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Many people fail to save what they will need for retirement. Research on excessive discounting of the future suggests that removing the lure of immediate rewards by precommitting to decisions or elaborating the value of future rewards both can make decisions more future oriented. The authors explore a third and complementary route, one that deals not with present and future rewards but with present and future selves. In line with research that shows that people may fail, because of a lack of belief or imagination, to identify with their future selves, the authors propose that allowing people to interact with age-progressed renderings of themselves will cause them to allocate more resources to the future. In four studies, participants interacted with realistic computer renderings of their future selves using immersive virtual reality hardware and interactive decision aids. In all cases, those who interacted with their virtual future selves exhibited an increased tendency to accept later monetary rewards over immediate ones.

Keywords: retirement saving, temporal discounting, future self-continuity, immersive virtual reality, intertemporal choice

Increasing Saving Behavior Through Age-Progressed Renderings of the Future Self

Although the age associated with retirement is 65 in the United States, people are expected to live approximately 16 years in retirement on average (Arias 2007), which reflects a gradual increase in retirement length observed since the nineteenth century (Lee 2001). Unfortunately, with this prolonged amount of time spent in retirement, people run the risk of outliving their money or undergoing a sudden decrease in quality of life. Using data from the 2004 Survey of Consumer Finances, Munnell, Webb, and Golub-Sass (2007) calculate a benchmark replacement rate for each household and find that 43% of households fell at least 10% short of reaching target replacement rates. When taking into account the recent financial crisis, the retirement picture grows even bleaker. Using the same benchmark replacement rate, Munnell, Webb, and Golub-Sass (2009) find that a few years later, the percentage of households that would fall short of reaching their retirement goals had grown to 51%. Moreover, the McKinsey Global Institute (2008) observes that fully two-thirds of early baby boomers (born between 1945 and 1955) do not have the resources to maintain their preretirement standards of living in retirement, perhaps resulting from their inability to forecast the consequences of their investment decisions (Goldstein, Johnson, and Sharpe 2008). Such a lack of preparedness is particularly problematic in the United States given the status of the already weakened Social Security system. In the words of Federal Reserve Chairman Ben

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Bernanke, "The arithmetic is, unfortunately, quite clear" (Chan and Hernandez 2010). Thus, to avoid overwhelming budget cuts, saving behavior needs to change.

Discounting of the future has long been described as exponential in economic models (e.g., Samuelson 1937), but recent behavioral research suggests that it is better explained by a hyperbolic or quasi-hyperbolic function in certain situations (Kirby and Marakovic 1996; Laibson 1997; Laibson, Repetto, and Tobacman 1998; Strotz 1956; Zauberman et al. 2009). In particular, rather extreme discounting is believed to occur in situations in which immediate gains (as opposed to short-term gains) are traded off against long-term ones (Chapman 1996; Frederick, Loewenstein, and O'Donoghue 2002; Laibson 1997; O'Donoghue and Rabin 1999). Such steep discounting is believed to lead to decisions that would be rejected with enough planning (Hoch and Loewenstein 1991; Lynch et al. 2010), and failure to save for retirement is considered a prototypical example of discounting to excess (Diamond and Köszegi 2003; Laibson, Repetto, and Tobacman 1998).

Two broad types of remedies aim to increase saving and reign in excessive discounting (for a review of other interventions in multiple domains, see Ho, Lim, and Camerer 2006). Remedies of the first type reduce the lure of immediacy and the amount that can be consumed in the present through precommitment to starting to save at a later date (e.g., Thaler and Benartzi 2004). Precommitment involves any device that consumers use to enact constraints in the present to limit undesirable (or promote desirable) behaviors in the future (Ariely and Wertenbroch 2002). Elster (1977) highlights the example of Ulysses tying himself to the ship mast so that he could listen to the Sirens' songs without jumping overboard, and Schelling (1983) notes that alcoholics take the drug Antabuse to help them avoid engaging in future drinking. To this end, several companies have successfully implemented programs that use precommitment strategies that allow employees to commit future income to retirement plans (e.g., Choi et al. 2006; Thaler and Benartzi 2004).

Remedies of the second type increase the appeal of waiting to spend and the expected enjoyment of future spending by directing people's imagination to future uses for money. If consumers are often insensitive to the ways present consumption necessarily limits their ability to spend money later on (Frederick et al. 2009), this may be due to their failing to understand the positive future consequences of waiting (Nenkov, Inman, and Hulland 2008; Nenkov et al. 2009). Indeed, prior research has shown that interventions that encourage people to elaborate on future outcomes and consider future uses for money to increase patience on intertemporal choice tasks (e.g., Weber et al. 2007).

In this article, we explore a third and complementary route, one that deals not with present and future rewards but with the connection between present and future selves. In line with research that shows that people may fail to identify with their future selves because of a lack of belief or imagination (Parfit 1971; Schelling 1984), we propose that having people interact with photorealistic age-progressed renderings of themselves will cause them to allocate more resources to the future. In four studies, participants interacted with computer-generated representations of their future selves using immersive virtual reality hardware and interactive decision aids before making decisions about whether to consume in the present or future.

FUTURE SELF-CONTINUITY

Theoretical Foundations and Empirical Evidence

Philosophers, psychologists, and economists argue that an important determinant of intertemporal choice is a person's sense, or lack thereof, of psychological connection with his or her future self (Ainslie 1975; Elster 1977; Parfit 1971, 1987; Schelling 1984; Strotz 1956; Thaler and Shefrin 1981). Psychological connectedness is believed to vary with respect to the age difference between different "selves," such that a person might feel more connection with his or her future self in one year than in 40 years and, accordingly, might care less about a distant self (Parfit 1971). At the extreme, with a total lack of psychological connectedness, a person's future self might seem like a different person altogether. As Butler (1736, p. 344) first noted, "if the self or person of today, and that of tomorrow, are not the same, but only like persons, the person of today is really no more interested in what will befall the person of tomorrow, than in what will befall any other person." Parfit (1987, pp. 319–20) expands on this concept, as follows:

> If we now care little about ourselves in the further future, our future selves are like future generations. We can affect them for the worse, and, because they do not now exist, they cannot defend themselves. Like future generations, future selves have no vote, so their interests need to be specially protected. Reconsider a boy who starts to smoke, knowing and hardly caring that this may cause him to suffer greatly fifty years later. This boy does not identify with his future self. His attitude towards this future self is in some ways like his attitude to other people.

To people estranged from their future selves, saving is like a choice between spending money today or giving it to a stranger years from now. Presumably, the degree to which people feel connected with their future selves should make them realize that they are the future recipients and thus should affect their willingness to save. We hold the view that it is not important whether in various senses, a person *actually* changes over time. Although trait-level personality characteristics (Roberts and DelVecchio 2000) and general interests (Low et al. 2005) remain relatively constant over the course of a lifetime, the body's cells turn over, and attributes as personal as names, noses, and reputations can be willfully altered beyond recognition. What matters, however, in the sense of the law, is that one person has but one identity, and with this essential link, the assets of the present and future selves are yoked together. Similar to Parfit (1987), we hypothesize that people who *feel* as though the future self is a different person fail to acknowledge this connection, that is, fail to *identify* with themselves in the future.

Do people think of the future self as a different person? Research has demonstrated that people make attributions about the future self in the same manner as they do for others, by attributing the future self's behavior to dispositional factors rather than situational ones (Pronin and Ross 2006; Wakslak et al. 2008), and make decisions for the future self using a similar process they use to make decisions for other people (Pronin, Olivola, and Kennedy 2008). On an implicit level, Ersner-Hershfield, Wimmer, and Knutson (2009) show that thinking about the future self elicits neural activation patterns that are similar to neural activation patterns elicited by thinking about a stranger. More important, the degree to which people report feeling connected with their future selves is related to their intertemporal decision making. For example, Ersner-Hershfield et al. (2009) find that higher levels of future self-continuity are positively associated with financial assets, and Bartels and colleagues show that perceived connectedness with the future self is predictive of choices on several different temporal discounting tasks (Bartels and Rips 2010) and distinct from other constructs related to temporal preference, such as present bias (Bartels and Urminsky 2011). Moreover, in their neuroimaging study, Ersner-Hershfield, Wimmer, and Knutson (2009) demonstrate that participants who showed the greatest neural activation differences between thoughts about the current self and thoughts about the future self also showed the steepest discount rates.

Increasing Connectedness with the Future Self

Parfit (1987, p. 161) remarked that neglecting the future self might be "caused by some failure of imagination, or some false belief." The notion of a future self presents many challenges to the imagination. With the countless directions a life and appearance could take, a person might be unsure with which among this infinity of future selves to identify. The multiplicity of possible future selves is acknowledged by Parfit, who cites Proust ([1927] 1981, p. 631) to illustrate this point: "We are incapable, while we are in love, of acting as fit predecessors of the person whom we shall presently have become and who will be in love no longer." Similarly, a composite representation of all future selves would necessarily be impoverished, and the quest to identify a singular image may result in indecision or lack of confidence about what the future holds.

Parfit (1987, p. 161) also observes that "when we imagine pains in the further future, we imagine them less vividly, or believe confusedly that they will somehow be less real, or less painful." In line with this sentiment, recent research has argued that consumers suffer "empathy gaps" and may misunderstand how they will feel in the future about decisions they make in the present (Loewenstein, O'Donoghue, and Rabin 2003; Wilson and Gilbert 2005). Loewenstein (1996) theorizes that a more vivid impression of oneself engaging in some action in the future might intensify the emotions that are linked to thinking about that scenario. These intensified emotions might, in turn, enable a person to be better informed about the future consequences of a present decision. For example, pulmonologists tend to smoke less than other doctors, perhaps because seeing blackened and withered lungs on a daily basis increases the negative emotions associated with smoking (Loewenstein 1996).

AGE-PROGRESSED EMBODIMENTS OF THE FUTURE SELF

To the extent that people can feel more connected with a vividly imagined future self, they should be motivated to save more money for the future. Accordingly, in what follows, we examine the association between seeing an embodiment of one's self in the future and the propensity to save for retirement or accept later monetary rewards over immediate ones. Although philosophers and psychologists have used the term "embodied" to signify that organisms are influenced by their own physical, incarnate bodies (Lakoff and Johnson 1999), we borrow the term from virtual reality literature, in which it is associated with a particular visual or otherwise perceivable representation of a body. As Lanier (1992) notes, a perceivable embodiment helps forge an association with the self in a digital environment.

In this research, we present people with renderings of their future selves made using age-progression algorithms that forecast how physical appearances will change over time. People are capable of imagining their future selves at any time, so why should the presentation of renderings lead to different behavior than that resulting from day-to-day imagination? We suspect several reasons for this difference. First, though capable, people may not ordinarily elect to imagine their future selves. Second, even if people often imagine their future selves, they may not be imagining themselves at a distant retirement age. Third, imagination of the future may be propositional ("I will have enough money to leave to my children") rather than visual; vivid visual imagery is believed to exert strong influences on preferences and memory (Loewenstein 1996; Standing 1973). Fourth, as we discussed, an imagined self may be uncertain, vague, and probabilistic; in contrast, a computerized rendering is definite and specific. Fifth, because people may have variable confidence in their abilities to imagine their future selves, renderings created by an objective forecasting model may be viewed as more authoritative. Last, as Parfit (1971) notes, neglect of the future self can arise from a failure of the imagination. Because imagination from the starting point of a graphical rendering may require less effort and attention than imagination from a blank slate, people may more easily imagine the future self when seeded with an image based on their present appearance (as the renderings in the experiment are). These studies were motivated, in part, by others who have used virtual reality as a tool (Blascovich and Bailenson 2011) to influence consumer behavior (Ahn and Bailenson, in press), health behavior (Fox and Bailenson 2009), financial decision making (Yee and Bailenson 2007), and memory (Segovia and Bailenson 2009).

Our work adds to a growing body of literature that examines effective interventions for increasing saving behavior. Whereas previous work has explored how both changing one's environment in advance (Ariely and Wertenbroch 2002) and elaborating on potential outcomes can lead to more patient intertemporal choices (Nenkov, Inman, and Hulland 2008; Nenkov et al. 2009), our manipulations take an earlier starting point. Instead of altering the way consumers think about future rewards, the manipulations presented here seek to aid consumers in imagining the future self who will benefit (or suffer) from the outcomes of decisions made today.

OVERVIEW

We incorporated a variety of novel technologies in the current studies, including immersive virtual reality. Blascovich and Bailenson (2011) demonstrate the utility of this methodology for social science and posit that virtual reality can help recreate situations that are difficult to simulate in the physical world while maximizing mundane realism and experimental control. In Study 1, we used immersive virtual reality to put participants inside a visual representation of their body and face as they approximately will look in the future (Yee and Bailenson 2006). Study 2 extends the results of Study 1 by including more implicit dependent variables and rules out demand effects. Study 3a tests whether these interventions can work in field conditions—namely, delivery over the Internet—without special virtual reality hardware and with only a few user photographs as input. Finally, Study 3b assesses the generalizability of the results using a community sample and also examines the extent to which the manipulations enhance future self-continuity.

STUDY 1: IMMERSIVE VIRTUAL REALITY AND THE FUTURE SELF

In Study 1, we used collaborative virtual environments (CVEs; see Blascovich and Bailenson 2011) to study the effects of exposure to a digital representation of one's future self. Collaborative virtual environments are communication systems in which multiple participants share the same three-dimensional digital space despite occupying remote physical locations. In a CVE, immersive virtual environment technology monitors the movements and behaviors of individual participants and renders those behaviors within the CVE through avatars. These digital representations are tracked naturalistically by optical sensors, mechanical devices, and cameras. In Study 1, one group of participants saw a digital representation of their current selves in a virtual mirror, and the other group saw an age-morphed version of their future selves in the virtual mirror. To ensure identification with their avatars and an equal amount of time spent in the virtual reality environment, all participants briefly conversed with a confederate. We hypothesized that the participants who saw the age-morphed version of their future selves would be more likely to allocate money to a hypothetical retirement savings account after exposure than those who saw the current version of themselves.

Materials

Money allocation task. The money allocation task was a novel task created for the purposes of this experiment. In it, participants were told to imagine that they had just unexpectedly received $1,000 and were asked to allocate it among four options: "Use it to buy something nice for someone special," "Invest it in a retirement fund," "Plan a fun and extravagant occasion," and "Put it into a checking account."

Age progression. We first used preset algorithms from a computer software package (FaceGen Modeller from Singular Inversions), which (1) locates key points on the face from a front-on and profile photograph, (2) builds a three-dimensional model of the face, and (3) morphs the shape and texture of the model to simulate the aging process to create a persuasive visual analog of a 70-year-old version of a current college student. Figure 1 illustrates an example of the age-progression procedure. To create the aged photos, we applied the age-progression algorithm of the FaceGen Modeller software package with identical settings to each photo. Because the software is specifically designed to manipulate facial features and not hair, an artist digitally retouched each image using Adobe Photoshop to change the original hair color of the participant to gray. We used an identical procedure (i.e., creating the three-dimensional model) for the nonaged avatars, except that we did not use the aging algorithm or gray the hair color.

Figure 1
EXAMPLE OF MORPHING PROCEDURE

A: Actual Photo of First Author

B: Nonaged Digital Avatar

C: Aged Digital Avatar

Virtual reality. In immersive virtual reality environments, participants can enter an immersive virtual reality system and see their future self avatars in a virtual mirror (Bailenson, Beall, and Blascovich 2002). In the simulation, cameras monitor the movements and behaviors of participants and display those behaviors using avatars (digital representations of people). Figure 2 demonstrates the CVE apparatus that is in place in Stanford University's Communication Department, with the critical hardware labeled with letters. The virtual setting was a white room that had the exact dimensions as the physical room participants were in (see Figure 2). Two meters behind the participant was a virtual mirror that reflected the head orientation (rotations along pitch, yaw, and roll) and body translation (translation on X, Y, and Z) of the participant with the designated face. Thus, the mirror image tracked and reflected six degrees of freedom such that when the participant moved in physical space, his or her avatar moved in perfect synchrony in the mirror. The confederate's avatar was located five meters in front of the participant, facing the participant, and remained invisible until the conversational portion of the experiment began. In addition, the confederate physically remained behind a curtain until the conversational portion of the experimental task.

Apparatus. Perspectively correct stereoscopic images were rendered at an average frame rate of 60 Hz. The simulated viewpoint was continually updated as a function of the participants' head movements, which were tracked by a three-axis orientation sensing system. The position of the participant along the X, Y, and Z planes were tracked with an optical tracking system. Participants wore an nVisor SX head-mounted display (HMD) that featured dual 1,280 horizontal × 1,024 vertical pixel resolution panels that refreshed at 60 Hz (for the equipment setup, see Figure 2).

Figure 2
COLLABORATIVE VIRTUAL ENVIRONMENT

Notes: The top panel demonstrates the virtual reality technology: A = head-mounted display and orientation tracking device, B = behavior tracking cameras, and C = image generator. The middle panel demonstrates the image the user depicted in the top panel sees. As the user moves and gestures in the physical world, his or her aged virtual self-image in the mirror moves as well. The bottom panel is a diagram showing the layout of the room, with the position of the virtual mirror (M), the position of the participant (S), the curtain, and the position of the confederate (C).

Emotion questionnaire. Participants were asked to rate the extent to which they felt each of 15 different emotions (positive: accomplishment, amusement, contentment, excitement, happiness, interest, joy, and pride; negative: anger, anxiety, disgust, fear, frustration, irritation, sadness). They rated these emotions on a seven-point scale (from 1 = "not at all" to 7 = "extremely").

Method

Participants. Fifty participants (33 women; M = 20.13 years) took part in the study. Participants received course credit or $10.

Experimental procedure. Participants were randomly assigned to one of two conditions (current self or future self). Participants were told that they were going to enter the virtual reality environment to see their own (or aged) face on a digital avatar and that they would answer a series of personal interview questions. The experimenter then showed participants two images of their avatar before they entered the virtual reality environment. So that participants in both conditions saw an equal number of images, participants in the control condition saw a front and side view of their digital avatar, and participants in the experimental condition saw the young version of their avatar and then the age-morphed version.

Next, participants were outfitted in the HMD and entered the virtual environment, in which they could see their digital avatar in the virtual mirror in front of them. Participants saw themselves in a room that had exactly the same dimensions as the physical lab room depicted in Figure 2. In line with Yee and Bailenson's (2007) procedure, to enhance identification with the avatar, the experimenter asked participants to turn around 180 degrees and to verify that they saw a mirror in front of them. After verbal affirmation, several exercises (head tilting and nodding in front of the mirror) were used to ensure participants had enough time to observe their avatars' faces. Every participant thus was exposed to the designated face for between 60 and 75 seconds.

Participants were then asked to turn back around to face the front of the room (i.e., their original orientation). Slightly ahead of time, the experimenter had triggered the program to make the confederate's avatar visible to the participant in the virtual world. The lead research assistant then introduced the confederate to the participant. The confederate followed a strict script displayed in his or her HMD so that he or she could follow the specific verbal procedures while interacting with the participant inside the CVE (e.g., "What is your name?" "Where are you from?" "What is your passion in life?"). These interview questions served to enhance identification between the participant and his or her avatar (Yee and Bailenson 2007). Confederates' behaviors were not scripted, and they were instructed to use natural head movements when interacting with the participant.

Following the interview questions, the experimenter removed participants' HMD, and the participants then completed the money allocation task, the emotion questionnaire, and filler tasks for another experiment. After this, the participants were paid and debriefed.

Results and Discussion

We hypothesized that participants in the future self condition would allocate more money to retirement than participants in the current self condition. In line with this prediction, participants who were exposed to their future selves in virtual reality allocated more than twice as much money to the retirement account (M = \$172, SD = \$214) than participants who were exposed to their current selves (M = \$80, SD = \$130; $t(48) = 1.83$, $p = .035$ [one-tailed], $d = .519$).

It is possible, however, that seeing their aged face depressed participants' current mood. If this was the case, the appeal of the short-term options (e.g., planning a fun and extravagant occasion) in the monetary allocation questionnaire might have been diminished not because of enhanced connectedness with the future self but because these amusing options were less appealing when experiencing negative moods. (See the work of Cryder et al. [2008] though, which demonstrates that sadness leads to *more* spending.) Such a scenario would leave a larger amount of money to be devoted to the long-term saving option. However, the results indicate that participants in the future self condition (M = 2.52, SD = .95) did not exhibit significantly stronger negative emotions (M = 2.62, SD = 1.27) than participants in the current self condition ($t(48) = .33$, $p = .75$). Furthermore, when we control for the average of all negative emotions, condition is still a predictor of the amount of money allocated to retirement ($F(1, 47) = 3.19$, $p = .04$ [one-tailed]).

Thus, the results suggest that interaction with a vivid version of their future self causes people to give modestly greater weight to long-term saving. It is possible, however, that the study's demand characteristics played a role in participants' behavior (Orne 1962). Although informal postexperiment interviews suggested that this was not the case, in Study 2 we attempted to formally rule out these demand characteristics.

STUDY 2: RULING OUT DEMAND CHARACTERISTICS

In Study 2, we tried to rule out two alternative explanations for our findings from Study 1. First, because the monetary allocation task occurred directly after the virtual reality paradigm, it is possible that participants in the experimental condition felt pressure to allocate more to the long-term account. Thus, in Study 2, we separated the virtual reality portion of the study from the decision-making portion and provided a cover story that masked our research purposes. Second, it is possible that participants in the experimental condition were merely primed with the concept of aging, and this prime prompted them to save more for retirement (i.e., Bargh and Chartrand 1999). As such, in Study 2, we exposed participants to either their own aged avatar or another research participant's aged avatar. Finally, we attempted to extend our findings to three different dependent variables. That is, we used a short-term temporal discounting task, a long-term temporal discounting task, and a retirement spending questionnaire. Including all three measures enabled us to test the degree to which our manipulations increase a focus on the future self for all types of intertemporal choices rather than just long-term ones. Although short- and long-term discounting may have different processes (McClure et al. 2004), opting for larger later rewards in both cases might nonetheless be linked to better saving behavior. That is, by repeatedly forgoing short-term rewards, a person could inevitably end up saving more over the long run (Thaler and Shefrin 1981); money not spent on pleasurable experiences in the present can be used for other purposes in the future. Thus, we hypothesized that participants who interacted with avatars depicting their future selves, as opposed to future others, would demonstrate a greater willingness to choose larger, future rewards on all three tasks.

Materials

Short-term temporal discounting task. The temporal discounting task consisted of 21 choice trials (Kirby and Marakovic 1996). Each trial included one smaller immediate reward paired with one larger delayed reward. Immediate values ranged from \$15 to \$83, and the delayed values ranged from \$30 to \$85 over delays of 10 days to 75 days. The task was incentive compatible: Participants were instructed that at the end of the experimental session, one response would be chosen at random and participants would be paid 33% of that choice at the appropriate delay. For example, if on a given question a participant chose \$30 in 27 days, he or she would receive \$10 in 27 days. We counted the number of delayed choices to index discount rate (Magen, Dweck, and Gross 2008). Although Kirby and Marakovic's (1996) procedure excludes data from people who chose either all the immediate or all the delayed options, Magen, Dweck, and Gross's (2008) procedure has the advantage of retaining these people for subsequent analysis.

Long-term temporal discounting task. We created the long-term temporal discounting task for the purposes of this experiment, basing it on Kirby and Marakovic's (1996) short-term temporal discounting task. Again, each trial included one smaller immediate reward paired with one larger delayed reward. As in Kirby and Marakovic (1996), we used the hyperbolic discounting function $V = A/(1 + kD)$, where V is the value of a present (or immediately available) gain, A is the amount of a future gain, k is a discount parameter that varies across respondents, and D is the amount of time that respondents must wait for the future gain (Mazur 1987). Discount rates (k) ranged from .07 to .86. Immediate values ranged from \$2,575 to \$25,840, and the delayed values ranged from \$76,965 to \$98,191 over delays of 35 years to 40 years. Again, we counted the number of delayed choices to index the discount rate.

Retirement spending questionnaire. The retirement spending questionnaire (Binswanger and Carman 2009) consisted of one question that asked participants to choose between six options of how they would like to spend the money they earned during their lifetime. Each option detailed the amount of money the participant could spend monthly during his or her working life and during retirement. For example, Option 1 detailed a case in which the participant could spend \$2,950 per month during his or her working life and \$1,900 per month during retirement. At the other end of the spectrum, Option 6 detailed a case in which the participant could spend \$2,600 per month during his or her working life and \$3,600 per month during retirement. Thus, higher scores on this scale were associated with greater allocation to retirement. Participants were explicitly told to answer the question as if prices remained constant (i.e., as if there was no inflation).

Method

Participants. Twenty-one participants (15 women; M = 20.08 years) took part in the study. Participants received $10 and were told that the experiment would take approximately one hour to complete.

Experimental procedure. Participants were assigned to one of two conditions (future self or future other) and were given the following instructions: Participants were told that we were experimenting with technology that would put their own aged face (or someone else's aged face) on a digital avatar. Next, participants were brought into the same immersive virtual reality environment as Study 1, in which they could see either their own digital avatar in a virtual mirror in front of them (future self condition) or the aged digital avatar of another same-sex and same-race participant (future other condition). As in Study 1, we conducted Yee and Bailenson's (2007) procedure to enhance identification with the avatar.

Participants were allotted three minutes to talk about the ways they were similar (e.g., in personality, appearance, temperament, major preferences, beliefs, values, ambitions) to the person depicted by the avatar in the mirror. After three minutes, the experimenter took the HMD off the participants, and the participants then completed several short filler questionnaires asking them about their experience in the virtual reality environment. To eliminate demand characteristics, we ostensibly separated the manipulation from our main dependent variables. That is, after participants completed the questionnaires, a computer message appeared notifying them that they had completed the experimental session. At this point in the study, however, approximately 45 minutes had elapsed, and participants had been led to believe that they were participating in an hour-long experiment at a pay rate of $10 per hour. The experimenter feigned surprise at the early completion time and told participants that they were free to go but that to receive the full $10, they needed to be present for a full hour of research participation. Participants were then told that there were a few other short surveys that were being conducted in the lab by other researchers in which they could participate to earn the remaining pay. All participants agreed to participate in the additional survey. To further mask our research purposes, participants were ostensibly given a choice of three different surveys in which to participate. All three surveys, however, linked to the same set of questionnaires: the short-term temporal discounting task, the long-term temporal discounting task, and the retirement spending questionnaire. On completing these tasks, participants were debriefed and paid.

Results and Discussion

To measure the unique impact of interacting with one's future self on saving behavior, we conducted a repeated measures analysis of variance on standardized scores from the three dependent variables (short-term temporal discounting task: $M_{Future\ Self} = .36$, $SD_{Future\ Self} = 1.04$ and $M_{Future\ Other} = -.32$, $SD_{Future\ Other} = .89$; long-term temporal discounting task: $M_{Future\ Self} = .27$, $SD_{Future\ Self} = .83$ and $M_{Future\ Other} = -.25$, $SD_{Future\ Other} = 1.11$; retirement spending questionnaire: $M_{Future\ Self} = .28$, $SD_{Future\ Self} = .99$ and $M_{Future\ Other} = -.25$, $SD_{Future\ Other} = .99$). The results indicated that participants in the future self condition exhibited more saving behavior across the three tasks than participants in the future other condition ($F(1, 19) = 4.14$, $p = .056$).

Thus, Study 2 employed a well-masked paradigm in which we directly compared the effects of interacting with one's imagined future self with those of interacting with another imagined older person. In line with our prediction, vivid exposure to one's future self in an immersive virtual reality environment, compared with exposure to another person's older avatar, led to increased saving in both short- and long-term decision-making tasks.

In both Studies 1 and 2, we presented age-progressed renderings of the future self but did not discuss the consequences of decisions made in the present. Furthermore, although these findings are encouraging conceptually, because of high costs and time efficiency, most companies are not able to use immersive virtual reality to convince their employees to contribute additional money to retirement accounts. Accordingly, in Study 3a we strove to highlight future consequences of present decisions and to translate our methods and findings to more accessible formats for widespread use as an intervention.

STUDY 3A: GENERALIZATION TO FIELD CONDITIONS

Whereas Study 2 aimed to rule out demand effects, this study takes an applied perspective and gives the virtual renderings emotional qualities to intentionally exert a demand or "nudge" in the context of an online decision aid. The decision aid provides users with accurate estimates of present and future spending levels that will be attainable given various saving rates. Its estimates, which we describe in the appendix, take inflation, earnings growth, employer 401k contribution match, age, Social Security, and many other factors into account. The information is so useful that it alone could serve as a basis for prudent savings decisions, and providing participants with this information should greatly reduce their uncertainly about how saving will affect their material wealth in the short and long run. Owing to this, the present design enables us to mitigate the effect of income uncertainty when estimating the persuasive effect of the virtual renderings. The second objective of this study is to test whether the kind of intervention proposed can be practically adapted for widespread Internet participation from home, office, or elsewhere. To conduct this study, no virtual reality hardware was necessary, and people needed only to submit three digital photos to take part.

The ability to imagine vividly not just the face of the future self but also the emotional reactions of the future self may affect the willingness to save for the future. Virtual reality research has demonstrated that exposure to virtual cause-and-effect actions can change actual behavior. For example, participants shown virtual versions of themselves losing weight with exercise and gaining weight with inactivity were more likely than controls to exercise afterward (Fox and Bailenson 2009). To test whether exposure to an emotional future self can affect the propensity to save for retirement, participants in two conditions interacted with current or age-progressed renderings of themselves that appeared to respond emotionally to changes in income.

Materials

Age progression. In the first phase of the study, participants came in person to the laboratory, where they were photographed making happy, sad, and neutral facial expressions. They then were instructed that they would take part in the remainder of the study online.

Using the three photos as a starting point, we prepared three age-progressed photos (for participants in the future self condition) or three unaged photos (for participants in the current self condition). Each set of three photos served as the basis for 11 emotional variant photos in two sets. A "future" set of 11 photos showed the participants as they might look as older adults (approximately age 65), with levels of facial expression ranging from sad to happy. The "present" set had the same 11 levels of facial expression but showed the participants at their current age.

To create the three aged photos, we used the same procedure as Study 1, employing the age-progression algorithm of the FaceGen Modeller software package and Adobe Photoshop to change the hair color to gray. We created the 11 emotional variant photos within the present and future sets using FantaMorph software to make "morphs" of the sad, neutral, and happy input images. A morph is akin to a weighted average of two images and looks quite natural (Bailenson et al. 2008). We applied the weighting scheme in Table 1 to create the morphs. This process was the same for making the present and future photos, the only difference being the three starting images used.

Retirement allocation slider bar. In both conditions, participants decided how much they would like to contribute to their retirement fund. To help make this decision, they were given a slider that controls their level of contribution. Instead of showing participants the percentage of salary saved at each slider position (which is not particularly informative for making such decisions), as they explored various levels, the interface indicated how much their current and future income would be affected by their allocation decision. In Figure 3, the left-hand-side percentage displays current income as a percentage of salary remaining after contributions to Social Security and Medicare. The right-hand-side percentage value displays income in retirement expressed as a percentage of income in the year immediately before retirement. Both percentages updated dynamically as the cursor moved over the slider.

We calculated the values represented on the slider in the same manner in both conditions, and they are based on the detailed financial model summarized in the appendix. The inputs given to the model were the same for all participants and chosen to be representative for students at the university where the studies were conducted. In particular, the model made its calculations based on a person aged 22, starting work at age 23, retiring at age 68, and earning a salary of $64,000 (in today's dollars) by age 40. Allowable percentages of salary that could be saved toward retirement ranged from 0% to 10%. These parameters helped generate realistic trade-offs (in percentage terms) for typical American college students and were never seen by the participants.

Figure 3 depicts the interface in the present and future conditions, and Figure 4 gives an indication of how the movement of the slider bar affected the emotions of the

Table 1

WEIGHTING OF INPUT PHOTOS TO CREATE MORPHS

Expression Level	*Input Photo 1*	*Weight 1 (%)*	*Input Photo 2*	*Weight 2 (%)*
1 (saddest)	Sad	99	Neutral	1
2	Sad	80	Neutral	20
3	Sad	60	Neutral	40
4	Sad	40	Neutral	60
5	Sad	20	Neutral	80
6	Happy	1	Neutral	99
7	Happy	20	Neutral	80
8	Happy	40	Neutral	60
9	Happy	60	Neutral	40
10	Happy	80	Neutral	20
11 (happiest)	Happy	99	Neutral	1

Notes: Morphs are composite photos made from two input photos. Expression levels 1, 6, and 11 use 1% weighting to ensure that all photos will indeed be morphs and not original images.

Figure 3

THE CURRENT SELF (TOP) AND FUTURE SELF (BOTTOM) CONDITIONS OF STUDY 3A

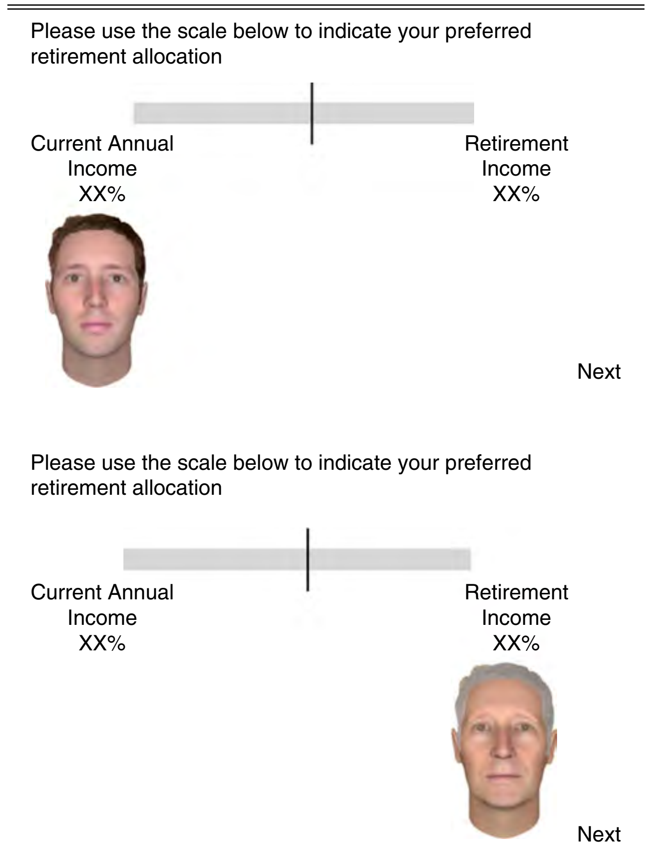
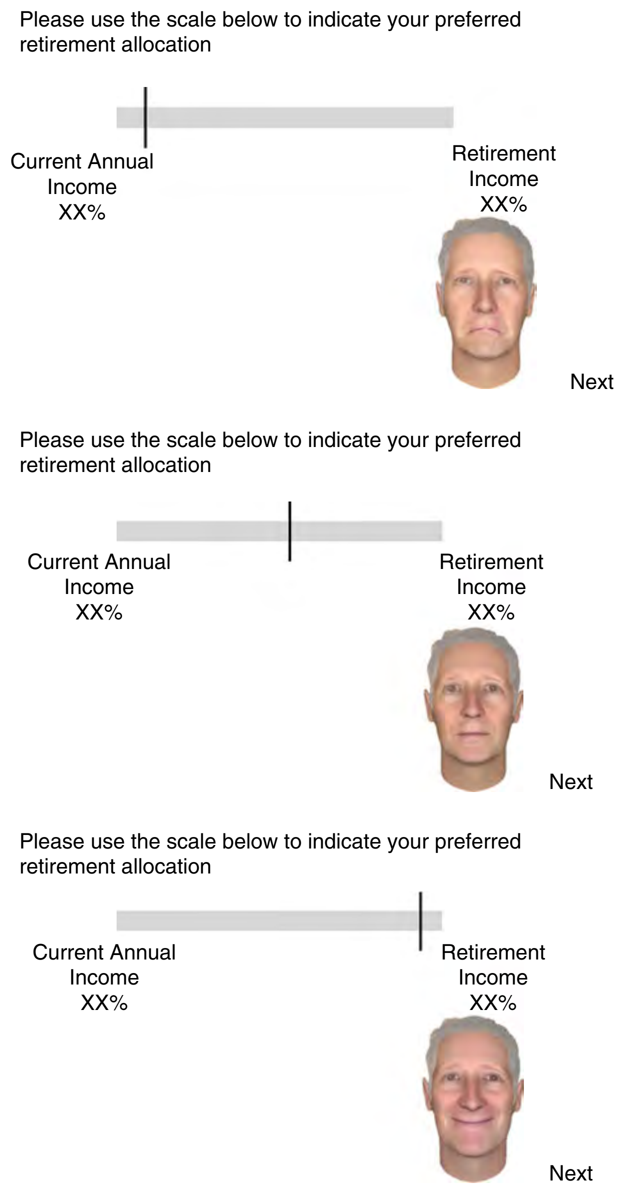


Figure 4
THE POSITION OF THE SLIDER AFFECTS FACIAL EXPRESSIONS IN THE PHOTOS DISPLAYED IN STUDY 3A



Notes: The position of the slider affects facial expressions in the photos displayed in Study 3a. This figure depicts the future self condition. As the slider moves to the left (top third), the future face becomes sadder, consistent with having less money in retirement. When the slider is in the middle (middle third), the future face has a neutral expression. As the slider moves to the right (bottom third), the future face becomes happier.

future face. We provide information on the behavior of the *present* face as follows: When the present face is displayed, it becomes happier as the slider moves left (and present income increases) and sadder as the slider moves right (and present income decreases). However, in the future self condition, the future self face becomes sadder as the slider moves left (and retirement income decreases) and happier as the slider moves right (and retirement income increases). Both percentages are always visible to participants in both conditions. Because these percentages provide detailed information about the trade-offs of saving and should reduce participants' uncertainty about the material consequences of saving, estimates of treatment effects should be conservative and relatively isolated from the effect of uncertainty. In practice, savers are not able to estimate their future income levels as easily as with the decision aid, so the persuasive effect of the faces may also be conservative relative to what would be obtained in the field. In addition, to control for other factors that might bias the results, we asked participants to complete two scales.

MacArthur Scale of Subjective Social Status. We used the MacArthur Scale of Subjective Social Status (Adler et al. 2000) to capture participants' socioeconomic status (SES). The scale is in a pictorial format, presents a ten-runged "social ladder," and asks participants to click on the rung on which they believe they stand in relation to other people in the United States. Scores on the ladder have been predicted by employment grade, education, household and personal income, household wealth, satisfaction with standard of living, and feelings of financial security (Adler et al. 2008) (M = 7.08, SD = 1.70).

Perceived income stability. To assess participants' beliefs about their future careers, we asked them to report how stable they believed the income flow would be in their future careers. They rated this on a five-point scale (M = 3.83, SD = .90).

Method

Participants. Participants were 42 students (22 women; M = 21.00 years) who were recruited from a university subject pool and agreed to participate in a study on decision making for a $15 Amazon.com gift certificate. Participants were randomly assigned to one of two groups: future self (n = 21) and current self (n = 21).

Procedure. In the second phase of the study, three to four weeks after the participants were photographed, all participants received an e-mail inviting them to complete the study online. The URLs in the e-mails were customized so that participants saw their own photos. Participants were given instructions on how the slider bar would affect current and future income and how to interpret the numbers at each end of the slider, after which they read a variant of the following sentence modified to reflect whether they would see their present face or future face: "Additionally, you will see a virtual image of yourself *now* (at retirement age), to clarify how the movements of the slider affect your *income while you are working* (future income)." The next web page contained a four-alternative multiple-choice question testing comprehension of the relationship between the slider bar movement and the amounts of present and future income. Participants failing to answer the question correctly were directed back to the instruction pages until they passed the test.

At this point, participants were presented with the decision aid. To avoid anchoring effects, the slider did not have a visible handle set to any point. Instead, a vertical line intersecting the slider appeared when the mouse hovered over the slider bar. The hovering point of the mouse determined the continuously updated current and retirement income percentages as well as the facial expression (from happy to sad), according to condition. When participants clicked on the slider bar, a gray line appeared to mark their last active choice, and they were given the option to submit this choice or to continue exploration. On submission, the slider bar position and sequence of clicks were recorded to the database.

After the retirement allocation task, participants completed a demographics questionnaire (in which they answered questions about sex, age, and race/ethnicity), the MacArthur Scale of Subjective Social Status, and the perceived income stability item. Participants were debriefed by e-mail.

Results and Discussion

Retirement allocation. We compared the effect of condition (current self or future self) on retirement allocation.[1] In line with our prediction, participants in the future self condition allocated a significantly higher percentage of pay to retirement ($M = 6.76\%$, $SD = 1.68\%$) than participants in the current self condition ($M = 5.20\%$, $SD = 2.35\%$; $t(38) = 2.38$, $p = .023$, $d = .771$). Although the effect size for this result is medium, the difference between conditions of 1.56 percentage points is practically quite significant.

Potential moderators. Because previous research has demonstrated that both SES (Grable 2000; Henry 2005) and income stability (Bajtelsmit and Bernasek 2001) affect retirement allocation decisions, we independently tested the moderating role of these variables. Following Judd and Kenny's (2010) recommendation, we first centered all predictor variables and created interaction terms by taking the product of condition and SES and the product of condition and perceived stability. The results indicated that neither SES (condition × SES interaction; $\beta = .24$, $t(36) = .99$, $p = .33$) nor perceived income stability ($\beta = -.15$, $t(36) = -.83$, $p = .41$) was a significant moderator, and condition remained a significant, positive predictor of retirement allocation when we controlled for SES ($\beta = .36$, $t(36) = 2.33$, $p = .025$) and perceived income stability ($\beta = .36$, $t(36) = 2.27$, $p = .029$).

STUDY 3B: STRONGER TEST OF GENERALIZATION TO FIELD CONDITIONS

In Study 3b, we attempted to rule out an alternative explanation for the findings from Study 3a. That is, it might be that instead of the results being due to exposure to the future self, they are due to participants reacting to the valence of the different faces. Rather than being motivated to save more by the presence of the future self, participants could have merely been moving the retirement slider bar toward whichever face was smiling. To correct for this potential confound, we conducted an additional experiment that was identical to Study 3a, except that instead of presenting participants with emotional images of their current or future selves, we exposed them to neutral versions of these selves (i.e., faces that neither frowned nor smiled).

Study 3b had two additional purposes. First, to ensure that the results from the first three studies were generalizable, participants in Study 3b were adults from a national online pool (as opposed to undergraduate students from a university). Second, we examined a potential mechanism that could underlie the relationship between exposure to the future self and enhanced saving behavior. Because impoverished intertemporal decision making has been linked to a lack of continuity with one's future self (Bartels and Rips 2010; Ersner-Hershfield et al. 2009), we assessed whether the present manipulation would actually boost continuity with that self. To do so, we gave participants the Future Self-Continuity Scale (Ersner-Hershfield et al. 2009). We hypothesized that participants exposed to images of their future selves would allocate more current income to retirement and report a greater sense of continuity with their future selves. We further hypothesized that future self-continuity would act as a mediator between experimental condition and retirement allocation.

Method

Future Self-Continuity Scale. The Future Self-Continuity Scale, which is based on Aron, Aron, and Smollan's (1992) Inclusion of the Other in the Self Scale, measures the degree to which participants feel similar to their future selves. Participants pick a pair of Euler circles (out of a possible seven pairs) that best represents how similar they feel to their future selves in ten years' time (for a more detailed description, see Ersner-Hershfield et al. 2009). Higher scores indicate more continuity with one's future self.

Participants. Participants were 40 adults of U.S. nationality aged 18 to 35 (22 women; $M = 26.27$ years) who were recruited from the Mechanical Turk online community and agreed to participate in a study on virtual reality in exchange for $11. The study comprised two parts. In the first part, potential participants submitted photographs of themselves holding up a sign that displayed the current date and time. This helped verify that the photos were indeed those of the participants and not stock photos. A few weeks later, in the second part, the 56 participants who submitted acceptable photos were randomly assigned to either the future self or the current self groups. The response rates did not differ significantly by condition (68% in the future self condition vs. 75% in the current self condition; $\chi^2(1, N = 40) = .35$, $p = .55$). During the experiment, we administered a question to ensure that participants understood the task instructions; one participant from each condition failed this test. Our final sample contained 18 participants in the future self condition and 20 in the current self condition.

Procedure. The experimental procedure was identical to that of Study 3a except for three key differences. First, participants uploaded their photos instead of being photographed in person. This helps ensure that a wide range of photos can be used for this type of treatment in the field. Second, and most important, instead of seeing an image of their current or future self that changed emotional expression as a function of their retirement allocation decision, participants saw a fixed image of their current or future self that maintained a neutral expression. That is, as participants altered their retirement allocations, the facial expression on the image of their current or future self (depending on the condition) did *not* change. Third, participants also completed the Future Self-Continuity Scale. Thus, we wanted to determine whether the result of Experiment 3a would

[1]Two participants from the future self condition were outliers in that they made a retirement allocation that was more than 1.5 times the interquartile range of all responses, and thus we excluded them from further analysis.

replicate (1) without the faces having emotional expressions, (2) with photos taken in a variety of conditions, and (3) with a national sample of participants.

Results

We compared the retirement allocations of the present self and future self conditions. In line with our prediction, participants in the future self condition allocated a significantly higher percentage of pay to retirement (M = 6.17%, SD = 2.30%) than participants in the current self condition (M = 4.41%, SD = 2.44%; $t(36) = 2.28$, $p = .029$, $d = .742$). As in Studies 1, 2, and 3a, exposure to an age-progressed rendering of the future self led to an increase in saving behavior.

Participants in the future self condition also reported a higher level of continuity with their future selves (M = 4.39, SD = 1.61) than participants in the current self condition (M = 3.25, SD = 1.92; $t(36) = 1.97$, $p = .057$, $d = .64$). Furthermore, we found evidence for mediation: When we regressed allocation percentage on condition and future self continuity, the direct effect from condition to retirement became nonsignificant ($\beta = .235$, $t(35) = 1.54$, $p = .134$), while future self continuity remained a significant predictor of retirement allocation ($\beta = .384$, $t(35) = 2.51$, $p = .017$). Preacher and Hayes's (2008) bootstrapping procedures establish that this mediation is indeed significant—the bias-corrected confidence interval (CI) of the bootstrapping mediation test did not include zero ($CI_{95\%} = .0757$, 1.5731; N = 38; 10,000 resamples).

GENERAL DISCUSSION

This work represents the first demonstration of a new kind of intervention in which people can be encouraged to make more future-oriented choices by having them interact with age-progressed renderings of their own likenesses. In four separate studies, using both undergraduate students and community members as participants, we provide evidence that manipulating exposure to visual representations of one's future self leads to lower discounting of future rewards and higher contributions to saving accounts. Moreover, Study 2 shows that these effects are not due to thinking about aging *per se* or to demand effects, but rather can arise simply from direct exposure to renderings of the future self. Studies 3a and 3b demonstrated that effects of this type may be able to translate to the field at low expense. The findings were modest with medium to large effect sizes (Cohen 1988) and were consistent across the four studies in the predicted direction. We set out to explore and test a novel methodology, and thus the results should be interpreted as preliminary. However, given the U.S. situation of low saving rates and increasing life expectancy, the results are encouraging and have a managerial implication: When people make important long-term decisions, vivid representations of their future selves should increase their future orientation of saving decisions.

This visual intervention may in some sense address the failures of belief or imagination about which Parfit (1987) wrote. Study 3b demonstrated that exposure to an image of one's future self increases continuity with that future self. However, we still do not fully understand all the underlying psychological processes that are affected by our manipulations, and there is much research to be done on this topic. It might be that exposure to the future self causes more parity in emotional experiences between the current self and the future self. As we noted previously, research on the hot–cold empathy gap (Loewenstein, O'Donoghue, and Rabin 2003) suggests that the emotions a person feels in the present are much stronger than the emotions he or she *expects* to feel in the future. Such empathy gaps are not borne out by experience: Most similarly valenced emotional occurrences take on a similar profile whether they occur today or in five years. Thus, a reason people make unwise intertemporal choices is that they erroneously allocate too much weight to the feelings of the seemingly more emotional current self and not enough to the future self. Our manipulation could work by helping consumers recognize that the future self will be just as emotional as the current self is. Alternatively, the effectiveness of our manipulation may rest in its ability to force consumers to temper the emotions they feel in the present to make them more in line with those they expect to feel in the future.

It is also possible that our manipulations were successful in part because they were considerably more engaging than traditional interventions. To the extent that consumers are more likely to follow through on self-control tasks that are fun and engaging (Laran and Janiszewski 2011), manipulations such as ours that rely on age-progression visualizations may, in addition to enhancing connectedness with the future self, make thinking about saving for retirement a more entertaining and compelling endeavor. A better understanding of the underlying process would inform future interventions aimed at helping people save more for retirement.

Limitations and Future Directions

Hypothetical exercises. We used novel technology—immersive virtual reality and realistic age-progression software—to assist the imagination. The theoretical foundation on which we based our hypotheses, however, does not necessarily suggest that people must *see* representations of their future selves. Parfit (1987), Schelling (1984), and Loewenstein (1996) simply claim that future focus will increase to the extent that a person is aware that his or her future self is a living, breathing individual who is dependent on the choices of the current self. We predicted that using immersive virtual reality and realistic age-morphing software would be a particularly compelling and effective method because it does not rely on differences in imagination abilities; age-progression software and immersive virtual reality can make the future self more realistic regardless of a person's ability to envision the future. Nevertheless, it possible that hypothetical exercises that bring the future self into one's mind (e.g., composing a letter to the future self) are also effective at increasing long-term saving behavior. We discussed how imagination differs from interacting with renderings, and further research could test whether such differences matter.

Temporal duration of effects. In all four studies, participants made intertemporal choices either during or shortly after exposure to their future selves (or current selves). As such, the temporal duration of our manipulations remains unknown. However, we believe that the most important practical application of future self saliency manipulations occurs in the actual decision-making moment. Indeed, the decision of how much of a paycheck to allocate to a 401(k) is normally made once and is rarely revisited (Benartzi and Thaler 2007; Madrian and Shea 2001; Samuelson and Zeckhauser 1988). Thus, the moment a person makes an intertemporal choice is arguably the most important time to consider the interests of the future self. To this end, in ongoing work, we are exploring the effectiveness of using the slider bar paradigm from Studies 3a and 3b to aid real employees when they are making their retirement decisions. This endeavor will help us determine whether decisions made on the hypothetical retirement allocation task from Studies 3a and 3b translate to incentive-compatible rewards. (Previous research has demonstrated that discounting rates of real versus hypothetical rewards show similar patterns [Coller and Williams 1999].)

Age differences in effectiveness of manipulation. Similarly, in the studies, we used a relatively young sample of research participants. This choice was deliberate because the optimal time to begin saving for retirement is early in life (Bernheim, Skinner, and Weinberg 2001). It is unclear, however, whether vivid exposure to the future self would hold such powerful effects for older consumers (Yoon, Cole, and Lee 2009).

Generalizability of novel technology. One final limitation of the current work is that we relied on technology that is not readily available. However, the use of avatars and virtual worlds is accelerating greatly. Game platforms, such as Nintendo's *Wii* and Microsoft's new *Kinect*, are transforming the realm of home entertainment into an immersive experience, and as a result of the recent success of three-dimensional movies, such as *Up* and *Avatar*, new stereo displays will be available for consumers to purchase in 2011 (Blascovich and Bailenson 2011). Technology's development is accelerating, and the notion of people interacting through avatars with their bank accounts or financial planners is not an outlandish one. The intervention in Studies 3a and 3b requires only a camera and a connection with the Internet, both of which can be found on many smartphones and other portable web-enabled devices. Similar face-rendering applications already exist; they require the user to upload a photo and wait approximately ten seconds for a result. On the iPhone platform, for example, one application allows a user to upload a photo taken with his or her phone and then instantly see what he or she would look like after gaining roughly 100 pounds. Nonetheless, given the general difficulty that most employers have in encouraging employees to sign up for benefits programs, implementing the interventions from Studies 3a and 3b on a mass-scale would by no means be a simple endeavor.

Conclusion

Because of the confluence of increasing life expectancy, a weakened economy, and a large number of underprepared households, persuading consumers to save more for retirement is an issue of great economic importance. To complement interventions that emphasize or deemphasize the appeal of present and future rewards, the current work operates on another distinction—that between present and future selves—to increase saving for the future.

APPENDIX: THE USER INTERFACE

The user is asked to give his or her sex. All other parameters are set by the software. The setting is one in which the user has one decision variable: the percentage of gross salary to be contributed to a 401(k) plan each year. The user chooses this percentage by moving a slider. The leftmost position involves no such contribution. The effect is shown by a number or picture representing the average percentage of net income to gross income during the working years. The net income is gross income less employee contributions for social security and Medicare and contributions to the 401(k) plan.

The output of the financial model is the ratio of net retirement income in the first year of retirement to the gross income in the year before retirement. This is shown by a number or picture on the right. As the slider moves right, the ratio for the working years falls and the ratio for the retirement years rises.

Preretirement Assumptions

The user is assumed to be 22 years old, to start work at 23, to have saved $5,000 already, and to retire at age 68. All calculations are in real terms. The user is assumed to have a salary history that follows a path consistent with the cross-section of average earnings for year-round workers in the United States and an annual progression of average real wages of 1.1% per year (consistent with the intermediate projections of the U.S. Social Security Administration). The assumed path is calibrated to reach a real value of $64,000 per year when the worker is age 40.

The position of the slider determines the user's desired contribution to a 401(k) plan, expressed as a percentage of salary. His or her employer is assumed to provide a contribution equal to 50% of the user's contribution, up to 6% of salary, the most common formula used by employers in the United States. The employee's contribution is capped at a real amount equal to $16,500 in real terms, increased by 1.1% per year, on the assumption that the law is changed to keep up with real wages.

During the working years, salary is reduced by deductions for Social Security and Medicare. The former is equal to 6.2% of employee pay up to a cap that starts at $106,800 and is assumed to increase in real terms by 1.1% per year. The latter is assumed to equal 2.9% of salary in every year.

Postretirement Assumptions

When the worker retires, income is assumed to come from Social Security payments less the Medicare deduction plus money received from an annuity purchased at retirement with the proceeds from the 401(k) fund.

The Social Security benefits are based on the average indexed Social Security earnings for the 35 highest years of contributions. The formula includes two breakpoints that are assumed to increase in real terms during the user's working life by the assumed real wage growth rate of 1.1%. From this amount, a constant real value of $1,152 is deducted each year to cover Medicare costs after retirement.

Contributions to the 401(k) account during the working years are assumed to earn an annual riskless real rate of interest of 2.5%. This falls between the real rate assumed in Social Security projections (2.9% in 2009) and typical rates on long-term Treasury Inflation Protected Securities (slightly under 2% in mid-2010). With these assumptions, the real value of the account when the user reaches retirement age is calculated. The proceeds are assumed to be used to purchase a single-person real annuity, priced using the Society of Actuaries' Table RP-2000 mortality assumptions, a real rate of interest of 2.5%, and a 15% surcharge for costs and compensation for mortality table risk.

Finally, real retirement income for the first postretirement year is computed by adding to the 401(k) annuity income the Social Security benefit and subtracting the Medicare deduction. This is divided by the real salary for the last working year to provide the value for the right-hand side of the slider.

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