Appetite 78 (2014) 63–67

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Research report

Robust relation between temporal discounting rates and body mass ☆

David P. Jarmolowicz [a], J.Bradley C. Cherry [b], Derek D. Reed [c], Jared M. Bruce [d], John M. Crespi [e], Jayson L. Lusk [f], Amanda S. Bruce [g,*]

[a] Department of Applied Behavioral Science, The University of Kansas, 4001 Dole Human Development Center, 1000 Sunnyside Avenue, Lawrence, Kansas 66045-7555
[b] Department of Psychology, University of Missouri–Kansas City, 324 Cherry Hall, 5030 Cherry Street, Kansas City, Missouri 64110
[c] Department of Applied Behavioral Science, The University of Kansas, 4001 Dole Human Development Center, 1000 Sunnyside Avenue, Lawrence, Kansas 66045-7555
[d] Department of Psychology, University of Missouri–Kansas City, 324 Cherry Hall, 5030 Cherry Street, Kansas City, Missouri 64110
[e] Department of Agricultural Economics, Kansas State University, 342 Waters Hall, Kansas State University, Manhattan, KS 66506-4011
[f] Department of Agricultural Economics, Oklahoma State University, 308 Agricultural Hall, Oklahoma State University, Stillwater, Oklahoma 74078
[g] Department of Psychology, University of Missouri–Kansas City, 324 Cherry Hall, 5030 Cherry Street, Kansas City, Missouri 64110

A R T I C L E   I N F O

Article history:
Received 5 December 2013
Received in revised form 18 February 2014
Accepted 22 February 2014
Available online 17 March 2014

Keywords:
Delay discounting
Delayed gratification
Depression
Impulsivity
Risk factors
Obesity

A B S T R A C T

When given the choice between $100 today and $110 in 1 week, certain people are more likely to choose the immediate, yet smaller reward. The present study examined the relations between temporal discounting rate and body mass while accounting for important demographic variables, depressive symptoms, and behavioral inhibition and approach. After having their heights and weights measured, 100 healthy adults completed the Monetary Choice Questionnaire, the Beck Depression Inventory-II, and the Behavioral Inhibition Scale/Behavioral Approach Scale. Overweight and obese participants exhibited higher temporal discounting rates than underweight and healthy weight participants. Temporal discounting rates decreased as the magnitude of the delayed reward increased, even when other variables known to impact temporal discounting rate (i.e., age, education level, and annual household income) were used as covariates. A higher body mass was strongly related to choosing a more immediate monetary reward. Additional research is needed to determine whether consideration-of-future-consequences interventions, or perhaps cognitive control interventions, could be effective in obesity intervention or prevention programs.

Introduction

Would you rather have $100 today, or $110 in 1 week? A person who chooses the immediate $100 reward is *discounting* the value of the additional $10. When choosing between rewards that vary in both immediacy and magnitude, trade-offs occur in which the subjective value of the delayed reward decreases as the time to its receipt increases (Epstein, Salvy, Carr, Dearing, & Bickel, 2010). People suffering from impulse control disorders such as drug addiction, pathological gambling, and, debatably, obesity, tend to discount delayed rewards more rapidly than controls, including both rewards related to addictive substances as well as monetary rewards. (Bickel et al., 2012a; Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012b; MacKillop et al., 2012).

Higher temporal discounting rates correspond with greater impulsivity and/or poorer executive function (Bickel, Jarmolowicz, Mueller, Gatchalian, & McClure, 2012). To date, the relations between temporal discounting rate and body mass are mixed. Some studies show that people with higher body mass discount more rapidly than those with lower body mass (Bickel et al., in press; Borghans & Golsteyn, 2006; Ikeda, Kang, & Ohtake, 2010). This relation, however, is typically demonstrated only in females (Davis, Patte, Curtis, & Reid, 2010; Fields, Sabet, & Reynolds, 2013; Weller, Cook, Avsar, & Cox, 2008) and was absent in a number of other studies (Manwaring, Green, Myerson, Strube, & Wilfley, 2011; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006). Most of the studies failing to demonstrate this relation, however, have used small sample sizes (e.g., fewer than 30 participants) or convenience samples (e.g., undergraduate students), or both. Moreover, studies of temporal dis-

☆ *Acknowledgments:* The present study was supported in part by a grant from the United States Department of Agriculture (2011-67023-30047). Data for the study were collected at the Hoglund Brain Imaging Center, supported by a generous gift from Forrest and Sally Hoglund and funding from the National Institutes of Health of the United States Department of Health and Human Services (S10 RR29577, UL1 RR033179). The authors have no competing interests.
* Corresponding author.
E-mail address: bruceam@umkc.edu (A.S. Bruce).

http://dx.doi.org/10.1016/j.appet.2014.02.013
0195-6663/

counting rate in obese people have yet to account for other psychological variables (e.g., response inhibition, depression) that are often found to relate to obesity (Luppino et al., 2010; Verdejo-García et al., 2010). The purpose of the present study was to use a large, diverse sample to clarify relations between temporal discounting rate and these obesity-related phenomena.

The current study furthers our understanding of the relationship between body mass index (BMI) and temporal discounting rates by also considering key demographic variables such as education, income, and gender. Age, education, and income have been shown to influence temporal discounting rates (Green, Myerson, Lichtman, Rosen, & Fry, 1996; Jaroni, Wright, Lerman, & Epstein, 2004; Steinberg et al., 2009). We also considered individual differences in self-reported depression and behavioral activation/inhibition. Measures of depression were included due to the high comorbidity of depression and overweight or obesity (Faith et al., 2011). By contrast, individuals' patterns of activation/inhibition were examined because of the conceptual correspondence of those constructs to the two-system theories often thought to undergird delay discounting (e.g., Koffarnus, Jarmolowicz, Mueller, & Bickel, 2013). We hypothesized that BMI would be significantly positively correlated with temporal discounting rates, but that this relationship may be mitigated by education and/or income.

Materials and methods

Participants

One hundred healthy adults (aged 18–55 years; $M = 30.7$ years; $SD = 10.1$; 49 females) were recruited from the Kansas City, Missouri area to participate in the present study, part of a larger study examining the neuroeconomics of controversial food technologies. It was a cross-sectional functional magnetic resonance imaging study examining consumer decisions about milk and egg products. Participants were recruited from both Kansas and Missouri using a variety of means, including online advertisements (i.e. Craigslist), flyers posted on the campus of the University of Missouri–Kansas City, and broadcast e-mails sent to the students, faculty, and staff of the University of Kansas Medical Center. In the state of Kansas, the population is composed of the following minorities: 5.7% Black, 0.9% American Indian or Alaskan native, 1.7% Asian, 7% Hispanic or Latino, 0% Native Hawaiian or other Pacific Islander, and 3.4% "other." In the Kansas City metropolitan area, the population is composed of the following minorities: 30.5% Black, 0.8% American Indian or Alaskan native, 1.7% Asian, 16.8% Hispanic or Latino, 0% Native Hawaiian or other Pacific Islander, and 8.6% "other." During recruitment, care was taken to ensure participants' demographic characteristics were representative of the regional population. Participants were excluded from participation if they reported lactose intolerance, a vegan diet, any condition contraindicating magnetic resonance imaging, current use of psychotropic medication, current or past abuse of illicit substances, diagnosis of severe neurological or psychiatric illness, inability to read and speak English fluently, left- and mixed-handedness, and pregnancy.

Measures

Height, weight, and body mass

Participants' heights and weights were measured using a Perspective Enterprises stadiometer, model PE-WM-60–84, and a Befour scale, model PS6600 ST, respectively. Participants' body masses (kg/m^2) were calculated using the body mass index (BMI) calculator provided by the Centers for Disease Control and Prevention, which defines body masses of less than 18.5 as "underweight," of between 18.5 and 24.9 as "healthy weight," of between 25.0 and 29.9 as "overweight," and of greater than 29.9 as "obese."

Education level and annual household income

Participants' education levels and annual household incomes were measured by self-report.

Temporal discounting rate

Participants' temporal discounting rates (k) were measured using the Monetary Choice Questionnaire (Kirby, Petry, & Bickel, 1999). This self-report questionnaire includes 27 questions, each of which solicits the respondent's preference for either of two monetary rewards: a smaller, immediate reward and a larger, delayed reward. Responses are used to calculate four temporal discounting rates for the respondent: one each for small, medium, and large reward sizes, and one across all reward sizes. Higher temporal discounting rates correspond with greater impulsivity and/or poorer executive function (Bickel et al., 2012b).

Depression

Participants' depressive symptoms were assessed using the Beck Depression Inventory-II (BDI-II) (Beck, Steer, & Brown, 1996). This self-report assessment includes 21 items, with higher scores indicating more depressive symptoms.

Behavioral inhibition and approach

Participants' abilities to regulate behavioral inhibition and approach were assessed using the Behavioral Inhibition Scale/Behavioral Approach Scale (BIS/BAS) (Carver & White, 1994). This self-report assessment includes 24 items that assess a person's tendency to avoid undesirable or unpleasant stimuli (i.e., inhibition) and, conversely, seek desirable or pleasant stimuli (i.e., approach). Responses are used to calculate scores along a single behavioral inhibition-related subscale and each of three behavioral approach-related subscales (i.e., drive, fun-seeking, and reward responsiveness).

Data analysis

The following approach was used with data analysis. First, raw data from the delay discounting surveys were scored using the technique used by Kirby et al. (1999). Consistent with prior research (Kirby & Maraković, 1996), because temporal discounting rates are nonnegative and not normally distributed, their natural logs ($\ln[k]$) were used for analyses. An analysis of variance (ANOVA) was then conducted comparing the log transformed discounting rates (i.e., $\ln[k]$) for small, medium, and large rewards in under/healthy weight individuals (UH) to those in overweight/obese individuals (OO). Because $\ln(k)$ was significantly different between the UH and OO groups, yet variables known to interact with $\ln(k)$ (i.e., age (Green et al., 1996; Steinberg et al., 2009), income (Green et al., 1996), and education (Jaroni et al., 2004)) were uncontrolled, a general linear model comparing $\ln(k)$ for each reward type while covarying out the influence of age, education, and income was conducted.

The choice to use these variables as covariates was driven by previous research; however, in the present dataset, $\ln(k)$ was significantly correlated with education (rho = –0.29, $p = 0.004$) and BMI was significantly correlated with age (rho = 0.39, $p < 0.001$) and the correlation between BMI and income approached significance (rho = 0.18, $p = 0.07$).

Next, because of prior studies showing that the relation between delay discounting rate and BMI interacts with gender (e.g., Weller et al., 2008), a two way ANOVA was conducted exploring effects of gender (i.e., male *versus* female) and obesity status (i.e., UH *versus* OO) on $\ln(k)$.

Spearman rank-order correlations were then conducted to examine relations between body mass, temporal discounting rate, and scores on the BDI-II and subscales of the BIS/BAS. Because the correlations between $\ln(k)$ and BDI-II scores and between $\ln(k)$ and