Effects of measurement methods on the relationship between smoking and delay reward discounting

Stillwell, D. J., School of Psychology, University of Nottingham, UK

Tunney, R. J., School of Psychology, University of Nottingham, UK

CORRESPONDING AUTHOR:

David J. Stillwell

University of Nottingham

School of Psychology, University Park, University of Nottingham, NG7 2RD, UK

lpxdjs1@nottingham.ac.uk

KEYWORDS:

Delay discounting; smoking; online social networks; impulsivity

RUNNING HEAD:

Link between delay discounting and smoking

WORD COUNT:

3717

DECLARATION OF INTEREST:

Abstract

Aims: Delay reward discounting (DRD) measures the degree to which a person prefers smaller rewards soon or larger rewards later. People who smoke have been shown to have higher DRD. There are several ways of measuring DRD and the method used might influence the association between smoking and DRD. The key differences are the order that the items are presented in, the delays used, and the magnitude of the delayed amount.

Setting: An international online study running from September 2010 to June 2011.

Participants: N = 9454; 38% male, mean age = 23.1.

Design and Measurements: Users completed a multi-item DRD task. They were randomly presented the immediate rewards in an ascending, descending, or randomized order. The delays were between 1 week and 5 years. The delayed amounts were $1000 for all delays, and $100 for 1 month. Users also self-reported their smoking status.

Findings: A hyperbolic DRD function fit better than an exponential function. There were differences in the derived DRD function based on methodology used. Items presented in a randomized order, longer delays and smaller rewards showed steeper discounting. However, these did not interact with smoking status, as for all methodologies used daily smokers showed the steepest discounting, followed by non-daily smokers, then non-smokers.

Conclusions: Smokers discount more steeply irrespective of which method is used. However, the methods of assessing DRD influence the parameters, which means that parameters estimated with different methods cannot be compared.

Introduction

Delay reward discounting (DRD) measures how a reward's subjective utility decreases as the interval before it is obtained increases. Steeper DRD has been found to be related to a range of addictive behaviours; smoking (3-8), the success of smoking cessation (9, 10), the initiation of regular smoking in adolescents (11), drinking (12), heroin and cocaine (13, 14), opioids (15) and marijuana (16). However, the measurement of DRD varies and it is possible that this may affect estimates of effect size or cross-experiment comparisons (1). We therefore compared multiple methods of measuring DRD to estimate whether the relationship between DRD and smoking changed depending upon the measurement method.

In humans, DRD is typically measured by giving individuals repeated choices between various immediate amounts and a larger amount delayed for various lengths of time. Normally the rewards are hypothetical, but equivalent results have been found whether DRD is measured using real or hypothetical rewards (17). For example, an individual is asked to choose either $500 today or $1000 in a month. The point at which an individual switches from preferring a delayed reward to an immediate reward allows estimation of how much they subjectively value the delayed reward in today's money.

In normative economics, it has been assumed that individuals have an exponential discounting function. This has the implication that individuals are time consistent. Using an exponential curve, a parameter *k* can be calculated which represents the individual's degree of DRD, where *D* is the delay in months, *A* is the amount of the reward and *V* is the subjective value of the reward as determined by an individual's preferences:

$V = A\mathrm{e}^{-kD}$

A large k indicates that the individual steeply discounts the future, whereas a low k indicates that the individual is more willing to wait. However, in humans DRD is typically found to follow a hyperbolic curve, such that small delays have a proportionately larger impact than longer delays (18):

$V = A / (1 + kD)$

This accounts for time inconsistent preferences, where an individual switches their preference from a delayed reward to an immediate reward as the time before the reward is available decreases. The exact form of the DRD function has important economic implications, as the regrets inherent in hyperbolic discounting could be corrected through taxation (19).

Although DRD has been conceptualised as a single stable trait that underlies decisions about delay in all domains (20), it has been found in the past that different methods or parameters used when measuring delay discounting leads to different DRD parameter estimates. It is possible that these variations could cause illusory or differing effects to be found between addictive behaviours and DRD. We set out to confirm the effect of these methodological differences and to see how they might interact with different groups of smokers.

The first is that there is evidence that the order that rewards are presented can affect the derived DRD parameter. Randomizing the order of the immediate rewards leads to the highest rate of discounting, followed by putting the rewards in an ascending order, and then in a descending order (21-23). People who smoke tend to be higher in impulsivity and impulsivity itself may lead to spurious findings that smoking is associated with delay discounting. For example, assessing delay discounting requires people to repeatedly rate a higher distant reward that remains constant against

5

a smaller reward that changes. One measure of impulsivity, the Barratt Impulsivity Scale (24, 25), measures a dimension called attentional impulsiveness (difficulty maintaining attention), which has been found by some researchers to be most closely related to DRD (26, 27). Smokers might switch to the immediate reward earlier simply because they want to stop choosing the same delayed reward. To mitigate order effects, researchers have used a titrating procedure, where the immediate amount decreases after the immediate amount is chosen, and increases after the delayed amount is chosen, leading to an increasingly accurate assessment of the switch point. Rodzon (28) found no difference in the derived DRD parameter between a fixed procedure and a titrating procedure (although with a sample size of just 24), but a titrating procedure still requires an initial amount, against which future amounts could be anchored by the participant. This could lead to unexpected effects due to trait impulsivity differentially interacting with the anchoring effect rather than differences in DRD. In the current experiment, participants were randomly allocated to three groups where the immediate rewards were either presented in an ascending, descending, or randomized order.

The second parameter difference is that typically in DRD studies multiple delays are used with anything from 6 hours to 25 years. Within a study, the DRD parameters for each delay are calculated and then averaged. This averaging is understandable if it is assumed that an individual has a single delay DRD parameter accurately measured by their discounting function and that variations around this are noise, however it may be that some individuals discount some delays more than others. For example, smokers could plausibly be expected to discount the distant future comparatively more than they discount tomorrow, since smoking involves negative returns over a decadal timeframe. In the current experiment, participants' DRD parameters were calculated separately for each delay and then compared to see whether smokers discounted certain timeframes more than others.

The third parameter difference is the size of the delayed amount. Often $1000 is used, however when other amounts are used studies find that that smaller amounts are discounted more steeply

than large amounts (29-31); this is commonly known as the magnitude effect. It is possible that

larger amounts may be discounted more by smokers than smaller amounts, since smoking involves

repeatedly choosing a smaller reward over a long-term health decline. In the current study, $1000

and $100 were compared within-subjects at a time delay of 1 month.

We aimed to test whether these differences in DRD methodology would systematically bias the

observed relationship between smoking and DRD, and to see whether the relationship is only found

under certain conditions. Since these effects are subtle, a large sample size was necessary to achieve

reliable results. We therefore used an application which runs on the Facebook social network. Nearly

9500 international users completed a multiple-item DRD task in return for feedback on their results,

and agreed to share their data with the researchers.

Method

Delay Reward Discounting Measure

Participants were asked to make repeated choices between two monetary amounts; various

amounts now compared to larger amounts at some future point. The delays and amounts are a

subset of those used in previous DRD research (3, 18). The 15 immediate monetary rewards were

$1000, $950, $900, $850, $750, $600, $500, $400, $250, $150, $100, $60, $20, $10, and $1, and the

six delays were 1 week, 2 weeks, 1 month, 6 months, 1 year, and 5 years. These were all compared

to $1000 at the future time point. Participants were also asked an extra set of questions which asked

for their preferences of rewards at a delay of 1 month that were a tenth of the size of those above

($100, $95, etc.) and compared to $100 at the future time point. This totalled seven sets of

questions, which were presented in a randomized order for each participant.

Participants were randomly allocated to one of three groups. Within each set of questions, the amounts were either presented in an ascending order ($1, $10, […], $1000), descending order ($1000, $950, […], $1), or randomized order.

To calculate the participant's hyperbolic DRD parameter (k) for each delay in both their feedback and for the research, an indifference point was established by calculating an average between the maximum immediate monetary amount chosen and the minimum delayed monetary amount chosen (3). The parameter was then calculated according to the hyperbolic DRD formula mentioned above. Since the distribution of k is often found to be non-normal (3, 18), the data were approximately normalised using the natural-log transformation. The k parameter reflects the steepness of the discount curve, whereby greater k values reflect a sharper decline in the subjective value of money as the delay to obtain that money increases.

Procedure

Users of the 'My Personality' application on the Facebook social network (32) were invited to participate in a new questionnaire called 'Today or Tomorrow?' and told that they would receive feedback on their results. Users who chose to start the 'Today or Tomorrow' questionnaire were given further information about the study (Appendix 1), including being told that their DRD function would be estimated but that the rewards were hypothetical. As 'My Personality' is used by an international audience, users were given the option to choose a currency that they either used or were most familiar with from 9 of the most widely used world currencies (British Pound, Canadian Dollar, Euro, Filipino Peso, Indian Rupee, Indonesian Rupiah, Singapore Dollar, South African Rand, United States Dollar). The delayed amounts were based on a published study that used US Dollars, and so the amounts were converted to the other currencies using the exchange rate from Google's exchange rate function on 22nd June 2010 (see Table 1).

8

Users were also asked to answer the question "Do you smoke?" with answers "daily or more", "less than daily", or "never", and complete the Cigarette Dependence Scale (CDS-5) (2). Users also completed the Alcohol Use Questionnaire (AUQ) (33), and the Assessment of Substance Misuse in Adolescence (ASMA) (34) although these results are not presented here. Users were told that completion of these questionnaires was optional and would not affect their feedback. Users then completed the DRD measure (Figure 1), including short instructions telling them to assume no inflation (35). Finally, for feedback users were told which quartile their calculated DRD parameter was in, and shown a graph with their personal DRD curve compared to the mean DRD curve (Figure 2).

The 'Today or Tomorrow' questionnaire received ethical approval from the University of Nottingham School of Psychology Ethics Committee. Respondents gave consent for their results to be used in an anonymised format for research, were able to stop at any time without pressure by simply closing the browser window, and were able to delete their information after completing the study through an automatic form mechanism within the 'My Personality' application.

Participants

From September 2010 to June 2011, 9454 unique users completed the full 'Today or Tomorrow' questionnaire, allowing their DRD parameter to be calculated. Respondents were tracked using their Facebook user ID, which allowed repeat respondents to be removed from the analysis. Of the 6549 who entered their gender, there were 2504 males (38%) and 4045 females (62%). Of the 6154 who entered their date of birth, the mean was 23.1 years old (SD = 9.1). Due to the random condition allocation process, there were 2964 participants in the ascending condition, 3195 in the descending condition and 3295 in the randomized condition. Table 1 shows the currencies chosen by participants and the demographic and smoking characteristics of users of each currency.

Results

In order to examine whether the exponential or hyperbolic discounting function fit individuals' DRD best, curves were fit for each participant using their 6 delays (between 1 week and 5 years). Sums of squared deviations were calculated for each participant's 6 indifference points from the curves generated by the discounting functions (36). It was found that the mean deviation from that predicted by the discounting function was smaller for the hyperbolic function (mean = 24150, SD = 32418, absolute difference = $155.40) than the exponential function (mean = 31558, SD = 41236, absolute difference =$177.65). For 86.8% of participants the hyperbolic function was a better fit to their DRD than the exponential function, which agrees with previous research (3, 36, 37). There was no significant difference in the percentage of daily, non-daily, and non-smokers who were best described by the hyperbolic function.

Since the hyperbolic discount function best describes most individuals' DRD, for each participant estimated DRD $\log(k)$ parameters were averaged over the six delays which used $1000 as the delayed amount. To test whether self-reported smoking behaviour affected any effect of DRD order condition, participants were split into three groups: daily smokers, non-daily smokers, and non-smokers. The validity of separating the daily and non-daily smoking groups was confirmed by the CDS-5 scores of the two groups; daily smokers scored 16.03 (SD = 4.60, N = 1520), and non-daily smokers scored 7.06 (SD = 2.67, N = 502). In all analyses, the group sizes are unequal and we therefore used a Type III sum of squares ANOVA method in which each effect is controlled for every other effect, which ameliorates the problem.

Using the 9038 respondents who reported their smoking behaviour[1], a 3 x 3 between groups ANOVA examined whether the order that the items were presented in is related to delay discounting. Condition (ascending, descending, and randomized) and smoking status (daily smoker, N = 1592; non-daily smoker, N = 669; non-smoker, N = 6777) were the factors and log(k) was the dependent variable (Figure 3). A main effect of smoking status was found ($F(2,9038) = 58.98$, MSE = .32, p <.001), and planned t-tests showed that daily smokers had a steeper DRD curve than non-daily smokers ($t(5887) = 3.02$, p = .003), who in turn had a steeper DRD curve than non-smokers ($t(7444) = 3.24$, p = .001). A main effect of condition was found ($F(2, 9038) = 11.20$, MSE = .32, p < .001) and planned t-tests found that all three conditions had different parameters from one another (ascending was steeper than descending $t(6157) = 2.48$, p = .013; randomized was steeper than ascending $t(6257) = 3.37$, p = .001; randomized was steeper than descending $t(6488) = 6.24$, p < .001). However, no interaction was found between smoking status and condition ($F(4, 9038) = .38$, MSE = .32, p = .82);.the differences between smoking groups within each condition are the same, so the different smoking groups are affected equally by the DRD order condition.

To find out whether there were differences in the estimated DRD parameters at different delay lengths, and whether any differences were affected by smoking status, a 3x3x6 mixed ANOVA was conducted with condition (ascending, descending, and randomized) and smoking status (daily smoker, non-daily smoker, non-smoker) as the between groups factors and delay length (1 week, 2 weeks, 1 month, 6 months, 1 year, 5 years) as the within groups factor. There was an effect of delay length ($F(5, 45145) = 3195.15$, MSE = .21, p < .001), such that shorter delays led to a steeper discounting parameter being estimated. The three-way interaction was not significant ($F(20, 45145) = 1.37$, MSE

---

[1] Johnson & Bickel (38) developed an algorithm for identifying inconsistent DRD responding. Using the parameters suggested we repeated all of our analyses and found the same pattern of results as those reported here.
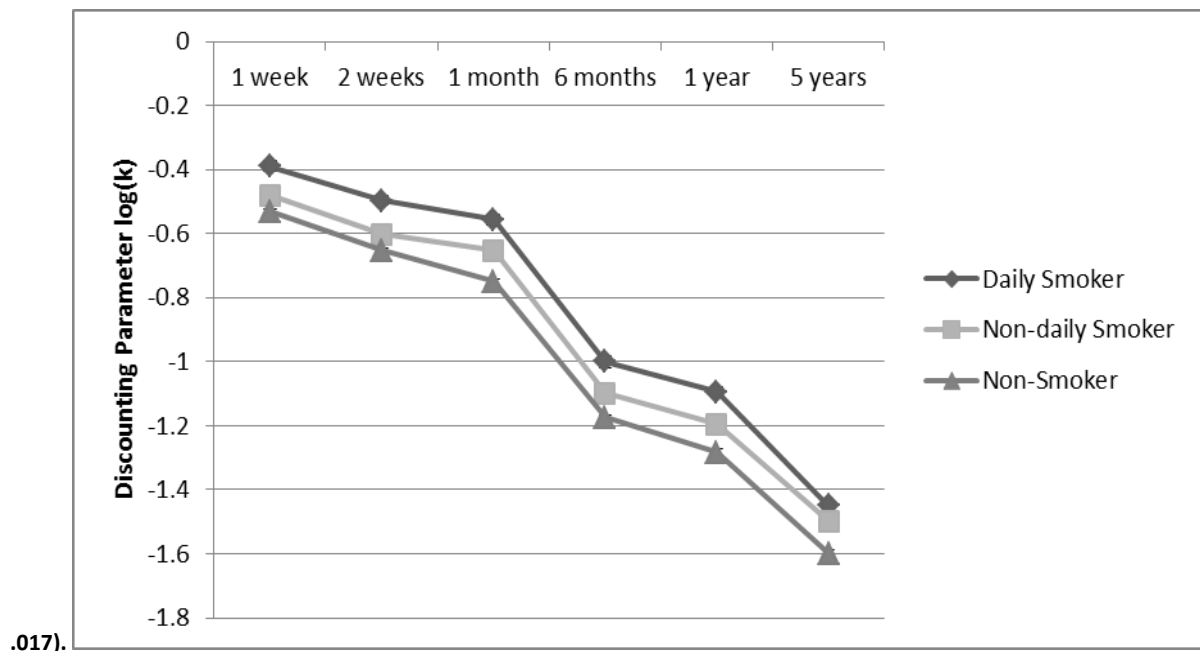
Figure 4 illustrates that for each of the smoking groups, the estimated DRD parameters become shallower as the delay length increased, but there was no clear pattern of changing differences between the smoking groups, indicating that similar results would be obtained no matter which delay period was used. Table 2 presents correlations between individuals' estimated log(*k*) parameters for various delays. It can be seen that as the time difference between two delays increases, the correlation between individuals' estimated DRD curves decreases (the smallest correlation is between 1 week and 5 years). This indicates that the delay length effect found in the ANOVA above is not simply due to a missing parameter in the hyperbolic discounting function which would affect the whole cohort of participants but not groups, and so we might still have expected to find differences between smoking groups. This nevertheless calls into question the estimation of a single DRD parameter across various delay lengths, as an individual's DRD parameter at one delay may not be strongly predictive of their parameter at another delay.

In order to investigate the effects of differing delayed rewards, the DRD parameters for $1000 in 1 month were compared to the parameters for $100 in 1 month. A 3 x 2 mixed ANOVA with smoking status (daily smoker, non-daily smoker, and non-smoker) as the between-groups factor, and delayed amount ($100, $1000) as the within-subjects factor found a main effect of delayed amount ($F_{(1, 8940)} = 259.51$, $MSE = .17$, $p < .001$), but no interaction ($F_{(2, 8940)} = 1.73$, $MSE = .17$, $p = .18$). These effects are shown in Figure 5 where the $100 delayed amount is discounted more steeply than the $1000 delayed amount and daily smokers discount more steeply than non-daily smokers. However, since the shape of the curves are identical the same differences between smoking groups would have been found no matter what delayed amount was used in the DRD procedure. This analysis relies on the subjective difference between $100 and $1000 being the same for all currencies. Despite our attempt to equalise them using the exchange rate, it may still be that our monetary values are perceived as larger or smaller for some currencies depending upon local prices. In order to control for this effect, we repeated the analysis using only respondents who picked the US Dollar as their currency. We again found a main effect of delayed amount ($F_{(1, 6362)} = 159.44$, $MSE = .17$, $p < .001$) but no interaction ($F_{(2, 6362)} = .23$, $MSE = .17$, $p = .79$), which corroborates our findings.

The daily, non-daily and non-smoker groups differed by demographic characteristics, particularly age; daily smokers were older than non-daily smokers, who were older than non-smokers. To control for any effects of age, the main analyses were repeated including age and gender as covariates (these are presented in the Supplementary Material). The pattern of results replicated the current results, indicating that irrespective of which method of measuring discounting is used, the same effect of smoking group would be found.

Discussion

We found three methodological differences that may challenge the assumption of a single DRD parameter across all situations. The order that immediate rewards were presented in led to differing derived discounting parameters, with the randomized order demonstrating the steepest discounting, followed by the ascending order, followed by the descending order. Also, smaller delay lengths led to a steeper discounting function, and small rewards were discounted more than large rewards. Finally, daily smokers demonstrated the steepest discounting, followed by non-daily smokers, followed by non-smokers. Nevertheless, despite the large sample size, there were no interactions between smoking status and any of the above effects. This indicates that the difference in DRD between different smoking groups is remarkably robust to the method of measurement: it does not matter what order the items are presented in, what delayed time is used, or what delayed amount is used. The results of this study do however underline the importance of not directly comparing discounting parameters between studies, as the method of eliciting them is important.

Consistent with previous research (3, 36, 37) it was found that a hyperbolic DRD curve fit better than an exponential curve. This implies that individuals have inconsistent time preferences and so may change their minds as the time before two rewards are available decreases. This has important implications for the external consequences that economists use when calculating the negative impacts of behaviours such as smoking (19), such that an individual may not take their future self's preferences fully into account.

There are other variables that could affect DRD that were not studied here. It is known that individuals differentially discount different types of rewards (39), so it might be that daily smokers discount cigarettes more than non-daily smokers. Additionally, this study does not shed light on whether the difference in DRD is due to an acute nicotine effect or whether it is a trait that may explain why people smoke, although there is evidence that steep DRD leads to smoking rather than the reverse (11).

Running an online study was successful in obtaining a large sample, and from countries that are underrepresented in traditional research (40), but it did present a methodological problem specific to DRD in that the currencies used by participants differ. In order to standardize amounts the exchange rate was used, but it could be more appropriate to use a measure of purchasing power which takes account of unequal prices for the same goods between different countries. Additionally, the exchange rates on one date were used throughout the 10 month study, however, exchange rates fluctuated during this time, for example the US Dollar to British Pound exchange rate peaked at 0.6513 and floored at 0.5984., Nevertheless, whichever exchange rate was used, the calculated discounting rate would remain unaffected, and so discounting rates in our experiment are comparable between currencies. However, since we found that larger amounts are discounted less steeply, the purchasing power of a currency could affect how long people are willing to wait to receive it.

We found differences in DRD rate between users who picked different currencies. Indonesian Rupiah users had the steepest DRD functions whereas Canadian Dollar users were most self-controlled. Nevertheless, we view these differences extremely cautiously because as well as the differences in purchasing power between currencies we also cannot be sure that the selection biases for 'My Personality' users are the same for each country. For example, users of 'My Personality' in the United States are more likely to be sociologically representative than users in countries such as India where internet use is less common and where only a certain sociographic would use our English-language Facebook application.In conclusion, irrespective of how we measured DRD – varying the order of the items, the length of the delay and the magnitude of the delay, daily smokers had a shorter temporal horizon than non-daily smokers, who in turn had a shorter horizon than non-smokers. This is strong evidence that smoking is reliably related to DRD as a generalised behavioural preference function, rather than only a particular method of measuring discounting. It also indicates

to researchers that the method they use to measure discounting should depend upon their convenience. However, researchers should only compare discounting functions within studies, or effect sizes between studies, as small changes in DRD methodology can significantly affect the derived DRD parameter.

Appendix 1

'Today or Tomorrow' information

1. Important information about the questionnaire

"Today or Tomorrow?" measures what economists call your delay discounting function. This describes how much you prefer the present over the future, or how willing you are to wait for a reward. You will be asked to answer 7 blocks of 15 questions asking whether you would prefer money now or in the future. Once you have done so, we will calculate your delay discounting function which estimates how much any reward drops in value as the delay to receive it increases. We will also compare this to others' delay discounting functions and will tell you whether you value the present or the future more than most others do.

The survey will take about 12 minutes to complete. Allow yourself enough time so that you do not have to rush. If you are interrupted you can return to the questionnaire and the questions that you have already submitted will be saved. To receive the most accurate results, you should complete the questionnaire in a quiet environment. You should specifically avoid taking the questionnaire while others are watching your responses. All answers you provide will be treated as confidential. We will only do research with your answers after the data has been anonymised so that it cannot be linked back to you.

Sadly we cannot actually give you the rewards that you prefer, but we would still ask you to answer as honestly as you can as if the rewards were for real. This will also give you the most accurate results.

The questionnaire has been made available as part of research by David Stillwell and Dr. Richard Tunney from the School of Psychology at the University of Nottingham. We are also grateful to Dr. Lee Hogarth for his invaluable assistance.

I have read and understood all of the above, and I will follow its recommendations. I know that I can withdraw at any time by closing my browser window and not answering further questions.

References

1.   Mackillop J, Amlung MT, Few LR, Ray LA, Sweet LH, Munafo MR. Delayed reward discounting and addictive behavior: a meta-analysis. Psychopharmacology. 2011;216(3):305-21.
2.   Etter JF, Le Houezec J, Perneger TV. A self-administered questionnaire to measure dependence on cigarettes: The Cigarette Dependence Scale. Neuropsychopharmacology. 2003;28(2):359-70.
3.   Bickel WK, Odum AL, Madden GJ. Impulsivity and cigarette smoking: delay discounting in current, never, and ex-smokers. Psychopharmacology. 1999;146(4):447-54.
4.   Heyman GM, Gibb SP. Delay discounting in college cigarette chippers. Behavioural Pharmacology. 2006;17(8):669-79.
5.   Johnson MW, Bickel WK, Baker F. Moderate drug use and delay discounting: A comparison of heavy, light, and never smokers. Experimental and Clinical Psychopharmacology. 2007;15(2):187-94.
6.   Baker F, Johnson MW, Bickel WK. Delay discounting in current and never-before cigarette smokers: Similarities and differences across commodity, sign, and magnitude. Journal of Abnormal Psychology. 2003;112(3):382-92.
7.   Reynolds B, Patak M, Shroff P, Penfold RB, Melanko S, Duhig AM. Laboratory and self-report assessments of impulsive behavior in adolescent daily smokers and nonsmokers. Experimental and Clinical Psychopharmacology. 2007;15(3):264-71.
8.   Sweitzer MM, Donny EC, Dierker LC, Flory JD, Manuck SB. Delay discounting and smoking: Association with the Fagerstrom Test for Nicotine Dependence but not cigarettes smoked per day. Nicotine & Tobacco Research. 2008;10(10):1571-5.
9.   Krishnan-Sarin S, Reynolds B, Duhig AM, Smith A, Liss T, McFetridge A, et al. Behavioral impulsivity predicts treatment outcome in a smoking cessation program for adolescent smokers. Drug and Alcohol Dependence. 2007;88(1):79-82.
10.   MacKillop J, Kahler CW. Delayed reward discounting predicts treatment response for heavy drinkers receiving smoking cessation treatment. Drug and Alcohol Dependence. 2009;104(3):197-203.
11.   Audrain-McGovern J, Rodriguez D, Epstein LH, Cuevas J, Rodgers K, Wileyto EP. Does delay discounting play an etiological role in smoking or is it a consequence of smoking? Drug and Alcohol Dependence. 2009;103(3):99-106.
12.   Vuchinich RE, Simpson CA. Hyperbolic temporal discounting in social drinkers and problem drinkers. Experimental and Clinical Psychopharmacology. 1998;6(3):292-305.
13.   Heil SH, Johnson MW, Higgins ST, Bickel WK. Delay discounting in currently using and currently abstinent cocaine-dependent outpatients and non-drug-using matched controls. Addictive Behaviors. 2006;31(7):1290-4.
14.   Kirby KN, Petry NM. Heroin and cocaine abusers have higher discount rates for delayed rewards than alcoholics or non-drug-using controls. Addiction. 2004;99(4):461-71.
15.   Madden GJ, Petry NM, Badger GJ, Bickel WK. Impulsive and self-control choices in opioid-dependent patients and non-drug-using control participants: Drug and monetary rewards. Experimental and Clinical Psychopharmacology. 1997;5(3):256-62.

16.   Johnson MW, Bickel WK, Baker F, Moore BA, Badger QJ, Budney AJ. Delay Discounting in Current and Former Marijuana-Dependent Individuals. Experimental and Clinical Psychopharmacology. 2010;18(1):99-107.

17.   Johnson MW, Bickel WK. Within-subject comparison of real and hypothetical money rewards in delay discounting. Journal of the Experimental Analysis of Behavior. 2002;77(2):129-46.

18.   Rachlin H, Raineri A, Cross D. Subjective-probability and delay. Journal of the Experimental Analysis of Behavior. 1991;55(2):233-44.

19.   Gruber J, Koszegi B. Is addiction "rational"? Theory and evidence. Quarterly Journal of Economics. 2001;116(4):1261-303.

20.   Odum AL. Delay discounting: Trait variable? Behavioural Processes. 2011;87(1):1-9.

21.   Robles E, Vargas PA, editors. Functional parameters of delay discounting assessment tasks: Order of presentation. Meeting of the Society-for-the-Quantitative-Analyses-of-Behavior (SQAB 2006); 2006 May 26-27; Atlanta, GA: Elsevier Science Bv.

22.   Robles E, Vargas PA. Parameters of delay discounting assessment: Number of trials, effort, and sequential effects. Behavioural Processes. 2008;78(2):285-90.

23.   Robles E, Vargas PA, Bejarano R. Within-subject differences in degree of delay discounting as a function of order of presentation of hypothetical cash rewards. Behavioural Processes. 2009;81(2):260-3.

24.   Koff E, Lucas M. Mood moderates the relationship between impulsiveness and delay discounting. Personality and Individual Differences. 2011;50(7):1018-22.

25.   Stanford MS, Mathias CW, Dougherty DM, Lake SL, Anderson NE, Patton JH. Fifty years of the Barratt Impulsiveness Scale: An update and review. Personality and Individual Differences. 2009;47(5):385-95.

26.   de Wit H, Flory JD, Acheson A, McCloskey M, Manuck SB. IQ and nonplanning impulsivity are independently associated with delay discounting in middle-aged adults. Personality and Individual Differences. 2007;42(1):111-21.

27.   Kirby KN, Petry NM, Bickel WK. Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. Journal of Experimental Psychology-General. 1999;128(1):78-87.

28.   Rodzon K, Berry MS, Odum AL. Within-subject comparison of degree of delay discounting using titrating and fixed sequence procedures. Behavioural Processes. 2011;86(1):164-7.

29.   Grace RC, McLean AR. Integrated versus segregated accounting and the magnitude effect in temporal discounting. Psychonomic Bulletin & Review. 2005;12(4):732-9.

30.   Loewenstein G, Prelec D. ANOMALIES IN INTERTEMPORAL CHOICE - EVIDENCE AND AN INTERPRETATION. Quarterly Journal of Economics. 1992;107(2):573-97.

31.   Mitchell SH, Wilson VB. The subjective value of delayed and probabilistic outcomes: Outcome size matters for gains but not for losses. Behavioural Processes. 2010;83(1):36-40.

32.   Stillwell DJ, Kosinski M. myPersonality Research Wiki. 2011; Available from: http://mypersonality.org/wikiAvailable from: (Archived by WebCite® at http://www.webcitation.org/60Jn4WfiF).

33.   Townshend JM, Duka T. Binge drinking, cognitive performance and mood in a population of young social drinkers. Alcoholism-Clinical and Experimental Research. 2005;29(3):317-25.

34.   Willner P. Further validation and development of a screening instrument for the assessment of substance misuse in adolescents. Addiction. 2000;95(11):1691-8.

35.   Kawashima K. The effects of inflation and interest rates on delay discounting in human behavior. Psychological Record. 2006;56(4):551-68.

36.   Lagorio CH, Madden GJ. Delay discounting of real and hypothetical rewards III: Steady-state assessments, forced-choice trials, and all real rewards. Behavioural Processes. 2005;69(2):173-87.

37.   Madden GJ, Bickel WK, Jacobs EA. Discounting of delayed rewards in opioid-dependent outpatients: Exponential or hyperbolic discounting functions? Experimental and Clinical Psychopharmacology. 1999;7(3):284-93.

38.   Johnson MW, Bickel WK. An algorithm for identifying nonsystematic delay-discounting data. Experimental and Clinical Psychopharmacology. 2008;16(3):264-74.

39.   Tsukayama E, Duckworth AL. Domain-specific temporal discounting and temptation. Judgment and Decision Making. 2010;5(2):72-82.

40.   Gosling SD, Vazire S, Srivastava S, John OP. Should we trust web-based studies? A comparative analysis of six preconceptions about Internet questionnaires. American Psychologist. 2004;59(2):93-104.

Table 1 – Currencies used, including exchange rates from Google's exchange rate function on 22nd June 2010

Name	Symbol used on 'My Personality'	Conversion per $1 USD	*N*	Mean Age (SD)	% Male	% daily/non-daily/non-smokers	Mean(log_k) (SD)
British Pound	£	0.68	915	25.0 (10.2)	38%	24/7/70	-.93 (.58)
Canadian Dollar	$	1.02	436	22.4 (9.2)	33%	17/6/76	-1.09 (.58)
Euro	€	0.81	644	24.7 (8.1)	42%	29/10/62	-.98 (.57)
Filipino Peso	P	45.45	159	22.5 (6.1)	42%	11/14/75	-.73 (.60)
Indian Rupee	Rs	45.65	156	23.1 (6.1)	56%	15/6/78	-.75 (.57)
Indonesian Rupiah	Rp	9009	51	22.9 (6.1)	59%	16/6/78	-.59 (.67)
Singapore Dollar	$	1.38	184	20.3 (6.4)	41%	10/4/86	-.91 (.58)
South African Rand	R	7.51	63	26.7 (9.1)	36%	32/5/63	-1.03 (.52)
United States Dollar	$	1	6430	22.8 (9.2)	36%	17/7/75	-.98 (.56)

Table 2 – Pearson correlations of individuals' estimated log(k) delay reward discounting parameters at various delays. All correlations are significant at p<.001

Delay	1 week	2 weeks	1 month	6 months	1 year
2 weeks	.736				
1 month	.647	.736			
6 months	.531	.619	.701		
1 year	.439	.529	.651	.767	
5 years	.302	.394	.478	.651	.715

Today or Tomorrow?

Which would you prefer? (Assume that there is no inflation. In other words, you could buy the same 'stuff' with your future money as you could buy with the same amount today.)

£680 now ○	or	○ £680 in 1 year
£646 now ○	or	○ £680 in 1 year
£612 now ○	or	○ £680 in 1 year
£578 now ○	or	○ £680 in 1 year
£510 now ○	or	○ £680 in 1 year
£408 now ○	or	○ £680 in 1 year
£340 now ○	or	○ £680 in 1 year
£272 now ○	or	○ £680 in 1 year
£170 now ○	or	○ £680 in 1 year
£102 now ○	or	○ £680 in 1 year
£68 now ○	or	○ £680 in 1 year
£40.8 now ○	or	○ £680 in 1 year
£13.6 now ○	or	○ £680 in 1 year
£6.8 now ○	or	○ £680 in 1 year
£0.68 now ○	or	○ £680 in 1 year

Please answer carefully as you cannot return to previous questions once you have submitted your answers. Ensure you have answered with *the immediate reward* on the left and the *delayed reward* on the right.

Submit these Answers

Figure 1 - Screenshot of 'Today or Tomorrow' questions on 'My Personality'. Immediate amounts are presented in descending order and have been converted into British Pounds.

Figure 2 - Screenshot of 'Today or Tomorrow' feedback on 'My Personality'. The lighter curve is the participant's personal DRD curve calculated from their DRD parameter. The darker curve is that of the average person.
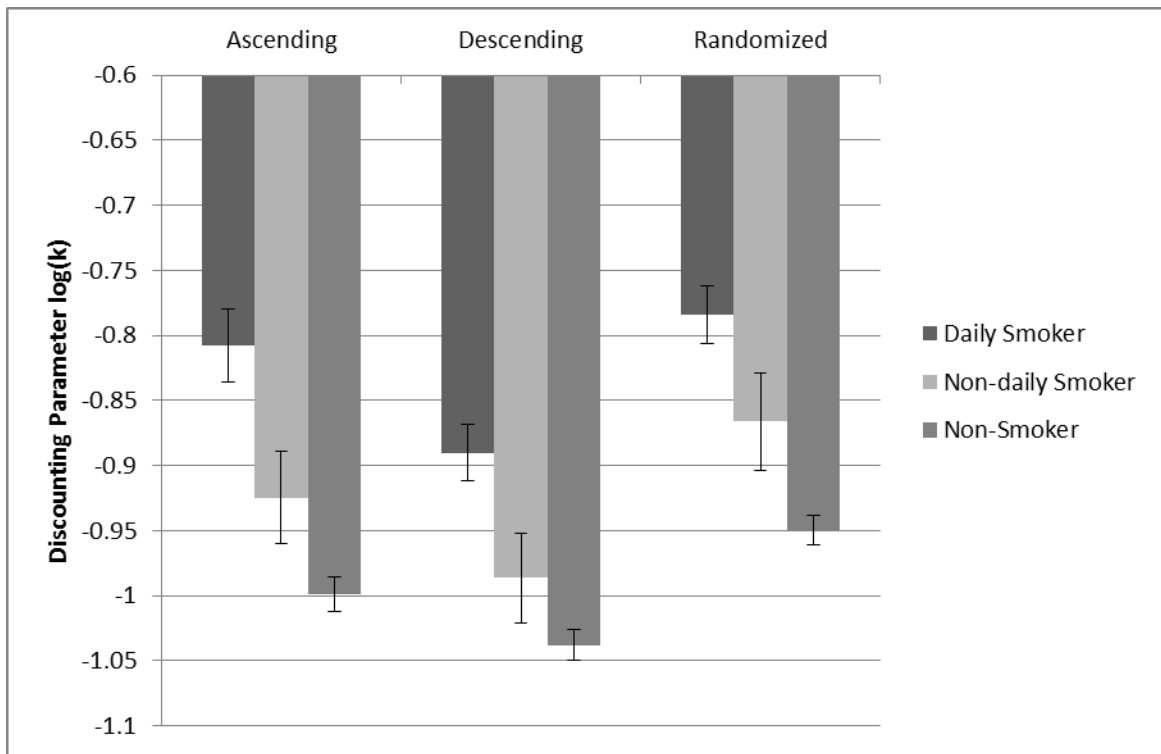
Figure 3 - Mean DRD parameter (log(k)) for the ascending, descending and randomized conditions, separated by smoking status. The identical differences for each condition illustrate that the three smoking factors are affected equally by the three order conditions. Error bars are standard errors.
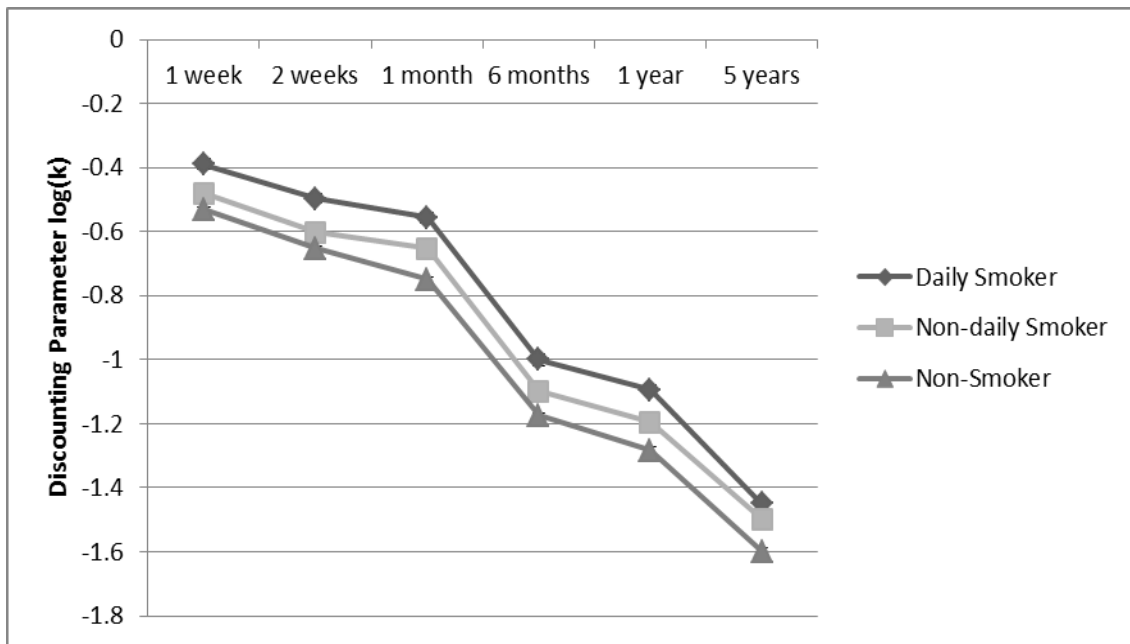
Figure 4 - Mean DRD parameter (log(k)) for the daily smoker, non-daily smoker, and non-smoker conditions, at various delays. The similar curves indicate that the same differences between smoking statuses would be obtained no matter what delay length was used. Standard error bars are too small to be seen.
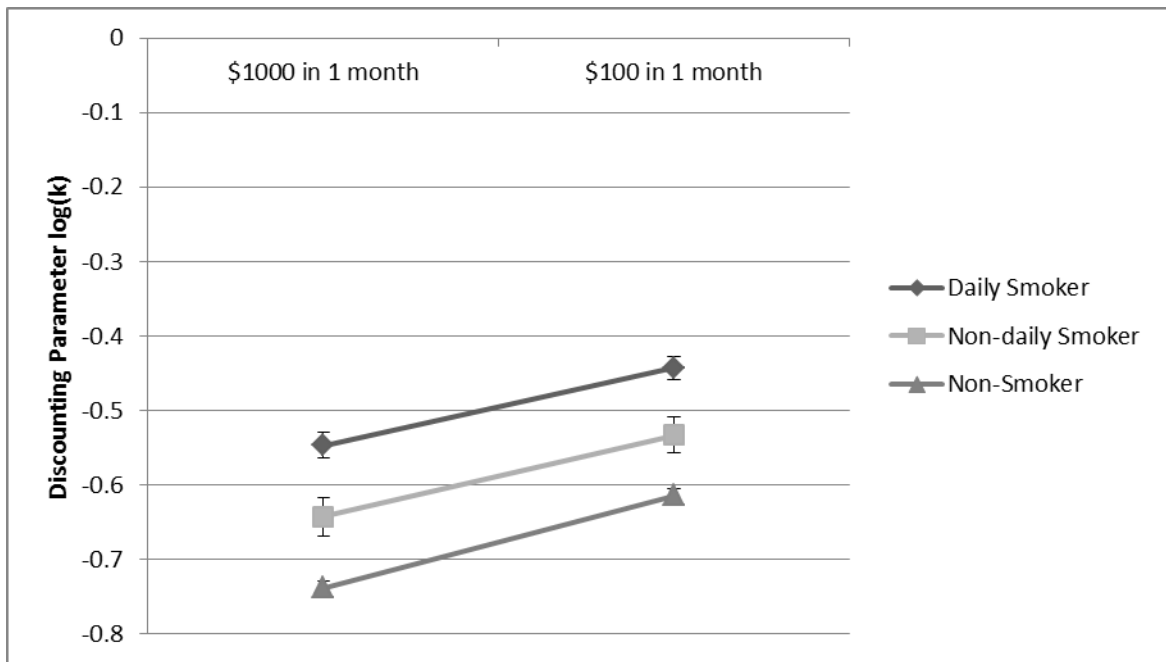
Figure 5 - Mean DRD parameter (log(k)) for the $1000 and $100 delayed amounts in 1 month. The matching curves indicate that the three smoking statuses are identically affected by the two delayed amounts. Error bars are standard errors.