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INITIAL EXAMINATION OF PRIMING TASKS TO DECREASE DELAY DISCOUNTING

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Dr. Sheffer developed the study concept and led the study team. All authors contributed to the study design and the development of the priming stimuli and tasks. Ms. Fernandez, Ms. Pittman and Ms. Panissidi prepared the data and scored the tasks with the assistance of Ms. Mathews and Mr. Williams. Dr. Sheffer performed the data analysis. Drs. MacKillop, Franck, and Christensen contributed the data analysis. All authors provided critical revisions. All authors approved the final version of the manuscript for submission.

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Abstract

Steep discounting of delayed rewards is linked with a variety of unhealthy behaviors that contribute to the major causes of preventable death and disease. Growing evidence suggests that decreases in delay discounting contribute to healthier preferences. This study sought to provide preliminary evidence for the viability of developing a brief priming task to reduce delay discounting in a large, diverse group of individuals. Participants ($n=1,122$) were randomized to one of three conditions: Future Focus (FF), Present Focus (PF), and Non-Temporal Focus (NTF) intended respectively to decrease, increase, or have no effect on delay discounting. Participants then completed the Monetary Choice Questionnaire, a brief assessment of delay discounting rate. Participants randomized to FF exhibited significantly lower discounting rates than those randomized to PF or NTF conditions. Race, Hispanic background, social self-monitoring, education, and cigarette smoking also accounted for a significant amount of variance in the discounting model. These findings provide support for the development of a brief priming intervention that might be examined in clinical or public health contexts to decrease discounting and support healthy choices.

Modifiable health behaviors are the leading causes of mortality in the United States today (Mokdad, Marks, Stroup, & Gerberding, 2004). Steep delay discounting (i.e., the rate at which one “de-values” a reward as a function of the amount of time to the receipt of the reward) is increasingly recognized as a trans-disease process and a biomarker for a wide variety of health risk behaviors (Bickel, 2012; Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012; Bickel & Mueller, 2009; Rachlin, Raineri, & Cross, 1991), including tobacco, drug, and alcohol abuse as well as overeating, risky sexual behaviors, and even the use of sunscreen and automobile seat belts (Bickel, Jarmolowicz, Mueller, Koffarnus, et al., 2012; Bickel & Mueller, 2009; Johnson & Bruner, 2012). The associations among delayed discounting rates and health risk behaviors are incremental, such that small decreases in discounting rates are associated with decreases in the frequency of risky behaviors as well as increases in the probability of successful treatment (Bickel, Jarmolowicz, Mueller, Koffarnus, et al., 2012; Bickel, Landes, Kurth-Nelson, & Redish, 2014; Bickel & Mueller, 2009; Bickel, Quisenberry, Moody, & Wilson, 2015; Sheffer et al., 2012; Stanger et al., 2012; Yoon et al., 2007). The range of influence of steep discounting on risky health behaviors is so large that interventions that could positively affect the valuation of long-term rewards, even with minimal effect sizes, could potentially have a significant impact on clinical approaches and population health.

Successful efforts to decrease delay discounting include intensive interventions such as working memory training (Bickel, Yi, Landes, Hill, & Baxter, 2011), contingency management treatments for substance use disorders, (Black & Rosen, 2011; Landes, Christensen, & Bickel, 2012; Yi et al., 2008) and stimulation of the dorsal lateral pre-frontal

cortex.(Cho et al., 2010; Sheffer et al., 2013). Less intensive interventions include evoking future thinking by developing subject-specific future events (Peters & Buchel, 2010), and re-framing choices to emphasize the implicit zero (e.g., Instead of asking “\$10 today OR \$15 in 30 days,” the choices become “\$10 today and \$0 in 30 days OR \$0 today and \$15 in 30 days”)(Magen, Dweck, & Gross, 2008; Radu, Yi, Bickel, Gross, & McClure, 2011). Discounting rates are also lower when delayed options are aligned to specific dates (Read, Frederick, Orsel, & Rahman, 2005). See Koffarnus et al.(Koffarnus, Jarmolowicz, Mueller, & Bickel, 2013) for a review of these efforts.

Priming is a well-established implicit memory phenomenon whereby exposure to specific stimuli influences responses to later stimuli in a predictable manner (Bargh & Williams, 2006; Meyer & Schvaneveldt, 1971; Meyer & Schvaneveldt, 1976; Meyer, Schvaneveldt, & Ruddy, 1974; Schvaneveldt & Meyer, 1976). Priming has been used to change a wide variety of complex social attitudes and behaviors, such as stereotypes, helping behaviors, opinions, and goals, but has not, as yet, been used to change delay discounting (Bargh & Williams, 2006; Carlson, Charlin, & Miller, 1988; Wheeler & Petty, 2001). The effects of priming appear to be associated with neural activation among related ideas in implicit memory and can manifest without engaging awareness; however, self-concept appears to have a particularly important role in the long-term acquisition of prime-to-behavior effects (Wheeler, Demarree, & Petty, 2007). The duration of the effects of priming tasks depends on the strength and type of priming stimuli. For instance, in a word completion task, the duration of semantic language priming is longer than non-semantic priming. Single word semantic priming has been shown to have word completion effects four days(Squire, Shimamura, & Graf, 1987), but repeated, powerful priming stimuli in the environment appear to contribute to the development of long-term attitudes (e.g., stereotyping) and goals (Bargh, Chen, & Burrows, 1996; Bargh & Williams, 2006).

According to the active-self account of prime-to-behavior effects, priming stimuli initially change behavior by affecting the active self-concept, the aspect of the self that shifts rapidly to respond to external stimuli (DeMarree, Wheeler, & Petty, 2005; Wheeler, et al., 2007). The long-term effects of priming, however, are mediated by self-monitoring, which is the degree to which individuals conform to situational demands (Wheeler, et al., 2007). High self-monitors change their attitudes and behaviors to conform to changing situations and are largely unaffected by perceived attitudinal or behavioral inconsistencies (Snyder & Swann, 1976; Snyder & Tanke, 1976). Low self-monitors change their attitudes and behaviors based on self-concept and are thus less likely to conform to changing social situations (Snyder & Swann, 1976; Snyder & Tanke, 1976). Nonetheless, low self-monitors view their own behaviors as important information about themselves and thus are more likely to modify their active self-concept to be consistent with their behavior if they believe they have acted inconsistently (DeMarree, et al., 2005; Wheeler, et al., 2007; Zanna, Olson, & Fazio, 1980). Low self-monitors show greater long-term prime-to-behavior effects than high self-monitors because they perceive the initial changes caused by the prime to be feedback about themselves and tend to incorporate this feedback into a modified active self-concept (e.g., “I behaved in this way, therefore I have these characteristics.”)(Wheeler, et al., 2007) Although many priming stimuli will activate the same behavior in many people, prime-to-behavior effects also can be idiosyncratic because the priming stimuli or the primed behavior are

sometimes related to idiosyncratic self-related constructs in the active-self (Wheeler, et al., 2007). Accordingly, prime-to-behavior effects might be affected by significant social identity categories such as sex/gender, race/ethnicity, partnered status, subjective social status, education, household income, etc.

Brief, precise interventions that change very specific psychological processes to improve individuals' outcomes have recently been dubbed "wise interventions" (Walton, 2014). Examples include: altering noun/verb wording in statements in a survey to increase voter turn-out (Bryan, Walton, Rogers, & Dweck, 2011), abstract re-framing of a compliment to improve relationships among those with low self-esteem (Marigold, Holmes, & Ross, 2007), engaging mothers in a specific line of questioning to decrease infant abuse (Bugental et al., 2002), and having couples use the third person perspective to reduce marital conflict (Finkel, Slotter, Luchies, Walton, & Gross, 2013). Wise interventions putatively work by targeting recursive processes associated with self that unfold over time. For instance, in a seminal example, students ranked 18 values, typically ranking freedom higher than equality. In the intervention condition, the meaning of the process of ranking these values was made explicit by explaining that ranking freedom above equality means that they "care a great deal about their own freedom but are indifferent to other peoples' freedoms." The students in the control condition simply completed the ranking. Seventeen months later, the students in the intervention condition were more likely to express support for the civil rights of African Americans (Rokeach, 1971). A wise intervention, using priming stimuli, might conceivably be developed to decrease delay discounting rates. The practical application of such an intervention could have broad clinical and public health applications. Clinically, individuals could be repeatedly provided with wise interventions to increase the perceived value of long-term rewards, improve health behaviors, and/or enhance treatment outcomes. Likewise, populations could be systematically presented with messages and/or activities that increase the perceived value of long-term rewards.

Delay discounting, however, is influenced by a variety of social and cultural influences including assessments of risk and attitudes toward time (Hsee, 1999; Weber & Hsee, 1999). Delay discounting is negatively associated with relative prosperity (Epstein et al., 2014), age (Green, Myerson, & O'Staszewski, 1999; Steinberg et al., 2009), income (Green, Myerson, Lichtman, Rosen, & Fry, 1996), education (Jaroni, Wright, Lerman, & Epstein, 2004), and socioeconomic status, particularly the socioeconomic status of childhood (Griskevicius, Tybur, Delton, & Robertson, 2011; Sweitzer, Donny, Dierker, Flory, & Manuck, 2008; Sweitzer et al., 2012), but little evidence links delay discounting rates to significant social categories such as sex/gender and race/ethnicity. Preliminary evidence supports a sex/gender difference in the comparative valuation of sex and money over time among stimulant dependent individuals (Jarmolowicz et al., 2014). Whites appear to discount less than African Americans and Hispanics in the US, but these differences were only found among gamblers and college students (Andrade & Petry, 2014; De Wit et al., 2007; Dennhardt & Murphy, 2011). Among some graduate students in the US, American and Chinese students discounted more than Japanese students (Du, Green, & Myerson, 2002). Others have found Americans to discount more than Koreans (Kim, Sung, & McClure, 2012). Increased discounting is strongly linked with tobacco and alcohol use, two relatively common risky behaviors (Bickel, Jarmolowicz, Mueller, Koffarnus, et al., 2012).

The goal of this study was to provide initial evidence for the development of a wise intervention using priming stimuli to decrease delay discounting in a relatively large, diverse group of individuals. In addition to the experimental condition focused on increasing the value of future thinking, participants were randomized to a neutral control condition and an active control condition focused on present thinking. The hypotheses were as follows: 1) Individuals randomized to Future Focus (FF) stimuli will demonstrate significantly lower discounting rates than individuals randomized to Present Focus (PF) or Non-Temporal Focus (NTF) stimuli. 2) Individuals randomized to PF stimuli will demonstrate significantly higher discounting rates than individuals randomized to FF or NTF. 3) Self-monitoring will account for a significant proportion of the variance associated with the relationship between the independent and the dependent variables. Because the relations between delay discounting and the conditions are likely to be affected by sociodemographic factors, time perception, and whether or not individuals engage in risky health behaviors, and the effect of the conditions might be obscured by significant group effects, we included variables representing these factors in the model used to examine the relationship between the intervention and delay discounting.

These hypotheses were tested using a crowdsourcing cohort from Amazon Mechanical Turk (MTurk), an online worker market. MTurk is increasingly being used as a research tool to access a widely diverse population (~N=200,000) of willing participant workers (Gosling, 2011; Mason & Suri, 2012; Paolacci, Chandler, & Ipeirotis, 2010; Ross, Irani, Silberman, Zaldivar, & Tomlinson, 2010). MTurk participant responses are comparable to that of laboratory subjects (Paolacci, et al., 2010) and demographic analyses show that MTurk participants are more representative of non-college participant populations than traditional samples of psychology participants (Gosling, 2011). Nonetheless, the MTurk population tends to be younger, have more education, and be more likely to be female than the population of the US (Ross, et al., 2010). MTurk has been successfully used to examine discounting rates in the past (Bickel et al., 2014; Bickel et al., 2012; Herrmann, Johnson, & Johnson, 2015; Jarmolowicz, Bickel, Carter, Franck, & Mueller, 2012; Johnson, Herrmann, & Johnson, 2015). For the purposes of this study, MTurk was ideal because an Internet platform is a likely modality for wide dissemination of a brief priming intervention.

METHOD

Priming Stimulus Development

The FF, PF, NTF priming stimuli were developed by the research team. Team members (CES, AF, LP, JW, MM) compiled lists of 20–30 candidate words for each condition. The lists were presented to experts in delay discounting who were not involved in the initial word selection (WKB, JM, DC, MWJ). The experts chose 10 words or phrases either by selection from the list or adding candidate words or phrases that they judged to best reflected the intention of the condition. A final list of 10 words for each condition was developed by reconciling the recommendations from each of the experts in the final round. The FF condition stimuli were: “future,” “self-discipline,” “willpower,” “discipline,” “restraint,” “self-control,” “long-term,” “save,” “planned,” and “investment.” The PF condition stimuli were: “impulsive,” “immediate,” “now,” “here and now,” “spontaneous,” “living in the

present,” “instant,” “fast,” “present,” “spur of the moment.” The NTF condition stimuli were: “pale,” “drab,” “informative,” “patriotic,” “detached,” “dispassionate,” “middle of the road,” “disinterested,” “loud,” and “formal.”

The tasks that provided exposure to the priming stimuli was intended to be interactive and to engage the active self. The instructions were: “Please read each of these words or phrases out loud and select each one. Please write each word on a piece of paper. You will need to use each word in the next step and you will not see this list again. Make sure you copy each word down on a piece of paper before you move forward.” Participants were required to click on a box next to each word in order to move forward. Participants were then presented with the sentence-writing task instructions and a text box for submission: “Please write 10 different sentences describing yourself using the words in the list of words you just read and copied down. Each sentence needs to include at least one of the words on your list. Be sure that each sentence uses the word describing yourself. Example: if the word is ‘concerned’ the sentence can be, ‘I am concerned about...’ or if the word is ‘proud’ the sentence can be ‘I’m not proud...’.” After submitting the sentences, they were presented with instructions for the final task: “Please use the 10 words given previously to write a short paragraph describing yourself. Please be sure to describe yourself only. Use each of the 10 words on your list in the paragraph. The sentences in the paragraph must be different from the ones that you just wrote in the task above.”

Participants and procedures

This study was approved by the Institutional Review Board at The City College of New York. Participants were recruited through MTurk, an online worker marketplace. (Buhrmester, Kwang, & Gosling, 2011; Ross, et al., 2010) Inclusion criteria were intended to be broadly inclusive of English-speaking, North American adults, aged 18 and over. Once consented, participants were presented with a link to a secure, online data collection and research tool for the administration of the measures, Qualtrics. Participants completed the measures, were randomized to a condition, were exposed to the corresponding priming stimuli, completed the delay discounting outcome measure, and were compensated \$2.00 in one online session. Data were collected in January of 2015.

Trained research assistants reviewed the sentence-writing and paragraph-writing tasks for degree of completeness with the overall objective of the tasks in mind (i.e., for participants to apply concepts to self-concept). The task was viewed as being comprised of 20 units which included 10 in acceptable sentences and 10 words used acceptably in a paragraph. A word in a sentence was acceptable if present and reflected self-reference. For instance, an acceptable sentence would be, “I impulsive” or “I like spur of the moment trips.” An unacceptable sentence would be, “My friend spur of the moment trips.” The percentage complete was calculated by the first reviewer (AF). random sample of 10% of participants was selected and independently reviewed by a second (JP) third (LP) reviewer. The inter-rater correlation in percent complete scores was .82. Percent complete was added to the model as a covariate to account for a proportionate effect of completing than 100% of the model.

Measures

Demographic characteristics included age, sex/gender, race, ethnicity, partnered status, educational level, household income, country, zip code, number of cigarettes smoked on a usual day, forms of tobacco use, and number of alcoholic drink per week.

MacArthur Scale of Subjective Social Status (SSS)—The SSS presents a 10-rung ladder to participants with instructions to imagine that it represents where people stand in society. Higher rungs represent higher status (e.g., more money, more or better education, better jobs). Participants were to select a rung that best represents where they think they stand right now. The responses reflect discrete continuous variable ranging from 0–10. (Adler, Epel, Castellazzo, & Ickovics, 2000; Reitzel al.)

Time Perspective—Temporal perspective was assessed with one item from the Fong and Hall Perspective Questionnaire (TPQ), “You spend a lot of time thinking about how what you do will affect your life and your future.” Response options range from strongly agree to strongly. Strongly agree and agree were coded as future oriented; disagree or strongly disagree were as not future oriented. (Fong & Hall, 2003; Hall et al., 2012; Sansone et al., 2013)

Self-Monitoring Scale (SMS)—The SMS is a 25 item instrument that assesses the degree to individuals consciously conform to social influences. Respondents are asked to respond to self-referential statements as “True” if it is true or mostly true about them and “False” if it is false or false about them. Example statements include: “I find it hard to imitate the behavior of other people,” and “I can only argue for ideas I already believe.” Scores range from 0 to 25. SMS scores are categorized as high = 15–25; intermediate = 9–14; low = 0–8. (Ickes & Barnes, 1977) One month test-retest reliability is .83. (Snyder, 1974)

Monetary Choice Questionnaire (MCQ)—Delay discounting rates were assessed with the MCQ, a 27-item questionnaire in which participants are asked to choose between smaller rewards offered sooner and larger rewards offered later. (Kirby & Marakovic, 1996; Kirby, Petry, & Bickel, 1999) Items include choices such, “Would you prefer \$54 today, or \$55 in 117 days?” and “Would you prefer \$55 today, or \$75 in 61 days?” The MCQ provides three sets of 9 questions based on the magnitude of the award (i.e., small (\$25, \$30, \$35), medium (\$50, \$55, \$60), large (\$75, \$80, \$85)) yielding small, medium, and large magnitude discounting rates. Discounting rates tend to be well-described by a hyperbolic function, $V = A/(1+kD)$ where V is the value of the delayed reward A at delay D and k is the discount rate (Mazur, 1987). Traditionally, items are scored using an algorithm that provides an estimate of participants’ k which is transformed by the natural or base-10 log of k for analysis. In this study, individual cases’ k -parameters were estimated using the method described in Kirby et al. (1999). The MCQ includes a range of nine k -parameters associated with item choices. Individuals’ are assigned a range of k -parameters consistent with their choices. An individual’s k -parameter is estimated as the geometric midpoint of the range. Alternatively, the MCQ can be scored by calculating proportionate choice, the proportion of delayed choices within each magnitude. Recent research indicates that the k -parameter is negative and strongly correlated with proportionate choice ($r_s > -.97$). (Myerson,

Baumann, & Green, 2014) The proportionate choice value also tends to be well distributed without transformation and is more accessible in terms of application than the k -value. In this study, we used the proportionate choice parameter as the dependent variable and the medium magnitude discounting rate to avoid magnitude effects.

Data analysis

We prepared the data ($n=1,466$) by excluding cases that completed 0% of the writing tasks and/or represented attempts beyond the first attempt at the tasks ($n=167$), cases that did not complete the medium magnitude MCQ ($n=158$), and cases with consistency scores $\geq .88$ for the medium magnitude ($n=19$). We used one-way analysis of variance and χ^2 analyses to compare those participants with consistency scores $\geq .88$ ($n=1,122$) with those participants with consistency scores $< .88$ ($n=19$). Participants with inconsistent medium magnitude scores ($< .88$; $n=19$) were younger ($F(1,1136) = 5.52$, $p=.02$; $M=28.1$ (SD 6.8) years vs. $M = 34.0$ (SD 11.0) years), reported higher subjective social status ($F(1,1139) = 5.97$, $p=.02$; $M = 5.58$ (SD 1.9) vs. $M = 4.53$ (SD 1.8); were more likely to smoke 1–4 cigarettes per day ($\chi^2(4, n=1,1139) = 10.89$, $p = .03$), and were more likely to be future oriented ($\chi^2(1, n=1,141) = 5.08$, $p = .02$). In order to standardize the k parameters, we calculated the natural log of the medium k ($\ln k$). Among the final selection of participants, we also conducted a 2-tailed Pearson correlation between the medium $\ln k$ and the medium proportionate choice (delayed choices/total choices) to examine the relationship between $\ln k$ and proportionate choice in this sample.

We conducted descriptive analyses (means, standard deviations, and frequencies) and one-way analysis of variance and χ^2 analyses to determine if there were differences among participants randomized to each condition. We addressed the hypotheses with a univariate analysis of covariance with medium proportionate choice as the dependent variable; condition, sex, race, ethnicity, partnered status, annual household income, other tobacco use, and time perspective as fixed factors; and age, years of education, subjective social status, alcoholic drinks per week, number of cigarettes per day, SMS total score, and percent complete as covariates. We examined the main effects of each factor and covariate and report the F-statistic, degrees of freedom for the variable and the model, p-values, the estimated marginal means, and observed power to support continued investigations.

Exploratory analyses were then conducted to examine differences in delay discounting rates by participant characteristics. Pearson product moment correlations were calculated among the continuous variables (age, years of education, subjective social status, number of alcoholic drinks per week, number of cigarettes per day, and the self-monitoring scale) and the proportionate choice parameter to report the strength and direction of the associations. Analysis of variance was used to test for significant differences in proportionate choice by sex/gender, age, race, Hispanic background, partnered status, education, annual household income, subjective social status, alcoholic drinks per week, cigarettes per day, other tobacco use, the SMS, and future orientation.

RESULTS

All participants ($n=1,122$) reported living in US. The mean age of participants was 34.0 years ($SD\ 11.0$); 52.0% of participants were male and 79.3% were White. About half of participants (49.3%) were partnered. The annual household income ranged from less than \$14,999 (13.5%) to greater than \$75,000 (21.5%) and the mean years of education completed was 15.1 ($SD\ 3.0$) with the majority (83.3%) attending at least some college. The majority of participants saw themselves as middle class ($M=4.5$ ($SD\ 1.8$)). Nearly half reported drinking no alcohol (44.6%) and most reported smoking no cigarettes (79.2%); 11.5% used other forms of tobacco. The mean score for the SMS was intermediate, 11.0 ($SD\ 4.8$). About one-quarter (24.0%) were high self-monitors, and about one-third were low self-monitors (32.4%). About two-thirds (64.6%) considered themselves future-oriented. Participants completed a mean of 95.1% ($SD\ 11.8$) of the intervention tasks (range 5–100%, median = 55%, mode = 100%). See Table 1 for details. Consistent with previous studies, the correlation coefficient between the k -parameter and the proportionate choice parameter of the medium magnitude was negative and very strong ($r = -.99$) (Myerson, et al., 2014).

There were no significant differences among participants randomized to the FF ($n=374$), PF ($n=375$), and the NTF ($n=373$) conditions for any of the participant characteristics: sex/gender χ^2 (2, $n=1,121$) = .05, $p=.98$; age F (2, 1,115) = .10, $p=.90$; race χ^2 (6, $n=1,119$) = 5.86, $p=.44$; Hispanic ethnicity χ^2 (2, $n=1,119$) = .29, $p=.86$; partnered status χ^2 (2, $n=1,115$) = .02, $p=.99$; years of education F (2, 1,116) = 1.23, $p=.29$; last grade completed χ^2 (4, $n=1,120$) = 4.20, $p=.38$; income level χ^2 (14, $n=1,120$) = 16.32, $p=.29$; SSS F (2, 1,118) = .59, $p=.56$; cigarettes per day F (2, 1,117) = .29, $p=.75$; number of alcoholic drinks per week F (2, 1,119) = 1.81, $p=.16$; SMS F (2, 1,071) = 2.74, $p=.07$; TPQ χ^2 (2, $n=1,122$) = 4.14, $p=.13$; percent of intervention completed F (2, 1,119) = .87, $p=.42$.

Analysis of covariance

In the model, condition, race, ethnicity, education, cigarettes per day, self-monitoring, and percent complete were significant. The strength of the associations and the estimated marginal means (i.e., means adjusted for other variables in the model) are reported in Table 2. The hypotheses were partially supported. As predicted, the main effect of condition was significant, $F(2,24)=3.98$, $p=.02$. 1), and individuals randomized to the FF condition ($M=.41$, $SE=.02$) demonstrated significantly lower discounting rates than individuals randomized to PF ($M=.37$ $SE=.02$) and the NTF ($M=.37$ $SE=.02$) conditions; however, the PF and the NTF conditions produced results that were essentially identical. As predicted, self-monitoring accounted for a significant proportion of the variance, $F(1, 24) = 8.26$, $p=.004$ in the model. Among the sociodemographic and health risk behavior variables, race, Hispanic background, education, and cigarette smoking accounted for a significant proportion of the variance in the model; however sex/gender, partnered status, subjective social status, income, other tobacco use, and alcoholic drinks per week did not. Time perspective did not account for a significant amount of the variance. The proportion of the intervention that was completed accounted for a significant proportion of the variance. See Table 2 for details.

Exploratory analyses

Keeping in mind that participants were randomly assigned to condition and there were no significant differences among participants between conditions, several characteristic differences were individually associated with delay discounting rates across conditions. See Table 1. Whites and Asians and non-Hispanics discounted the least, African Americans the most. More education and higher SSS were strongly associated with lower discounting rates. No significant differences in discounting rates were found between men and women, by partnered status, by age, and by income. A greater number of cigarettes per day and other tobacco use were associated with higher discounting. The number of alcoholic drinks per week was not significantly associated with discounting rate. Self-monitoring had a significant negative relationship with delay discounting.

DISCUSSION

These findings provide evidence that a brief priming task can potentially decrease delay discounting in a large, diverse group of individuals. Priming tasks have the potential to be developed into “wise” clinical and/or public health interventions that might be used to decrease delay discounting rates. While this has not yet been accomplished, evidence suggests that interventions to decrease delay discounting have the potential to nudge health behaviors into more productive and healthy directions. If developed appropriately, interventions such as this might be offered to patients by clinicians in the context of multi-modal behavior change treatments, similar to the way in which affirmations or self-talk are used in psychology. They might also be used in health messaging, advertising, or the promotion of healthy behaviors among defined patient populations by health care insurers or other health care groups. They might also be incorporated into health messaging by public health organizations. Individuals might use these interventions as part of a self-help regime as well. If they can be applied with large, diverse groups, priming interventions might be found to be quite cost-effective.

The exploratory findings provide some evidence that some significant social groups might demonstrate characteristic differences in delay discounting, and that some of these differences appear to influence relations between priming tasks and delay discounting. Consistent with previous studies, those with the most education, Whites, Asians, and non-Hispanics discounted the least, African Americans, the most. Of note, these findings were similar to those found in the model, where other factors are accounted for. Inconsistent with previous studies, income, age, and time perspective were not significantly associated with discounting rates, even when all other factors were accounted for in the model. While a negative relationship between SSS and discounting was found, when all other factors were accounted for in the model, SSS was not significantly associated with delay discounting, so it appears that the influence of SSS might be accounted for by education or other socioeconomic factors. We found no differences in discounting rates for sex/gender and partnered status either individually or in the model. Surveys using stratified random samples are needed to indeed determine whether these important social groups demonstrate characteristic differences in delay discounting.

These findings support the broad notion that social factors such as race, Hispanic background, and educational level are strongly associated with delay discounting and need to be taken into account when developing interventions to decrease discounting. Baseline discounting rates have an effect on the potential to change discounting. Among drug dependent individuals, those with the highest discounting rates (i.e., who are potentially at greatest risk), show the greatest decreases in discounting rates after an intervention (W.K. Bickel, et al., 2014; Bickel, et al., 2015). This suggests that priming interventions to decrease delay discounting might have a larger effect on individuals with lower discounting rates which might include individuals lower educational levels, with a Hispanic background, or who identify as African American.

These findings provide initial evidence that discounting rates are positively associated with social self-monitoring. High self-monitors, compelled to change their behaviors based on social circumstances, appear to value long-term rewards less than low self-monitors. This finding suggests that self-monitoring might be a significant factor associated with variability in delay discounting rates in previous studies and might perhaps have some explanatory role in future studies. These findings have implications for the development of theoretical frameworks that explain discounting rates and health behaviors. Because self-monitoring has such a strong association with delay discounting, self-monitoring might also have strong relationship with health behaviors. If so, self-monitoring might be a new target for health risk behavior interventions.

Consistent with previous studies, cigarette smokers and other tobacco users discounted more steeply than their non-using counterparts (Murphy & Mackillop, 2012). In fact, cigarette smoking demonstrated some of the strongest association with delay discounting; however, we found no significant relationship between alcohol use and discounting.

These findings naturally raise questions about the ethics of applying interventions to individuals or communities without their consent or awareness. If developed, an appropriate and ethical manner for applying a wise intervention such as this would be to empower individuals or communities to use the intervention intentionally and with full awareness of the expected outcomes. Nonetheless, the concept of using stimuli to change health behaviors without the consent of individuals or the community is not without precedent. Advertising and even health messaging is applied to individuals and communities by profit, non-profit, and governmental organizations with the intention of changing individuals' behaviors. One might argue that there is sometimes awareness among the implementers that there will be differential effects on different social groups as well. Before the innovation proposed here is developed into an intervention, a thorough discussion of the ethics of the application would be in order.

This is an initial, formative examination into the development of a wise intervention based on priming to decrease delay discounting. As such, the findings represent a proof of concept with a number of limitations. Future research will need to obtain baseline discounting rates to rule out differences in discounting rates among the participants assigned to the conditions. Although unlikely, possibilities exist that baseline differences in discounting rates contributed to the findings in this study. Ideally, baseline discounting rate assessments would

be sufficiently separated in time from the outcome assessment to prevent carry over effects. Future research will need to provide evidence of the effects of patterns of exposure especially if the intervention is expected to have long-term effects health behaviors. These findings might be limited by the characteristics of the population of MTurk workers who participated. Applications in other groups, especially groups at highest risk for problematic health behaviors, are needed. Finally, it should be noted that the active control, the PF condition, was not effective at increasing delay discounting. We speculate that these findings might have resulted from inadequate stimulus development, or perhaps discounting is more amendable to reductions through this type of intervention or platform, or in this population. Nonetheless, the goal of the study was to decrease discounting because of the associated health benefits, but increasing discounting should also be the focus of future research because it is likely to elucidate the parameters of altering this important and modifiable characteristic.

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Highlights

- A brief, written priming task can significantly decrease delay discounting.
- Ethnic and racial groups appear to demonstrate characteristic differences in delay discounting.
- Delay discounting rates are positively associated with social self-monitoring.
- Priming interventions might be used to enhance multi-modal behavior change treatments.
- Priming interventions might be incorporated into health messaging by public health organizations.

Table 1

Participant characteristics and mean proportionate choice by category (n=1,122)

Characteristic	Range or Categories	Mean (SD) or percent (n)	Proportionate choice [^] Mean (SD)	Eta Squared or Pearson r
Sex/Gender	Male	52.0 (583)	.45 (.24)	.000
	Female	48.0 (538)	.44 (.22)	
Age (yrs)	18–77	34.0 (11.0)	.44 (.23)	r=.050
Age categories	18–25	23.7 (265)	.44 (.24)	.003
	26–31	26.7 (299)	.43 (.24)	
	32–40	26.0 (291)	.44 (.22)	
	40–77	23.5 (263)	.46 (.20)	
Race ***	White ^a	79.3 (887)	.46 (.22)	.020
	Black ^{a, b}	7.3 (82)	.33 (.24)	
	Asian ^b	7.7 (86)	.44 (.22)	
	Other	5.7 (64)	.43 (.25)	
Hispanic **	Yes	7.6 (85)	.38 (.22)	.006
	No	92.4 (1,034)	.45 (.23)	
Partnered	Yes	49.3 (550)	.45 (.22)	.001
	No	50.7 (565)	.44 (.23)	
Education (yrs) **	1–27	15.1 (3.0)	.44 (.23)	r=.146
Educational level ***	High school or less ^{a, b}	16.7 (187)	.39 (.24)	.023
	Attended college ^{a, c}	67.9 (760)	.44 (.22)	
	Attended graduate School ^{b, c}	15.4 (173)	.51 (.22)	
Annual household income	Less than \$10,000	7.8 (87)	.45 (.25)	.011
	\$10,000–\$14,999	5.7 (64)	.44 (.23)	
	\$15,000–\$24,999	12.6 (141)	.42 (.23)	
	\$25,000–\$34,999	15.5 (174)	.42 (.23)	
	\$35,000–\$49,999	18.4 (206)	.44 (.24)	
	\$50,000–\$74,999	18.6 (208)	.44 (.22)	
	\$75,000–\$99,000	10.2 (114)	.50 (.23)	
	Greater than \$99,000	11.3 (126)	.47 (.21)	
Subjective social status *	0–10	4.5 (1.8)	.44 (.23)	r=.061
Subjective social status categories	0–3	30.7 (344)	.42 (.23)	.006
	4	18.2 (204)	.44 (.20)	
	5	19.0 (213)	.44 (.23)	
	6–10	32.1 (360)	.47 (.24)	

Characteristic	Range or Categories	Mean (SD) or percent (n)	Proportionate choice [^] Mean (SD)	Eta Squared or Pearson r
Alcoholic drinks per week	0–60	2.8 (5.3)	.44 (.23)	r=–.031
Alcoholic drinks per week categories	0	44.6 (640)	.46 (.24)	.005
	1	13.2 (189)	.45 (.22)	
	2	11.5 (165)	.44 (.23)	
	3–5	15.6 (224)	.41 (.19)	
	6–60	14.8 (217)	.44 (.22)	
Cigarettes per day ^{**}	0–50	2.28 (5.9)	.44 (.23)	r=–.147
Cigarettes per day categories ^{***}	0 ^a	79.2 (887)	.46 (.23)	.039
	1–4 ^a	5.4 (61)	.35 (.19)	
	5–10 ^b	7.0 (78)	.43 (.22)	
	11–20 ^{a, b}	7.1 (80)	.31 (.18)	
	21–50	1.3 (14)	.37 (.15)	
Other tobacco use [*]	Yes	11.5 (129)	.40 (.22)	.004
	No	88.5 (992)	.45 (.23)	
Self-monitoring scale ^{**}	0–25	11.0 (4.8)	.44 (.23)	r=–.089
Self-monitoring categories ^{**}	High ^{a, b}	24.0 (258)	.40 (.21)	.011
	Intermediate ^a	43.6 (468)	.45 (.24)	
	Low ^b	32.4 (348)	.47 (.22)	
Time perspective questionnaire	Not Future-Oriented	35.4 (397)	.44 (.22)	.000
	Future-Oriented	64.6 (725)	.44 (.23)	

[^] delayed choices/total choices;

Other=Multi-ethnic, American Indian, Alaska Native, Pacific Islander; Partnered = Married or living with significant other; Categories within a characteristic with the same superscript are significantly different from one another;

^{*} p<.05;

^{**} p<.01;

^{***} p<.0001

Table 2Results from analysis of covariance with medium magnitude proportionate choice[^] as the dependent variable

Fixed factors				
Characteristic F(df)		Estimated marginal means (SE)	95% Confidence Interval	
			Lower	Upper
Condition * (2,24)=3.98	Future Focus ^{a, b}	.41 (.02)	.37	.45
	Present Focus ^a	.37 (.02)	.33	.41
	Neutral ^b	.37 (.02)	.33	.41
Sex/gender (1,24)=1.57	Male	.39 (.02)	.35	.43
	Female	.37 (.02)	.33	.41
Race *** (3,24)=9.02	White ^a	.43 (.02)	.40	.46
	Black ^{a, b}	.29 (.03)	.23	.35
	Asian ^b	.39 (.03)	.33	.45
	Other ^b	.41 (.03)	.36	.48
Hispanic * (1,24)=4.63	Yes ^a	.35 (.03)	.29	.41
	No ^a	.41 (.02)	.38	.44
Partnered (1,24)=.04	Yes	.38 (.02)	.34	.42
	No	.38 (.02)	.34	.42
Annual Household Income (7,24)=.75	<\$10,000	.39 (.03)	.33	.45
	\$10–14,999	.38 (.03)	.31	.44
	\$15–24,999	.37 (.03)	.31	.44
	\$25–34,999	.36 (.02)	.31	.41
	\$35–49,999	.38 (.02)	.33	.43
	\$50–74,999	.36 (.02)	.32	.41
	\$75–99,000	.41 (.03)	.36	.46
	> \$99,000	.39 (.03)	.34	.45
Other tobacco use (1,24)=.52	Yes	.37 (.03)	.32	.42
	No	.39 (.02)	.36	.42
Time Perspective Questionnaire (1,24)=.19	Not Future-Oriented	.38 (.02)	.34	.42
	Future-Oriented	.38 (.02)	.35	.42

Table 3

Covariates	
Characteristic F(df)	
Age (yrs)	(1,24)=.18
Education (yrs) ***	(1,24)=19.49
Subjective Social Status	(1,24)=.03
Number of alcoholic drinks per week	(1,24)=.76
Number of cigarettes smoked per day ***	(1,24)=17.21
Self-monitoring scale **	(1,24)=8.26
Percent intervention complete **	(1,24)=11.64

*
p<.05;

**
p<.01;

p<.0001;

Categories within a characteristic with the same superscript are significantly different from one another; Estimated marginal means are adjusted for all other variables in the model.

^
delayed choices/total choices;

Other=Multi-ethnic, American Indian, Alaska Native, Pacific Islander; Partnered = Married or living with significant other;