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Associations between a one-shot delay discounting measure and age, income, education and
real-world impulsive behavior

Stian Reimers
University College London, UK

Elizabeth A. Maylor
University of Warwick, UK

Neil Stewart
University of Warwick, UK

Nick Chater
University College London, UK

Stian Reimers
Department of Psychology
University College London
26 Bedford Way
London WC1H 0AP
United Kingdom

Tel: +44 20 7679 7570

Fax: +44 20 7436 4276

s.reimers@ucl.ac.uk

Abstract

There has been discussion over the extent to which delay discounting – as prototypically shown by a preference for a smaller-sooner sum of money over a larger-later sum – measures the same kind of impulsive preferences that drive non-financial behavior. To address this issue a dataset was analyzed, containing 42,863 participants' responses to a single delay-discounting choice, along with self-report behaviors that can be considered as impulsive. Choice of a smaller-sooner sum was associated with several demographics: younger age, lower income, lower education; and impulsive behaviors: earlier age of first sexual activity and recent relationship infidelity, smoking, and higher body mass index. These findings suggest that at least an aspect of delay discounting preference is associated with a general trait influencing other forms of impulsivity, and therefore that high delay discounting is another form of impulsive behavior.

KEYWORDS: Delay discounting; smoking; obesity; drug use; sexual behavior; age; education; income

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Introduction

Given the choice, people generally prefer to receive pleasant things – such as money, food, or in the case of smokers, nicotine – sooner rather than later, and the attractiveness of a reward is reduced by increasing delay until its receipt. Often, people are willing to accept a smaller-sooner reward in lieu of a larger-later reward. Thus, most people would prefer \$999 in a day's time to \$1,000 in a year's time. Some people would be willing to forgo much more, for example choosing \$500 in a day over \$1,000 in a year. The more that people are willing to give up to reduce the delay to receipt of a reward, the higher their delay discounting.

From this description, it is clear that high levels of delay discounting are a form of financial impulsivity, a preference for immediate gratification over long-term financial benefits. Although choosing a smaller-sooner sum over a larger-later sum is often described as being an 'impulsive' choice, there is equivocal empirical evidence for (e.g., de Wit, Flory, Acheson, McCloskey, & Manuck, 2007; Kirby, Petry, & Bickel, 1999) and against (e.g., McLeish & Oxoby, 2007; Mitchell, 1999; Reynolds, Ortengren, Richards, & de Wit, 2006) an association between discounting and trait-level impulsivity. This has led to discussion about the extent to which 'impulsive' choices in a delay discounting procedure generalize beyond the financial domain.

Individual Differences in Discounting: Age, Education, and Income

Many attempts to explain individual differences in delay discounting have focused on demographics, in particular, age. Green, Fry, and Myerson (1994) found that children discounted future rewards more than younger adults (aged around 20), who in turn discounted future rewards more than older adults (aged around 68; see also Green, Myerson, &

Ostaszewski, 1999). Green, Myerson, Lichtman, Rosen, and Fry (1996) compared the discounting rate of 30-year-old participants with income-matched 70-year-old participants, and found no difference. Combining their findings with those from Green et al. (1994), they hypothesized that discount rate was higher in young adults, declined to age 30, and remained relatively constant after that. A similar finding was reported by Whelan & McHugh (2009). Conversely, Read and Read (2004) found a curvilinear effect of age, with middle-aged participants (mean age = 44) discounting less than both younger (mean age = 25) and older (mean age = 75) participants. Harrison, Lau, and Williams (2002) found similar trends in their data, although the only significant age effect was higher discounting among retired people than those still working. Thus, discounting appears to be lower in middle age than in young adulthood, but there are conflicting accounts of how it varies between middle age and old age.

Other demographics, notably education and income, have been associated with discounting. De Wit et al. (2007) found higher education associated with lower discounting. Similarly, Jaroni, Wright, Lerman, and Epstein (2004) found a negative association between education and delay discounting in smokers (see also Harrison et al., 2002). De Wit et al. (2007) found that higher income was associated with lower discounting and lower non-planning impulsiveness. Similarly, Green et al. (1996) and Harrison et al. (2002) found less discounting among high-income participants.

The effects of gender are less clear-cut, and for delay discounting there is evidence for women discounting more than men (e.g., Reynolds et al., 2006), no difference between men and women (e.g., Harrison et al., 2002) and men discounting more than women (e.g., Kirby & Marakovic, 1996). Thus, it appears that gender differences are particularly unstable.

Associations with Behavioral Impulsivity

Part of the validation of impulsivity and discounting measures has come from the fact

that they have behavioral correlates that can be seen as reflecting impulsive decision making. Several areas of impulsive behavior have been investigated. These include obesity, substance use, and sexual behavior. Research in each area will now be briefly discussed.

Time Preference and Sexual Behavior

In deciding whether to resist an opportunity for an extradyadic sexual encounter, one pits desire for immediate sexual gratification against the long-term benefits of an existing relationship. Similarly, during adolescence, there is a conflict between the immediate excitement and social acceptance of sexual experimentation and longer-term happiness from ‘saving oneself’ for a more satisfying significant romantic attachment, along with avoiding risks of sexually transmitted diseases, pregnancy, and, at least for women in many cultures, a negative reputation. As such, age of first sexual activity and infidelity rate might be expected to be correlated with other measures of impulsivity.

McAlister, Pachana, and Jackson (2005) found that propensity toward extradyadic kissing or sexual activity was positively associated with dysfunctional impulsivity. Furthermore, they found strong first-order correlations between dysfunctional impulsivity and age of first sexual encounter: higher impulsivity was associated with earlier age of first sexual encounter. Clift, Wilkins, and Davidson (1993) found that of patients attending a Genito-urinary medicine clinic, those who reported having sex without condoms scored higher on impulsivity than those who used condoms (see also Horvath & Zuckerman, 1993). McCoul and Haslam (2001) found similar results in heterosexual, but not homosexual, men.

Time Preference and Substance Use

In deciding whether or not to smoke cigarettes, drink alcohol in large quantities, or take illicit drugs, people make a choice between the short-term pleasure of the substance in question and longer-term health and financial benefits of abstinence. Unsurprisingly, then, there is a large body of research investigating the association between delay discounting,

impulsivity and substance use (for a review, see Reynolds, 2006). The general pattern is similar for cigarette, alcohol and illicit drug use: regular users tend to discount future money more than non- or ex-users.

There is robust evidence that smokers discount future rewards more than non-smokers (e.g., Bickel, Odum, & Madden, 1999; Mitchell, 1999; Reynolds, Richards, Horn, & Karraker, 2004). Similar, although more equivocal, results have been found for alcohol consumption. Some research has found a positive association between alcohol consumption and delay discounting (e.g., Vuchinich & Simpson, 1998; Mitchell, Fields, D'Esposito, & Boettiger, 2005), whereas other research has failed to find an effect (e.g., Kirby & Petry, 2004).

Finally, there is strong evidence that regular use of illicit drugs such as heroin and cocaine is associated with higher discounting of delayed rewards. For example Kirby et al. (1999) found higher discounting of money among opioid-dependent participants than controls. Madden, Petry, Badger, & Bickel (1997) found a similar result using hypothetical money, and a similar finding has been shown in cocaine-using individuals (Coffey, Gudleski, Saladin, & Brady, 2003).

Time Preference and Body Mass Index

Another form of impulsive behavior is choosing the pleasure of overeating now over longer-term health benefits of limiting one's consumption. As such, one might expect body mass index (BMI) to be related to other measures of time preference including delay discounting. There is some evidence for this. Recently, Zhang and Rashad (2008) reported an association between BMI and time preference, measured by self-reported willpower (participants who reported having problems with willpower were categorized as having more immediate time preference). Borghans and Golsteyn (2006) found a marginally significant association between delay discounting rate and BMI in men, but not in women. They did,

however, find a significant negative association between BMI and ability to manage finances and control expenditure, suggesting an association between gustatory and financial impulsivity. Conversely, Weller, Cook, Avsar and Cox (2008) found higher levels of discounting in obese women relative to controls, but no such effect in men.

However, Nederkoorn et al. (2006) found no association between delay discounting and BMI, or between trait-level impulsiveness and BMI. Similarly, Epstein et al. (2003) found no association between BMI and delay discounting.

The Present Study

A review of the existing literature suggests that there exist a number of associations between facets of impulsivity or discounting and many types of behavior that might be classed as impulsive, as well as demographic associations with younger age, lower income and lower education. However, many of these effects are rather equivocal, with a significant number of studies failing to find an association between laboratory-based impulsive choice, and real-world impulsive behavior.

The purpose of this research was therefore two-fold. As much existing research has focused on behavioral correlates of trait-level impulsiveness rather than discounting, the first aim was to examine whether delay discounting showed associations with the same 'impulsive' behaviors as did self-report impulsivity measures, using a sample of participants from a broad demographic. The second aim was to examine behaviors across domains of substance use, sexual activity, and obesity, to examine both intercorrelations between behaviors, and the extent to which behaviors in different domains made independent contributions to predicting delay discounting. Almost all studies published so far have focused on only one behavioral area, and it is clearly of interest to examine whether, say, sexual behavior is associated with discounting after taking into account substance use and BMI.

It was possible to recruit a large number of participants through involvement with a BBC television series *Secrets of the Sexes*. A large web-based study about sex differences was set up on the BBC Science and Nature website. The study, which took around 40 minutes to complete, included questions on demographics, attitudes towards gender and relationships, face preferences, finger and body measurements and reaction time measures on cognitive tasks such as mental rotation. For a full overview see Reimers (2007).

Also included was a single, two-choice hypothetical delay discounting question, where participants chose between £45 in 3 days and £70 in 3 months. Previous work on several thousand participants indicated that this choice bisected the UK population fairly effectively. The measure was separately tested in our laboratory by making a within-subjects comparison between choices on this one-shot measure and delay discounting parameters elicited using more traditional adjusting-immediate-amount procedures and fitting hyperbolic functions for each participant to the immediate values of £75 or £125 in 3 days, 1 week, 2 weeks, 1 month, and 6 months. Preference on the one-shot measure gave the same results as placing participants into low- or high-discounting bins using a median split of discounting parameters for 60/69, or 87% of, participants. (Full details are available from the authors.)

For the present analysis, we examined the demographics of age, gender, education and income. We also examined the original set of questions participants responded to, searching for behaviors that might be considered impulsive, in particular looking for the sorts of measure that have been examined in existing research. As such, the analysis is *post hoc*. Although this may not be the ideal way to set up a study, it has some advantages, inasmuch as there is no deliberate or inadvertent association between the behavioral measures and the delay discounting measure in the participant's head, minimizing demand and consistency effects in the experiment.

Method

Participants. This analysis started with a set of around 48,000 UK-resident participants, aged between 21 and 65. (Non-UK participants were excluded as they may not have understood the value of £45 and £70) Further exclusions, based on responses to the additional measures used in this analysis, are reported below.

Measures. The dependent measure was obtained from the hypothetical delay-discounting binary choice between £45 in three days and £70 in three months. To indicate their preference, participants clicked a radio button beside the option they preferred. Options were presented vertically, with the £45 option always above the £70 option. To the left of the options was the text ‘Which would you rather have?’.

Demographics were recorded as follows: Age was a free text field. Gender was a dropdown box with values ‘male’ and ‘female’. Education was a dropdown menu with options that were coded for this analysis as secondary (to age 16) = 1, college (to age 18) = 2, university = 3, postgraduate = 4. Income was a dropdown menu with four options: 0 - £10,000, £10,000 - £25,000, £25,000 - £50,000, and £50,000+.

Age of first sexual experience was recorded using the following question: ‘About what age were you when you first had sexual intercourse?’ Participants who entered a number less than 12 or greater than 40 were excluded from subsequent analysis. Infidelity was assessed with the following question: ‘In the last five years have you ever been sexually unfaithful (sexual intercourse) to a partner?’ to which participants selected either ‘yes’ or ‘no’. Participants who did not give a response were excluded.

Substance use was assessed on a single page, headed with the text ‘How would you describe your intake/experience of the following:’ followed by ‘Coffee’, ‘Nicotine’, ‘Alcohol’, ‘Sex’, ‘Medicines’, ‘Drugs’. Participants indicated intake for each category by selecting from one of the following options: Never, Rarely, Monthly, Weekly, Daily, Daily+. We included in the analysis only responses to substances that might generally be considered

addictive: Coffee, nicotine, alcohol, and drugs. Participants who did not give a response were excluded. To make categories more similar to those in other studies, we recoded these as binary variables. Thus, participants were classed as coffee drinkers, smokers or alcohol drinkers or if they indicated intake of the relevant substance was 'Daily' or 'Daily+'; and drug users if reported intake of drugs was 'Weekly', 'Daily', or 'Daily+'.

Finally, BMI was calculated using participants' self-reported height and weight. Height and weight could be entered as metric or imperial measurements, but were stored as inches and pounds. As BMI uses metric units, for the analysis these values were then converted into metric measurements and BMI was calculated as $\text{weight (kg)} / \text{height}^2 (\text{m}^2)$. Participants with BMI values less than 15 or greater than 45 were excluded from subsequent analysis because there were very few participants in those ranges, and we suspected that of those, a large proportion were people who had made an error entering their data.

Procedure. The full procedure is given in Reimers (2007). At the start of the study, participants created a username, which was associated with a unique ID number in a cookie stored on their machine. After submitting a username, participants saw a page showing the current block. Participants clicked to start a block, which opened a 600 x 440 pixel pop-up window. Participants could close the window at any point. When they logged in again, they would automatically be taken to the start of the task or page they were completing when they shut the window previously.

Participants progressed from page to page by pressing a 'next' button. It was not possible to return to a page after the 'next' button was pressed.

Results

----- Table 1 about here -----

Data from a total of 42,863 participants entered the analysis. Descriptive details of the demographics and other choices of participants who chose the smaller-sooner, or larger-later

reward are shown in Table 1. Raw correlations among the variables are shown in Table 2.

----- Table 2 about here -----

There was a clear, near-linear effect of age, with preference for the smaller-sooner sum declining with participant age (Figure 1). Similarly, there were monotonic effects of education and income (Table 1) on preference: Participants with less education and on lower incomes were more likely to choose the smaller-sooner sum of money.

----- Figure 1 about here -----

Early sexual activity, infidelity, smoking, and drug use all appeared to be associated with increased preference for the smaller-sooner sum (Table 1). As predicted, BMI above the normal (20-25) range was associated with increased preference for the smaller-sooner sum (Figure 2). However, there was also a small trend towards increased discounting in the participants classed as underweight (BMI < 20). There were relatively few participants in this category, but it suggests that examining the association between impulsivity and underweight might be fruitful.

----- Figure 2 about here -----

A binary logistic regression was used to examine the unique associations between each of the behaviors and delay discounting choice, with delay discounting choice (1 = £45 in 3 days; 0 = £70 in 3 months; thus a higher value indicates higher discounting of future rewards) as the dependent variable, and age, gender, education and income, BMI, age of first sexual intercourse, infidelity (1 = yes, 0 = no), status as coffee drinker, smoker, heavy alcohol consumer, and drug user (each coded as 1 = yes; 0 = no), as independent variables.

A null model – in which the most frequent choice was always picked – correctly predicted discounting choice for 51.1 % of participants. A model that included the independent variables described above correctly predicted discounting choice for 58.2 % of participants, a highly significant, if numerically modest, increase $\chi^2(11) = 1697.9, p < .001$.

Of the demographics, there were significant effects of age, Wald $\chi^2(1) = 116.5, p < .001$, odds ratio = .987, gender Wald $\chi^2(1) = 37.9, p < .001$, odds ratio = 1.14, education, Wald $\chi^2(1) = 357.1, p < .001$, odds ratio = .81, and income Wald $\chi^2(1) = 62.7, p < .001$, odds ratio = 0.90. Of the behavioral measures, there was a significant effect of BMI, Wald $\chi^2(1) = 129.4, p < .001$, odds ratio = 1.026; age of first sexual intercourse, Wald $\chi^2(1) = 32.8, p < .001$, odds ratio = 0.981; infidelity, Wald $\chi^2(1) = 97.3, p < .001$, odds ratio = 1.272, and smoking, Wald $\chi^2(1) = 238.7, p < .001$, odds ratio = 1.487. There was no effect of coffee ($p = .80$), alcohol ($p = .051$) and drug ($p = .36$) intake.

The absence of an effect of drug intake on discounting was surprising, given the strong evidence for an association in the literature. As the differences in discounting between drug users and non-users are particularly strong, and drug use and smoking are highly correlated in our data and in other research findings (e.g., Henningfield, Clayton, & Pollin, 1990), we reran the binary logistic regression, leaving out smoking status. This time, drug and alcohol use were both significantly positively associated with choosing the smaller-sooner sum, Wald $\chi^2(1) = 25.4, p < .001$, odds ratio = 1.23 for drug use and Wald $\chi^2(1) = 4.8, p = .002$, odds ratio = 1.08 for alcohol use.

Discussion

Responses on a simple binary measure of delay discounting –£45 in 3 days versus £70 in 3 months – were predicted by several demographic and behavioral variables. Specifically, the preference for a smaller-sooner sum of money was independently associated with younger age, lower income, lower education, female gender, higher BMI, younger age of first sexual intercourse, recent sexual infidelity, and regular smoking.

Effects of Age, Education, and Income

The findings of this study replicate previous research suggesting that higher discounting is associated with lower income and lower education. The effects of age support

theories in which discounting decreases monotonically through adulthood to retirement age, rather than those in which it remains constant or increases (as it would if mortality risk were the main driver of discount rate). However, as meaningful data for above age 65 are not available, these findings are also compatible with U-shaped models (e.g., Read & Read, 2004), in which discounting decreases through young adulthood and middle age, then increases again beyond retirement age. However, these data constrain the shape that any curvilinear function could take.

Effects of Other Impulsive Behavioral Variables

The behavioral associations suggest that impulsive decision making crosses from hypothetical discounting measures to reported real-world choices, and across behavior relating to sex, smoking, and obesity. These findings lend support to other research demonstrating associations between discounting and obesity, sexual behavior, and substance use, and extend these separate findings to a single study, which can control for each of the other variables.

It is not clear why there was no significant association between drug use and discounting, after controlling for smoking status. One explanation may be the vagueness of the questions and response options. The definition of ‘drugs’ was left to the participant, which meant that different participants might use different definitions. Furthermore, participants did not indicate which drugs they used, how much they used different substances, or the psychosocial impact of the use. An alternative explanation would be that most studies examining drug use and delay discounting control for many important variables, but not for smoking status (e.g., Kirby et al., 1999; Madden, et al., 1997). Given the strong association between many types of drug use and smoking (Henningfield et al., 1990), and the fact that smokers discount more than non-smokers (e.g., Mitchell, 1999), it is possible that controlling for smoking status might reduce somewhat the differences in discounting between drug users

and non-users.

Experimental Approach

The approach taken here has both advantages and disadvantages relative to the traditional lab-based testing of participants. It made it possible to test a large number of people from a broad demographic, which may have made it easier to find associations that are not observable in a more homogeneous student sample. However, with such large numbers of participants, even very small effects become significant, and there is the risk of overstating the relationships among variables under analysis. In addition, there is no way of checking that people are reporting their behavior honestly. There is some – albeit very limited – evidence that people appear more inclined to give honest responses to sensitive questions when they respond using a computer rather than more personal approaches like experimenter-led surveys or computer-assisted telephone interviews (see Tourangeau & Yan, 2007), meaning that a web-based study might lead to greater honesty. A further issue is that for negative behaviors, it is possible that impulsivity affects disclosure as well as behavior: Assuming most people prefer to tell the truth, the impulsive option might be to respond honestly, whereas the self-controlled option might be to consider whether it is wise to admit to such activity, and therefore to respond ‘no’.

Finally, we note that our approach necessarily used a crude one-shot measure of delay discounting. It is of course possible that different discounting measures may have different behavioral associations. However, the measure we used correlated well in lab-based testing with longer, more traditional procedures for eliciting time preference, which suggests that it reflects similar processes to longer measures. That said, we are wary about drawing strong conclusions about the associations between behavioral impulsivity and *all* possible measures of delay discounting, as all researchers who measure discounting using a single procedure should be. Our approach is more a demonstration that some forms of financial delay

discounting are associated with a range of other real-world impulsive behaviors.

Overall, then, the results of this study do suggest that delay discounting choice is not purely an economic decision, in which individual differences arise from previous financial experience or domain-specific financial heuristics. Rather, it seems discounting may partially reflect some aspect of impulsivity that is also implicated in other impulsive behaviors, such as impulsive sexual activity, substance use, and overeating.

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Table 1

Proportion of Participants Choosing Smaller-Sooner Sum as a Function of Demographics and Behaviors

	£45 in 3 days	£70 in 3 months
Gender		
Female	51.8%	48.2%
Male	46.9%	53.1%
Education		
Secondary	59.3%	40.7%
Sixth Form	55.4%	44.6%
University	46.1%	53.9%
Postgraduate	40.1%	59.9%
Income		
£0-10k	52.7%	47.3%
£10-25k	53.1%	46.9%
£25-50k	45.0%	55.0%
Over £50k	39.1%	60.9%
Sexual Behavior		
Had sex before age 16	55.5%	45.5%
Had sex after age 16	47.7%	52.3%
Been unfaithful	54.9%	45.1%
Not been unfaithful	47.3%	52.7%
Substance use		
Coffee drinkers	48.9%	51.2%
Smokers	59.5%	40.5%
Regular drinkers	48.5%	51.5%
Drug users	56.6%	43.4%
BMI		
Normal	47.2%	52.8%
Overweight	49.8%	50.2%
Obese	54.2%	45.8%

Table 2

Spearman Correlations among the Variables Analysed

	Variable										
	Age	Sex	Education	Income	First sex	Unfaithful	BMI	Coffee	Nicotine	Alcohol	Drugs
Delay Choice	-.05	.05	-.13	-.09	-.10	.06	.05	.01	.12	-.01	.04
Age		-.08	-.09	.37	.11	-.04	.26	.23	-.02	.15	-.07
Sex			-.03	-.28	-.16	-.04	-.12	-.11	.00	-.11	-.07
Education				.18	.22	-.04	-.13	.01	-.18	.05	-.06
Income					.10	.05	.12	.16	-.07	.15	-.05
First sex						-.19	-.03	.00	-.24	-.01	-.11
Unfaithful							-.02	.03	.11	.05	.05
BMI								.09	-.01	-.01	-.06
Coffee									.12	.12	.02
Nicotine										.08	.28
Alcohol											.05

All correlations in bold are significant at the $p < .001$ level. Sex is coded male = 0 female = 1. Unfaithfulness, and coffee, nicotine, alcohol, and drug intake are all binary variables (0 = no; 1 = yes). See text for description of the other variables.

Figure Captions

Figure 1. Effects of age on proportion of participants choosing smaller-sooner sum of money.

Error bars represent standard error of the mean.

Figure 2. Effects of BMI on proportion of participants choosing smaller-sooner sum of money.

Figure 1

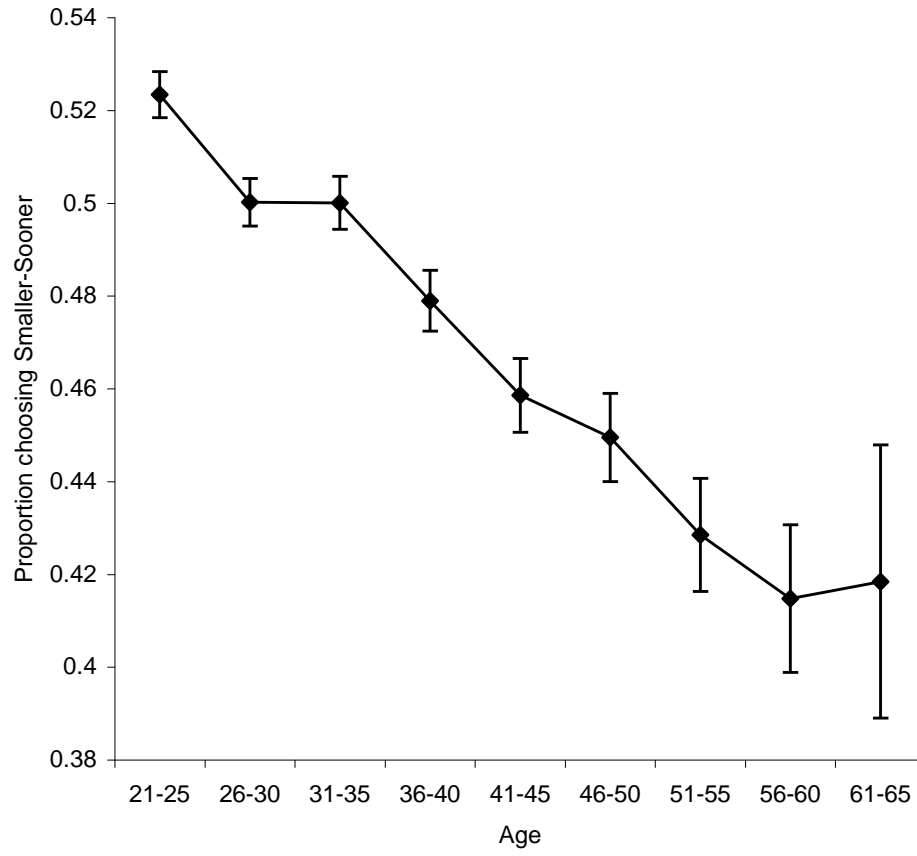


Figure 2

