing future self-continuity. Toward this purpose, the current study exposed participants to their age-progressed doppelgangers. Nonetheless, participants in the aged-self condition did not report feeling more psychologically connected with their future selves, when compared to participants in the control conditions. Moreover, participants in the aged-self condition did not engage in less temporal discounting, when compared to their control group counterparts. Participants did not seem to have enjoyed seeing their age-progressed doppelgangers. Participants found their doppelgangers to be somewhat unrealistic, and had difficulties identifying with these digital renderings.

Implications for the Temporal Discounting Phenomenon

The main objective of the current study was to manipulate temporal discounting. Nonetheless, the present study has also observed a number of interesting properties of the temporal discounting phenomenon. As shown in Figure 8, participants across all three conditions consistently discounted monetary resources more steeply than they discounted non-monetary resources. One-way ANOVA confirmed that the main effect of resource type was statistically significant at $p < .001$ level across all six periods of time delay. This observation is consistent with the domain independence notion of temporal discounting (Chapman, 1996); that is, the discount rate of one domain (e.g. money) does not necessarily correspond to the discount rate of another domain (e.g. well-being).

Note that the comparison between monetary discounting and non-monetary discounting calls for extreme caution. In the current study design, for instance, monetary discount rates were based on the measurement unit of “dollars”, whereas non-monetary discount rates were based on the measurement units of “days”. Additionally, monetary reward was a tangible and easily relatable concept, whereas well-being reward was an intangible and hypothetical concept. In a sense, it is actually somewhat inappropriate to directly compare monetary discount rates with non-monetary discount rates. The current study is not proposing that participants would always discount monetary rewards more steeply than they would discount non-monetary rewards. Rather, this paper aims to illustrate that individuals tend to discount monetary resources in a somewhat *different* manner that they would discount non-monetary resources.

Interestingly, participants only discounted monetary and non-monetary resources differently when a given reward was *postponed* (e.g. receive \$500 in 5 years or \$_____ in 10 years), but not when a given reward was *preponed* (receive \$_____ in one year or \$500 in 5 years). As illustrated by Figure 9 and Figure 10, the differences between monetary and non-monetary discounting were statistically significant only in the reward postponement scenarios (Figure 9), but not in the reward preponement scenarios (Figure 10). This pattern suggests that reward postponement and reward preponement may be capitalizing on very different mechanisms. Intertemporal choices that involve a postponed reward might rely on participants being future-oriented (e.g. how well they can postpone gratification), whereas intertemporal choices that involve a preponed reward might rely on participants being present-oriented (e.g. how bad they want the reward now). In order to effectively manipulate or accurately measure discount rates, researchers must pay special attention not only to resource domains (monetary or non-monetary), but also to the wording of the intertemporal tasks (postponement or preponement).

Implications for the Future Self-continuity Hypothesis

The current study did not effectively diminish temporal discounting by enhancing psychological connectedness with the future selves. Nonetheless, the correlational relationship between psychological connectedness and temporal discounting remained to be statistically robust. Consistent with the procedure used by Bartels and Rips (2010), the current study correlated the discount factor for each time interval (e.g. δ for the 5 – 10 year interval) with the psychological connectedness drop-offs over the same interval (e.g. connectedness rating for 5 years delay minus the rating for 10 years delay). This procedure was repeated over each individual participant. After obtaining these within-participant correlations, the current study compared the central tendency of these correlations against zero using the one-sample t-test. The mean[3] of these within-subject correlations was -.1098 [t (112) = -2.431, p = .017] when the future reward was monetary and postponed. Similar patterns emerged both when the future reward was monetary, as well as when the future reward was non-monetary. Similar patterns also emerged both when the reward was postponed, as well as when the reward was preponed. Results suggest that participants engaged in more temporal discounting over those time intervals that they anticipated large drop-offs in psychological connectedness with the future selves. This finding lends addition support to the future self-continuity account of temporal discounting.

Implications for Digital Doppelgangers

Digital doppelgangers have been previously deployed as an intervention instrument to alleviate a number of societal problems (Ahn, 2011; Fox et al., 2009; Fox & Bailenson, 2009; Hershfield et al., 2011). The current study deployed age-progressed doppelgangers in an attempt to diminish temporal discounting. Nonetheless, many participants did not seem to have enjoyed the encounter with their digital doppelgangers. Hershfield (2011) argued that, in order for doppelgangers to be effective, the digital renderings must: (1) look physically similar to the participants (similarity), (2) look vivid and realistic to the participants (realism), and (3) liked and cared for by the participants (identification). Aligning with Hershfield's proposition, the current study has identified two key aspects that may be vital for the general effectiveness of digital doppelgangers.

[3] Bartels and Rips reported the median of their within-subject correlations. For the current study, the median of these correlations was -.1050, when the future reward was monetary and postponed.

Importance of Realism. Digital doppelgangers would be ineffective if participants find them to be unrealistic. In the current study, for instance, participants in the aged-self condition and the aged-other condition both rated the digital renderings to be only somewhat realistic. One possibility is that the aging algorithm of AgingBooth was not powerful enough to impress the participants. Unlike FaceGen, APRIL, Poser, and other industrial-grade modeling programs, AgingBooth is a free-to-use age progression application that can be easily acquired by the general public. Some participants might already have first-hand experience with the application, either for educational purposes, or for recreational purposes. Such ease of access might have undermined the perceived realism of the doppelgangers that AgingBooth can generate. Another possibility is that participants might have stumbled upon the "Uncanny Valley". The Uncanny Valley (Mori, 1970; as cited in Coulson, Barnett, Ferguson, & Gould, 2012) refers to the phenomenon in which people are repulsed by hyperrealistic human replicas that look very much like humans, but are not *quite* humans. In other words, participants still would not resonate with their digital doppelgangers even when the renderings look realistic and lifelike. In order for these digital doppelgangers to be effective, they might need to also possess interactive qualities that make them "humane", qualities with which the participants can easily relate.

Importance of Identification. Doppelgangers would be ineffective if participants fail to identify with their digital doubles. In the current study, for example, participants in the aged-self condition reported feeling more negative emotions after being exposed to their digital doppelgangers. Moreover, participants in the aged-self condition indicated that they simply somewhat disliked their digital doppelgangers. Participants found it difficult to identify with their digital doubles, possibly because the digital renderings in the current study were static and lacked interactivity. Hershield and colleages (2011) enjoyed great success with age-progressed doppelgangers that can interact with the participants in a meaningful manner. These digital doppelgangers would frown if the participants consistently prefer immediate rewards over future rewards. Correspondingly, these digital doppelgangers would smile delightfully if the participants consistently prefer future rewards over immediate ones. Such high interactivity can induce a sense of *presence* – the psychological state of feeling that a virtual experience is real (Ahn & Bailenson, 2011). When participants experience a heightened sense of presence, they would start to consider the “feelings” of their digital doppelgangers, and would also start to care for the well-being of their doppelgangers. In other words, digital doppelgangers can become effective if participants start to identify with their digital doubles.

Limitations and Future Research

The current study suffered from a number of limitations. A major challenge for the present study was to measure temporal discounting of both monetary and non-monetary resources in general. Toward this purpose, the current study adapted the free-response (fill-in-the-blank) temporal discounting procedure from Bartels and Rips. The free-response procedure can obtain a large variety of discount rates from the participants in an extremely time-efficient manner. In the current study, for example, each participant can provide up to 17 different discount rates in less than 5 minutes of time. Nonetheless, the free-response procedure could not prevent participants from filling in extreme, or at times, impossible values (e.g. 999,999 days, which equates to 2,738 years). Future studies can benefit by implementing the titration procedure of measuring temporal discounting (Bartels & Rips, 2010). The titration procedure forces participants to progressively choose from a given set of intertemporal responses (e.g. $100 now or $120, $140, $160, and $180 in 1 year). Although such procedure can be relatively time consuming, titration can remove a substantial amount of noise from the data. The titration procedure might be more sensitive to experimental manipulations of temporal discounting, comparing to the free-response procedure.

Another challenge for the present study was to generate age-progressed doppelgangers that are realistic and relatable. Toward this purpose, the current study relied exclusively on the aging algorithm of AgingBooth – a non-commercial aging algorithm that is easily accessible by the general public. AgingBooth can generate static digital renderings that are somewhat realistic. Nonetheless, in order for these digital doppelgangers to be effective, they might need to possess not only realism, but also meaningful interactivity. Future studies can benefit from industrial-grade age progression solutions such as Facegen, APRIL, or Poser. Although relatively costly, these powerful solutions can generate digital doppelgangers that are lifelike and convincing. Furthermore, the doppelgangers that these applications generate can be readily imported into virtual realities or other virtual environments, such as Second Life. A virtual environment can often serve as an ideal platform for participants to experiment, explore, and interact with their digital doubles.

Conclusion

The current study attempted to diminish temporal discounting by exposing participants to age-progressed doppelgangers of their futures selves. Nonetheless, these digital doppelgangers did not effectively reduce temporal discounting of either future monetary resources or future non-monetary resources. Many participants did not consider their digital doppelgangers to be realistic and vivid. Furthermore, many participants did not identify with the age-progressed renderings of their future selves. In order for these digital doppegangers to be effective, these digital renderings might need to not only *look* like real humans, but also need to *behave* like real humans.

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